Florida Commission on Hurricane Loss Projection Methodology

Professional Team Report

2021 Flood Standards


Hurricane Michael, Bay County


Hurricane Irma, Osceola County

Florida International University

On-Site Review: May 13-17, 2024

Additional Verification Review: Sept 4-6, 2024

On May 13-17, 2024, the Professional Team conducted an on-site review of the Florida Public Flood Loss Model (FPFLM) Version 1.0 at Florida International University. The following individuals participated in the review.

FPFLM

Bachir Annane, Ph.D., Senior Research Associate III, Hurricane Research Division – CIMAS, NOAA Atlantic Oceanographic and Meteorological Laboratory, Miami, FL

Christian Bedwell, Ph.D. Candidate in Civil Engineering, University of Florida

Qiang Chen, Ph.D., Coastal Research Specialist, Extreme Events Institute and Research Associate, Laboratory for Coastal Research, Florida International University

Shu-Ching Chen, Ph.D., Professor and Executive Director, Data Science and Analytics Innovation Center, University of Missouri-Kansas City

Steve Cocke, Ph.D., Senior Research Scientist, Center for Ocean-Atmospheric Prediction Studies, Florida State University (virtual)

Ayushman Das, Ph.D., Candidate, Computer Science, University of Missouri-Kansas City

Gail Flannery, FCAS, MAAA, Consulting Actuary, AMI Risk Consultants, Miami, FL

Sneh Gulati, Ph.D., Professor Mathematics & Statistics, College of Arts, Sciences & Education, Florida International University

Kurt Gurley, Ph.D., Professor and Associate Director, Department of Civil and Coastal Engineering, University of Florida

Shahid Hamid, Ph.D., CFA, Professor, Department of Finance, College of Business, and Director, Laboratory for Insurance, Financial and Economic Research, International Hurricane Research Center, Florida International University

Andrew Kennedy, Ph.D., Professor, Civil and Environmental Engineering and Earth Sciences, University of Notre Dame

B.M. Golam Kibria, Ph.D., Professor, Mathematics and Statistics, College of Arts, Sciences & Education, Florida International University

Yuepeng Li, Ph.D., Senior Research Scientist, Extreme Events Institute, and Interim Director, Laboratory for Coastal Research, Florida International University

Namuun Lkhagvadorj, MS Student, University of Missouri-Kansas City

Efthymios Nikolopoulos, Ph.D., Associate Professor, Civil and Environmental Engineering, Rutgers University

Jean-Paul Pinelli, Ph.D., P.E., Professor, College of Engineering and Science – Mechanical and Civil Engineering, Florida Institute of Technology

Zimeena Rasheed, Ph.D. Candidate, Civil and Environmental Engineering, Rutgers University (virtual)

Mei-Ling Shyu, Ph.D., Professor, Electrical and Computer Engineering, Division of Energy, Matter and Systems, School of Science and Engineering, University of Missouri-Kansas City

Humberto Vergara, Ph.D., Assistant Professor, Civil and Environmental Engineering, University of Iowa

Tianyi Wang, Ph.D., Computer Scientist, Extreme Events Institute, Florida International University

Wensong Wu, Ph.D., Associate Professor, Mathematics and Statistics, College of Arts, Sciences & Education, Florida International University

Professional Team
Jimmy Booth, Ph.D., Meteorology
Paul Fishwick, Ph.D., Computer/Information
Mark Johnson, Ph.D., Statistics, Team Leader
Chris Jones, P.E., Vulnerability (virtual)
Stu Mathewson, FCAS, MAAA, Actuarial
Del Schwalls, P.E., CFM, Hydrology & Hydraulics
Donna Sirmons, Staff
Blake Tullis, Ph.D., Hydrology & Hydraulics, observer
Masoud Zadeh, Ph.D., P.E., Vulnerability, observer

The Professional Team began the review with an opening briefing and introductions were made. The following institutions participated in the development and maintenance of the flood model.

- Florida International University/International Hurricane Research Center, lead institution
- Florida State University
- University of Florida
- Florida Institute of Technology
- University of Missouri-Kansas City
- NOAA Hurricane Research Division
- University of Miami
- University of Notre Dame
- Rutgers University
- University of Iowa
- AMI Risk Consultants

The FPFLM team provided detailed presentations on each flood model component.

- Meteorology
- Coastal Flood Hazard (CEST)
- Wave
- Inland Flood Hazard (pluvial and fluvial)
- Vulnerability
- Insured Loss Cost

The major components were developed independently before being integrated. The computer platform is designed to accommodate future connections to additional sub-components or enhancements.

For the meteorology component, meteorological input data is obtained directly from the Florida Public Hurricane Loss Model. The only modifications made to the data were to extend some storm tracks earlier in time prior to landfall in order to provide sufficient spin-up for the coastal and estuarine storm tide surge model. The wind model is the same as the one used in the hurricane loss model.

The storm track generator generates tracks which have position, intensity, and storm parameters for the duration of a storm. The wind model generates a surface windfield for each storm. The rain model generates rainfall for stochastic events using historical or stochastic track information. Rain rates are determined using the NOAA HRD R-CLIPER algorithm.

The Modeler addressed how the storm surge model, coastal and estuarine storm tide (CEST), provides: 1) stability referring to the mathematical property that the numerical solution to the governing equations remains bounded and behaves in a physically meaningful way as a simulation progresses, 2) accuracy referring to the degree to which the result of numerical simulation aligns with the physical observations, and 3) efficiency referring to the capability of the model to produce accurate and reliable results within an acceptable time frame. The CEST model contains four basins covering Florida, and the flood model requires CEST to simulate more than 50,000 stochastic storms for each basin for the loss cost estimation. The CEST model can simulate all the 200,000 stochastic storms for the four basins in two weeks. The CEST model has been approved by the National Oceanic and Atmospheric Administration (NOAA) for use in National Hurricane Center (NHC) operations. Examples of calibration and validation were presented.

Discussed that the wave model works with outputs from the surge and wind models. It is the STWAVE (STeady-state spectral WAVE) model that was developed by the US Army Corps of Engineers (USACE) for computing nearshore wave propagation and transformation. It is a steady-state model with no time variation, and includes wave generation, dissipation, refraction, and breaking. Considerations for implementation of STWAVE, the implementation strategy, and testing were presented. STWAVE uses 116 subgrids covering the Florida coastline. Discussed that the threshold for running the wave model in a subgrid is 0.75m simulated storm surge at one or more locations within the subgrid.

An overview of the inland flood model was provided, starting with the riverine (fluvial) model. The Modeler discussed that the riverine model uses the Ensemble Framework for Flash Flood Forecasting (EF5) which is a distributed hydrologic modeling system that features multiple water balance models and two routing schemes. EF5 is used to simulate hydrologic variables such as streamflow and soil saturation. EF5 implementation uses the CREST (Coupled Routing and Excess Storage) model for the water balance component, kinematic wave for overland and channel routing, and a linear reservoirs scheme for subsurface routing. Soil moisture and surface/subsurface runoff are simulated at ~90m spatial and 1-hour temporal resolution at ~1.3 million grid points. Schematics of the processes resolved at each grid point and of the input data and parameters required were presented. Examples of calibration and validation were presented. Discussed the calibration of input parameters using Multi-Radar/Multi-Sensor System (MRMS) precipitation.

The pluvial model uses grid cells defined by the input Digital Elevation Model (DEM) data at a 30m resolution for flow. Flow velocity is governed by Manning's equation. There is an option that is being developed to use the inertial shallow water equation in Bates et al. (2010) which is not currently in the model under review. Velocity increases with channel slope and depth, but decreases with increasing surface roughness. A one-dimensional (1D) routing method is incorporated for flow that is not adequately represented by the DEM. Soil infiltration uses a modified Horton method. Infiltration parameters depend on soil type and vegetation cover. Soil type is based on Global Hydrological Soil Group 1566. Vegetation cover is an input option that ranges from bare soil to dense cover. Moderate coverage is assumed for residential exposure areas.

For precipitation input, the model can use any gridded precipitation product or a manually specified rainfall amount. NOAA Atlas 14 intensity-duration maps are used for return periods of extreme events. Manning's coefficient is used to model terrain roughness impacts on the rate of flow. Higher roughness impedes the flow of surface water and can temporarily enhance the local accumulation of surface water. Roughness is based on Multi-Resolution Land Characteristics (MRLC) 2016 National Land Cover Database (NLCD). The Manning's coefficient is assigned based on a Hydrologic Engineering Center River Analysis System (HEC-RAS) two-dimensional (2D) table that assigns a value based on NLCD classification. The computation aspects of the pluvial model were discussed.

Validation of the pluvial model was presented using comparisons of 1) return period flood maps for the entire State of Florida based on NOAA Atlas 14 data, 2) simulations performed for major recent historical flood events in Florida using observed rainfall data, 3) return period maps with the First Street Foundation LISFLOOD model, 4) a 100-year return period map with the Federal Emergency Management Agency (FEMA) flood zones, 5) simulated flood depths using historical rainfall data, and 6) return period maps with National Flood Insurance Program (NFIP) claims data. The FPFLM project was given special permission to use full FEMA claims data, which provides precise location of the flooded properties.

Discussed that the FPFLM has a comprehensive exposure set of over 1 million insurance policies for testing and reporting modeled results.

The following features of the vulnerability component were presented.

- Vulnerability of unmitigated residential construction
- Vulnerability of site-built residential structures to coastal and inland flood
- Vulnerability of manufactured housing (tied down or untied) to coastal and inland flood
- Tsunami damage fragilities
- Coastal flood fragilities
- Equivalent coastal flood and tsunami water forces
- Quantification of damage states
- Development of coastal flood vulnerability functions
- Inland flood building vulnerability functions based on USACE (2015)
- Initiation of damage in the coastal flood vulnerability functions
- Mitigated vulnerability functions
- Comparisons of the model vulnerability functions with the USACE vulnerability functions for coastal and inland personal residential structures, and for manufactured homes

Discussed the use of NFIP claims data to validate the vulnerability component. Examples of building vulnerability validation with NFIP claims data were presented.

Discussed that the USACE (2015) data used for the inland flood building vulnerability functions are shifted to reflect first floor elevation (FFE) relative to the ground. A lognormal cumulative distribution function (CDF) is used to fit the empirical points.

Discussed the behavior of mitigated vulnerability functions for

- Elevated structures
- Elevating utilities
- Wet floodproofing
- Dry floodproofing
- Combined mitigation

Examples of vulnerability functions for elevated structures, elevating utilities up to 1, 2, and 3ft, wet floodproofing, dry floodproofing, and combinations of elevating utilities and wet floodproofing were presented.

Discussed the three-tier computer system architecture: user interface layer, application logic layer, and database layer. The FPFLM is designed and operates on a computing cluster of 60 servers interconnected by network routers. The user-facing part of the system consists of a collection of scripts written in Bash and Python. Backend probabilistic calculations are coded in C++ and Python. The system uses a PostgreSQL database that runs on a Linux server.

For the wave model computational implementation, all runs are trivially task-parallel where different storms are run on different cores/machines. MATLAB scripts set up and distribute the runs and organize the output results for use by the engineering team to assess damage. Grid inputs from topobathy and land use/land cover do not change. Storm-specific water levels and winds come from the surge team. Results are consolidated into lookup tables for interpolation to individual properties.

Professional Team final preparations for the FIU on-site review were to commence May 10, 2024, upon access to the FIU on-site review presentations, including a flood model overview, responses to pre-visit letter items, and responses to audit items in the Report of Activities (ROA). Only a fraction of the required material was available by the May 10 deadline, as prescribed in the pre-visit letter and in the On-Site Review chapter of the ROA. A few additional presentations, as well as some revised presentations, were made available during the weekend (May 11-12). The efficiency of the audit is greatly enhanced by review of the required materials in advance.

The Modeler started with an opening high-level overview of the flood model followed by overview presentations from team leaders in Meteorology, Coastal Flooding, Waves, Pluvial Inland Flooding, Riverine Inland Flooding, and Vulnerability. These presentations had various levels of detail (e.g., Vulnerability was quite detailed).

Due to incomplete materials provided by the deadline, the audit proceeded on the first day with a review of the Actuarial Flood Standards pre-visit letter items and audit items, since the Actuarial Flood Standards was the only complete section submitted on time and prior to the Professional Team's arrival. The second day of the audit commenced with a review of the materials provided by the statistical team, followed by a review of the Meteorological and Hydrological and Hydraulic (H&H) Standards. The Modeler presented the H&H information split into Coastal Flooding, Waves, Pluvial Inland Flooding, and Riverine Inland Flooding, which did not conform to the ROA format and resulted in an inefficient process. The presentation of Standards sections proceeded with Vulnerability and Computer Information (pre-visit letter items and audit items), and concluded with the General Flood Standards which are typically presented before other standards. In addition, the structure of the provided materials and presentations often resulted in delayed or deferred review of standards and sections pending receipt of other material. In summary, the late and disorganized receipt of materials disrupted the on-site review, and greatly reduced the efficiency of the audit.

Discussed with the modeling computer science team the need for improvements in the coding guidelines and legacy code, as well as improvements in coordination, communication, and documentation among the different modeling teams. An improvement plan, with a time schedule, on upgrades and changes to coding guidelines, legacy code, and coordination, communication, and documentation processes was required and provided.

In the course of the audit, the Modeler reinforced material in the submission that inland rainfall events were driven solely by tropical cyclones. This confirmation raised the question as to how rainfall events for non-tropical storms are accounted for in the model. The Modeler initiated a study to address this concern by comparing empirical cumulative distribution functions of historical United States Geological Survey (USGS) rain gauge data (annual maxima at 6 locations) to the cumulative distribution of a multitude of stochastic storm simulations. However, additional locations were needed to demonstrate that this approach yields a scientifically justifiable comparison throughout Florida in order for verification of specific standards.

In addition, justification for using NLCD 2011 data for the STWAVE model was needed for verification of specific standards.

Several standards were not verified, and an additional verification review is anticipated. Discussed with the Modeler options as provided in the ROA Acceptability Process.

On May 23, 2024, the Modeler requested an additional verification review with revised documentation due on June 24, 2024. On June 13, 2024, the Modeler requested an extension for submission of the revised documentation. The Commission Chair granted an extension to August 12, 2024. An additional verification review was held virtually on September 4-6, 2024. Comments related to the additional verification review are provided under the applicable standards proceeded with "September Additional Verification Review Comments:".

The Professional Team recommends the following data and information be presented to the Commission during the meeting to review the model for acceptability under the 2021 Flood Standards.

1. Use photographs to illustrate building damage states. Explain the basic difference between fragility and vulnerability functions, and how the two are related. Explain why tsunami fragility functions from Japan were used to derive coastal flood vulnerability functions for Florida.

2. Justify the use of NLCD 2011 data in the wave model.

3. Justify the methodology used to incorporate non-tropical precipitation into the model.

September Additional Verification Review Comments:

FIU submitted a revised submission on August 12, 2024. The Professional Team completed an additional verification review virtually on September 4-6, 2024.

The following individuals participated in the additional verification review.

FPFLM

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Jimmy Booth, Ph.D., Meteorology
Paul Fishwick, Ph.D., Computer/Information
Mark Johnson, Ph.D., Statistics, Team Leader
Chris Jones, P.E., Vulnerability
Stu Mathewson, FCAS, MAAA, Actuarial
Donna Sirmons, Staff
Blake Tullis, Ph.D., Hydrology & Hydraulics

Changes in the August 12, 2024, submission were reviewed. Open items from the initial May on-site review and from the September additional verification review were reviewed and resolved.

1) Justification for the continued use of NLCD 2011 data for the STWAVE model
2) Development and implementation of a new non-tropical cyclone rainfall model that resulted in increased loss costs and probable maximum loss (PML) levels
3) Addition of a fourth basin established for storm surge simulation to complete coverage of the whole Florida coastal area
4) Update on the treatment of potential levee failure based on empirical modeling studies
5) Updated plots of simulation results exhibiting the logical relationship of model parameters and water surface level by increasing imperviousness in different Florida regions
6) Revised Forms AF-1, AF-4, AF-6, and AF-8

All standards are now verified by the Professional Team.

Report on Deficiencies

The Professional Team reviewed the following deficiencies cited by the Commission at the April 4, 2024, meeting. The deficiencies were eliminated by the established time frame, and the modifications have been verified.

1. Incomplete. No time stamp in footer throughout the submission.

2. Incomplete. Provide the tables in Forms HHF-3 and HHF-5 in Excel format.

3. Notification Letter, page 3: Incomplete. Letter does not reference signed Expert Certification forms and does not include a statement that the model is ready to be reviewed by the Professional Team.

4. GF-1.2, page 30: Unclear. Provide a reference for the "Matinal Lancover" Dataset from the Geodatabase in Figure 9.

5. GF-1.2, page 35: Unclear. Clarify the vintage of land use and land cover (LULC) data used in the model. For example, the submission indicates that 2006 National Land Cover Dataset (NLCD) was used to estimate Manning's coefficients for grid cells (page 35, page 112) and 2011 NLCD was used in the wave model (page 38). However, HHF-1.A indicates 2016 NLCD was used (page 157, page 161).

6. GF-1.6, pages 78-89: Incomplete. Rosseto et al. 2013 (page 58), Pinelli et al. 2019 (page 63), USACE 1992 (page 67), Dewitz 2019 (page 161), and Michalski 2014 (page 201) references are not included in list of references.

7. MF-4.A, page 133: Non-responsive. This standard is not limited to the coastal model.

8. MF-4.B, page 133: Non-responsive. This standard is not limited to the coastal model.

9. MF-4.7, page 136: Incomplete. Figure 40 does not include STWAVE (Steady-state spectral WAVE) or show how outputs for wave and engineer teams result in flood damage estimates.

10. MF-5.A, page 155: Non-responsive. This standard is not limited to the coastal model.

11. HHF-1.B, page 157: Non-responsive. Provide scientific or technical literature references regarding calibration of parameters related to soil effects.

12. HHF-1.D, page 157: Non-responsive. Provide scientific or technical literature references regarding treatment of hydraulic systems.

13. HHF-1.3, page 158: Incomplete. Only assumptions related to soil moisture are discussed. Provide assumptions for additional initial and boundary conditions.

14. HHF-1.4 page 159: Incomplete. Only sensitivity to soil water/moisture is documented. Provide sensitivity for additional initial and boundary conditions.

15. HHF-1.10, page 161: Incomplete. Provide a reference to the specific HEC-RAS (U.S. Army Corps of Engineers' River Analysis System) 2D Model roughness data table.

16. HHF-3.C, page 174: Non-responsive. Provide scientific or technical literature references regarding how the potential failure of flood control (e.g., levee failure) measures are handled in the model.

17. Form HHF-1, pages 319, 320, and 328, Figures 123, 124, and 139: Incomplete. Provide data within/relevant to Florida, rather than Louisiana.

18. Form HHF-3.2, pages 341-343: Incomplete. The FEMA National Flood Hazard Layer (NFHL) includes 0.002 Aggregate Exceedance Probability (AEP) coverage for the indicated locations except for Bay County. Provide maps for the 0.002 AEP.

19. Form HHF-5.A.2, pages 356-359: Non-responsive. The figures reflecting the FEMA 0.002 AEP appear to be showing all Zone X as 0.002 AEP, which includes all area. Revise the figures to show Zone X (shaded) instead, which corresponds to the 0.002 AEP.

20. HHF-5.B.3, page 368: Incomplete. Flooding associated with the lakes is omitted.

Professional Team Pre-Visit Letter

The Professional Team's pre-visit letter questions are provided in the report under the corresponding standards. Following is the pre-visit letter preamble.

The purpose of this pre-visit letter is to outline specific issues unique to FIU's model submission under the 2021 flood standards, and to identify lines of inquiry that will be followed during the on-site review in order to allow time for adequate preparation. Aside from due diligence with respect to the full submission, various questions that the Professional Team will ask during the on-site review are provided herein. This letter does not preclude the Professional Team from asking for additional information during the on-site review that is not given below or discussed during an upcoming conference call to be held if requested by FIU. The goal of a potential conference call is to address your questions related to this letter or other matters pertaining to the on-site review. The overall intent is to help expedite the on-site review and to avoid last minute preparations that could have been undertaken earlier.

It is important that all material prepared for presentation during the on-site review be provided to the Professional Team and presented using a medium that is readable by all members of the Professional Team simultaneously.

The Professional Team will begin the review with an opening briefing. FIU should then proceed with thorough, detailed presentations on each model component. Afterwards, a review of the flood standards in the *Flood Standards Report of Activities as of November 1, 2021,* will commence. Each flood standard should be addressed beginning with responses to the pre-visit letter questions for that specific standard followed by responses to all of the audit items for that standard.

If changes have been made in any part of the model or the modeling process from the descriptions provided in the initial January 30, 2024, submission, provide the Professional Team with a complete and detailed description of those changes, the reasons for the changes (e.g., an error was discovered), and any revised forms. For each revised form, provide an additional form with cell-by-cell differences between the revised and the original submitted values.

Refer to the On-Site Review chapter of the *Flood Standards Report of Activities as of November 1, 2021*, for more details on materials to be presented and provided to the Professional Team. Particular attention should be paid to the requirements under Presentation of Materials.

In addition to the 6 items listed under Presentation of Materials, provide copies of:

1. Flowchart standard documents if internally developed, or references to published standards, and

2. Software engineering practice and coding guidelines if internally developed, or references to published standards.

In an effort to reduce the time and cost involved in producing hard copy materials, only 6 printed copies of the presentations, printed two slides per page and duplexed, need to be provided.

All documentation should be easily accessible from a central location in order to be reviewed electronically.

The following pre-visit questions are arranged by flood standard groups.

GENERAL FLOOD STANDARDS – Mark Johnson, Leader

GF-1 Scope of the Flood Model and Its Implementation*

*(*Significant Revision)*

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

B. A documented process shall be maintained to assure continual agreement and correct correspondence of databases, data files, and computer source code to presentation materials, scientific and technical literature, and modeling organization documents.

C. All software, data, and flowcharts (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.

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

E. Vintage of data, code, and scientific and technical literature used shall be justifiable.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

1. GF-1.2, page 26: Provide the temporal resolution of Tropical Rainfall Measuring Mission (TRMM). Discuss if the TRMM rain rate data are instantaneous or averaged.

   Discussed that the TRMM rain rates are instantaneous.

2. GF-1.2, page 35: Justify the specific choices made for Manning coefficients given that many of the primary sources in the literature provide ranges for the various land use codes.

   Discussed that the choices for Manning's coefficients follows the work of Zhang et al. (2012b) which verifies a comprehensive Manning's coefficient table by simulating historical hurricanes using CEST.

   Reviewed Zhang et al. (2012b), which was written by some of the coastal flood team members.

3. GF-1.2, page 38: Clarify how Figure 11 regions are related to the regions shown on Figures 33 and 34 (page 126). Explain the partial overlap.

   Discussed that the reason for using different basins in Figures 33 and 34 is to further examine the effect of domain size and resolution for computing storm surges. The basins were designed to simulate Hurricanes Ike (2008), Ivan (2004), and Dennis (2005).

4. GF-1.2, page 44: In the paragraph above "Vulnerability Component", in the last sentence, "… of flood depths for a large number of policies and simulated…." Clarify the use of "policies" in this context.

   Discussed that in the context of the paragraph, policies refers to the policy locations within a given insurance portfolio for which flood depths need to be calculated for each rain event.

5. GF-1.2, page 63: Discuss validation using claims data other than Hurricane Ivan (2004).

   Discussed that only Hurricane Ivan (2004) was used for validation because of the detailed independent hazard data obtained for Hurricane Ivan (2004) from FEMA high water marks. Using another storm would require the use of the surge model to identify claims with hazard inundation depth, thus polluting the vulnerability validation with uncertainties from another component of the flood model. For independent validation of vulnerability, Hurricane Ivan (2004) was the only claims data used.

   Discussed the process used for filtering Hurricane Ivan (2004) claims. The NFIP Hurricane Ivan (2004) claims were categorized by structure type to create subsets corresponding to single-family residential, one-story, slab on-grade wood frame and masonry structures. The subset was further reduced to those with a high confidence in the surge inundation height assigned. The process resulted in 132 individual claims for wood frame structures and 376 individual claims for masonry structures.

   Reviewed plots of the mean damage ratios from Hurricane Ivan (2004) claims data including multiple coastal flood conditions and FFE values for both old (weak) and new (strong) masonry construction.

6. GF-1.2, page 63: Provide a map of Hurricane Ivan (2004) claims data used for validation.

   Reviewed maps of the filtered Hurricane Ivan (2004) claims data used for vulnerability validation.

Audit

1. Automated procedures used to create forms will be reviewed.

   Reviewed flowchart for the form completion process.

   Reviewed the script to complete Form AF-2.

2. All primary scientific and technical literature that describes the underlying flood model theory and implementation (where applicable) should be available for review in hard copy or electronic form. Modeling-organization-specific publications cited must be available for review in hard copy or electronic form.

   All references were available electronically and were reviewed as necessary.

3. Compliance with the process prescribed in Flood Standard GF-1.B in all stages of the flood modeling process will be reviewed.

   Reviewed the documented process followed by the modeling team as described in Figure 1, in order to assure continual agreement and correct correspondence of databases, data files, and computer source code to slides and technical papers. Reviewed several examples throughout the course of the audit.

4. Items specified in Flood Standard GF-1.C will be reviewed as part of the Computer/ Information Flood Standards.

   Reviewed a summary of externally acquired flood-model-specific software and data assets.

   All data used in the generation of the submission documentation was available for review.

5. Maps, databases, and data files relevant to the modeling organization’s submission will be reviewed.

   All maps, databases, and data files were available for review. Reviewed samples throughout the course of the audit.

6. Justification for the differences in modeled versus historical flood losses will be reviewed, recognizing that flood loss data may be limited to internal or proprietary datasets.

   Reviewed comparison of modeled versus historical losses under the Statistical Flood Standards.

7. Justification for the vintage of data, code, and scientific and technical literature used will be reviewed.

   Discussed that the vintage of the flood model data meets the standard requirements.

   Discussed that auxiliary datasets have been updated or are otherwise reasonable given the availability of the data or the intended use of the data.

8. The modeling-organization-specified, predetermined, and comprehensive exposure dataset used for projecting personal residential flood loss costs and flood probable maximum loss levels will be reviewed.

   Reviewed the development and key elements of the FPFLM comprehensive exposure dataset.

   Discussed that the exposure data were sourced from NFIP 2012 exposure file for Florida, the 2019 exposures of a manufactured home insurer whose policies include flood coverage, and post-2012 construction for frame and masonry owners policies located in coastal ZIP Codes as reported by the Florida Office of Insurance Regulation for 2019 stress testing.

9. The following information related to changes in the flood model, since the initial submission for each subsequent revision of the submission, will be reviewed.
   A. Flood model changes:
      1. A summary description of changes that affect, or are believed to affect, the personal residential flood loss costs or flood probable maximum loss levels,
      2. A list of all other changes, and
      3. The rationale for each change.
   B. Percentage difference in average annual zero deductible statewide flood loss costs based on a modeling-organization-specified, predetermined, and comprehensive exposure dataset for:
      1. All changes combined, and
      2. Each individual flood model component and subcomponent change.
   C. For any modifications to Form AF-4, Flood Output Ranges, since the initial submission, a newly completed Form AF-5, Percentage Change in Flood Output Ranges, with:
      1. The initial submission as the baseline for computing the percentage changes, and
      2. Any intermediate revisions as the baseline for computing the percentage changes.
   D. Color-coded maps by rating area or zone reflecting the percentage difference in average annual zero deductible statewide flood loss costs based on the modeling-organization-

specified, predetermined, and comprehensive exposure dataset for each flood model component change, between:

1. The currently accepted flood model and the revised flood model,
2. The initial submission and the revised submission, and
3. Any intermediate revisions and the revised submission.

Not applicable as this is the first submission of the Florida Public Flood Loss Model.

September Additional Verification Review Comments:

Figure 40 (Figure 41 in August 12, 2024, revised submission) is a flowchart illustrating the coastal surge model with other components of the flood model. The process for modeling waves in the Florida Keys was questioned during the May on-site review which could not be resolved during that audit.

Discussed how the flowchart captures modeling of waves along the entire State coastline, including in the Florida Keys. Reviewed a flowchart that was corrected during the additional verification review to conform to ISO 5807 standards.

Reviewed the new non-tropical cyclone rainfall model that resulted in increased loss costs and PML levels due to the inclusion of non-tropical events.

Reviewed the loss cost changes with the inclusion of non-tropical events.

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

*(*Significant Revision)*

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.

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 currently licensed Professional Engineer, with experience in coastal and inland flooding), meteorology (advanced degree), statistics (advanced degree or equivalent experience), structural engineering (currently licensed Professional Engineer, with experience in the effects of coastal and inland flooding on buildings), 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.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

7. GF-2.2.A, pages 93-95: Provide, electronically only, resumes of personnel listed in Table 11.

   Reviewed resumes of personnel and consultants involved in the flood model:

   - Bachir Annane, Ph.D. in Meteorology, Florida State University, Tallahassee, FL; M.S. in Meteorology, Florida State University, Tallahassee, FL; M.S. in Mathematics, University of Central Florida, Orlando, FL; Deiplome d’etude superieur in Mathematics, University of Science and Technology, Algiers, Algeria

   - Odai Athamneh, Ph.D. Candidate in Computer Science, University of Missouri, Kansas City, MO; M.S. in Data Science, University of Missouri, Kansas City, MO; B.S. in Computer Science, University of Missouri, Kansas City, MO

   - Christian Bedwell, Ph.D. Candidate in Civil Engineering, University of Florida, Gainesville, FL; M.Eng. in Civil Engineering-Structural Engineering, University of Florida, Gainesville, FL; B.S. in Civil Engineering, University of Florida, Gainesville, FL

- Qiang Chen, Ph.D. in Civil Engineering, University of Bath, Bath, UK; M.S. in Harbor, Coastal and Offshore Engineering, Dalian University of Technology, Dalian, China; B.S. in Channel, Ports and Coastal Engineering, Hohai University, Nanjing, China

- Shu-Ching Chen, Ph.D. in Electrical and Computer Engineering, Purdue University, West Lafayette, IN; M.S. in Computer Science, Purdue University, West Lafayette, IN; MSEE in Electrical Engineering, Purdue University, West Lafayette, IN; M.S. in Civil Engineering, Purdue University, West Lafayette, IN; B.M. in Traffic & Transportation Engineering and Management, Feng Chia University, Taiwan, Republic of China

- Steve Cocke, Ph.D. in Physics, University of Texas, Austin, TX; B.S. in Physics and B.S. in Mathematics, Florida State University, Tallahassee, FL

- Jeet (Ayushman) Das, Ph.D. Candidate in Computer Science with a focus on AI, University of Missouri, Kansas City, MO; M.S. in Computer Science and Data Science, University of Missouri, Kansas City, MO; B.S. in Computer Science, University of Missouri, Kansas City, MO

- Gail Flannery, M.S. in Statistics, Florida State University, Tallahassee, FL; B.S. in Mathematics, Hollins College, Roanoke, VA

- Sneh Gulati, Ph.D. in Statistics, University of South Carolina, Columbia, SC; M.A. in Mathematics, University of South Carolina, Columbia, SC; B.A. in Mathematics, St. Stephen's College, Delhi University, Delhi, India

- Kurt Gurley, Ph.D. in Civil Engineering, University of Notre Dame, Notre Dame, IN; M.S. in Civil Engineering, University of Notre Dame, Notre Dame, IN; B.S. in Aeronautical and Astronautical Engineering, University of Illinois, Urbana-Champaign, IL

- Shahid Hamid, Ph.D. in Economics, University of Maryland, College Park, MD; M.A. in Economics, University of Maryland, College Park, MD; B.B.A. in Business Administration, Kent State University, Kent, OH

- Peng Hou, M.S. in Computer Science, Florida International University, Miami, FL; B.S. in Computer Science, Harbin University of Economics, Harbin, Heilongjiang, China

- Bob Ingco, B.S. in Mathematics and Physics, United States Naval Academy, Annapolis, MD

- Andrew Kennedy, Ph.D. in Mechanical Engineering, Monash University, Melbourne, Australia; M.A.Sc. in Civil Engineering, University of British Columbia, Vancouver, British Columbia, Canada; B.Sc.E. in Civil Engineering, Queen's University, Kingston, Ontario, Canada

- Golam Kibria, Ph.D. in Statistics, University of Western Ontario, London, Canada; M.S. in Statistics, Carleton University, Ottawa, Canada; M.S. in Statistics, Jahangirnagar University, Dhaka, Bangladesh; B.S. in Statistics, Jahangirnagar University, Dhaka, Bangladesh

- Marika Koukoula, Ph.D. in Civil and Environmental Engineering, University of Connecticut, Mansfield, CT; M.S. in Environmental Physics and Meteorology, University of Athens, Zografou, Greece; B.S. in Geography, Harokopio University, Athens, Greece

- Yuepeng Li, Ph.D. in Marine Science on Physical Oceanography, The College of William and Mary, Williamsburg, VA; M.S. in Environmental Oceanography, Ocean University of Qingdao, Qingdao, Shandong Province, China; B.S. in Meteorology, Ocean University of Qingdao, Qingdao, Shandong Province, China

- Numuun Lkhagvadorj, M.S. Candidate in Data Science Analytics, University of Missouri, Kansas City, MO; B.B.A. in Finance, National University of Mongolia, Ulaanbaatar City, Mongolia

- Efthymios Nikolopoulos, Ph.D. in Civil and Environmental Engineering, University of Connecticut, Storrs, CT; M.S. in Civil and Environment Engineering, University of Iowa, Iowa City, IA; Eng. Diploma in Environmental Engineering, Technical University of Crete, Chania, Greece

- Andres Paleo, Ph.D. in Civil Engineering (Structures), University of Florida, Gainesville, FL; M.S. in Civil Engineering (Structures), Autonomous University of Yucatan, Mérida, Mexico; B.S. in Civil Engineering, Autonomous University of Yucatan, Mérida, Mexico

- Jean-Paul Pinelli, Ph.D. in Civil Engineering, Georgia Institute of Technology, Atlanta, GA; M.S. in Civil Engineering, Georgia Institute of Technology, Atlanta, GA; B.S. in Civil Engineering, University of Buenos Aires, Buenos Aires, Argentina

- Zimeena Rasheed, Ph.D. Candidate in Civil Engineering, Rutgers, New Brunswick, NJ; Ph.D. in Civil Engineering, Florida Institute of Technology, Melbourne, FL; M.S. in Civil Engineering, Florida Institute of Technology, Melbourne, FL; B.S. in Civil Engineering, Florida Institute of Technology, Melbourne, FL

- Dongwook Shin, Ph.D. in Meteorology, Florida State University, Tallahassee, FL; M.S. in Meteorology, Florida State University, Tallahassee, FL; B.S. in Atmospheric Sciences, Pusan National University, Korea

- Mohammad Shoraka, Ph.D. in Civil Engineering, Florida Institute of Technology, Melbourne, FL; M.S. in Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA; M.S. in Natural Disaster Management, University of Tehran, Tehran, Iran; B.S. in Civil Engineering, University of Tehran, Tehran, Iran

- Mei-Ling Shyu, Ph.D. in Electrical and Computer Engineering, Purdue University, West Lafayette, IN; M.S. in Restaurant, Hotel, Institutional and Tourism Management, Purdue University, West Lafayette, IN; M.S. in Electrical Engineering, Purdue University, West Lafayette, IN; M.S. in Computer Science, Purdue University, West Lafayette, IN

- Joeffrey Somerea, B.S. in Chemical Engineering, University of the Philippines Diliman, Quezon City, Philippines

- Humberto Vergara, Ph.D. in Civil/Water Resources Engineering, University of Oklahoma, Norman, OK; M.S. in Water Resources Engineering, University of Oklahoma, Norman, OK; B.S. in Environmental Engineering, El Bosque University, Bogota, Colombia

- Tianyi Wang, Ph.D. in Computer Science and Electrical Engineering, University of Missouri, Kansas City, MO; M.S. in Computer Science, Florida International University, Miami, FL; M.S. in Accounting, Washington State University, Pullman, WA; B.S. in Accounting, Tianjin University of Finance and Economics, China

- Wensong Wu, Ph.D. in Statistics, University of South Carolina, Columbia, SC; M.S. in Mathematics, University of South Carolina, Columbia, SC; B.S. in Computational Mathematics, Nanjing University, China

- Keqi Zhang (deceased), Ph.D. in Coastal Geomorphology, University of Maryland, College Park, MD

8. GF-2.3.A.1, page 98 and Arthur Taylor Expert Review Letter, page 276: Arthur Taylor noted in his report, “they could also review the impacts of TS-Gordon-2018, TS-Andrea-2013, TS-Lee-2011, and TS-Hermine-2010.” As Taylor concludes that his concerns have been addressed, present the results of the first three listed excluding Tropical Storm Hermine (2010) as it is now included in the submission.

   Discussed that TS-Lee-2011 and TS-Hermine-2010 were not simulated since the storms did not affect Florida.

   Reviewed the maximum storm surge and time series of water levels at NOAA tide gauges for TS-Gordon-2018 and TS-Andrea-2013.

Audit

1. The professional vitae of personnel and consultants engaged in the development of the flood model and responsible for the current flood model and the submission will be reviewed. Background information on the professional credentials and the requisite experience of individuals providing testimonial letters in the submission will be reviewed.

   See above for resumes reviewed.

2. Forms GF-1, General Flood Standards Expert Certification, GF-2, Meteorological Flood Standards Expert Certification, GF-3, Hydrological and Hydraulic Flood Standards Expert Certification, GF-4, Statistical Flood Standards Expert Certification, GF-5, Vulnerability Flood Standards Expert Certification, GF-6, Actuarial Flood Standards Expert Certification, GF-7, Computer/Information Flood Standards Expert Certification, and all independent peer reviews of the flood model under consideration will be reviewed. Signatories on the individual forms will be required to provide a description of their review process.

   Reviewed the signed expert certifications.

3. Incidents where modeling organization personnel or consultants have been found to have failed to abide by the standards of professional conduct adopted by their profession will be discussed.

   Discussed that there are no incidents to report.

4. For each individual listed under Disclosure 2.A, specific information as to any consulting activities and any relationship with an insurer, reinsurer, trade association, governmental entity, consumer group, or other advocacy group within the previous four years will be reviewed.

   Discussed that Dr. Jean Paul Pinelli is a co-PI in the WHIP-C, an industry university cooperative research center. The members of the center are insurance, re-insurance, modeling companies, and National Institute of Standards and Technology (NIST) which fund the research performed by the center.

   Discussed that Dr. Sneh Gulati received fellowships in 2021 and 2023 with the Naval Research Labs in Monterey where she worked on loss models for hurricane forecasting and extreme value estimations.

   Discussed that Gail Flannery routinely performs studies for various state and local government entities and a few insurance companies.

GF-3 Insured Exposure Location*

*(*Significant Revision)*

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.

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.

C. If any flood model components are dependent on databases pertaining to location, a logical process shall be maintained for ensuring these components are consistent with the horizontal location database updates.

D. Geocoding methodology shall be justified.

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

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

9. GF-3.B, page 100: Specify the commercial software used to geo-locate the structures. Discuss the process used to verify the accuracy and timeliness of the data.

   Discussed that the flood model uses ArcGIS StreetMap Premium North America to geo-locate structures.

   Discussed that ArcGIS uses the most up-to-date reference data from authoritative sources, including commercial, community, and governmental providers.

   Discussed the process the modeling team uses to perform internal verifications to verify the accuracy and timeliness of the data.

10. GF-3.E, page 100: Given that data sets with different vertical datum are used, identify the vertical datum that is ultimately used in the model.

    Discussed that NAVD88 (North American Vertical Datum) is used for the entire model. Data with alternate datums, including USGS data in NGVD29 (National Geodetic Vertical Datum), were converted to NAVD88 using NOAA's VERTCON (North American Vertical Datum Conversion) 2.1 tool.

11. GF-3.9, pages 102-103: Discuss how the different horizontal projections and datum, GCS_North_American_1983 and World Geodetic System 1984 (WGS84), are reconciled for coastal and inland flooding.

    Discussed that the surge model uses GCS_North_American_1983; however, all calculations in surge modeling were carried out in projected datums. The Modeler stated that the geo-location difference caused by using GCS_North_American_1983 or WGS84 (World Geodetic System) is negligible.

Audit

1. Geographic displays of the spatial distribution of insured exposures will be reviewed. The treatment of any variations for populated versus unpopulated areas will be reviewed.

   Reviewed map of the spatial distribution of insured exposures.

2. Third party vendor information, if applicable, and a complete description of the process used to create, validate, and justify geographic grids will be reviewed.

   Discussed that the flood model uses ArcGIS StreetMap Premium North America, which uses data from commercial, community, and governmental providers, to geo-locate structures.

3. The treatment of exposures over water or other uninhabitable terrain will be reviewed.

   Discussed that policies over water or uninhabitable terrain are removed.

4. The process for geocoding complete and incomplete street addresses will be reviewed.

   Discussed that policies with incomplete addresses are removed.

5. Flood model geocode location databases will be reviewed.

   See comments under PVL #9.

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.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Audit

1. The flood model components will be reviewed for adequately portraying flood phenomena and effects (damage, flood loss costs, and flood probable maximum loss levels). Attention will be paid to an assessment of (1) the theoretical soundness of each component, (2) the basis of the integration of each component into the flood model, and (3) consistency between the results of one component and another.

September Additional Verification Review Comments:

Verified after resolution of outstanding issues from other standards.

Reviewed the theoretical soundness, integration of components, and consistency across components throughout the course of the two audits.

There was no evidence to suggest that one component of the model was deliberately adjusted to compensate for another component.

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.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Audit

1. An assessment that the person who has reviewed the flood model submission has experience in reviewing technical documentation and that such person is familiar with the flood model submission requirements as set forth in the *Flood Standards Report of Activities as of November 1, 2021* will be made.

   Discussed the experience of Dr. Steve Cocke, the editorial compliance signatory, who reviewed the submission document.

2. Attestation that the flood model submission has been reviewed for grammatical correctness, typographical accuracy, completeness, and no inclusion of extraneous data or materials will be assessed.

   Discussed that the flood model submission was reviewed throughout the development process for grammatical correctness, typographical accuracy, completeness, and no inclusion of extraneous data or materials.

3. Confirmation that the flood model submission has been reviewed by the signatories on the Expert Certification Forms GF-1 through GF-7 for accuracy and completeness will be assessed.

   Confirmation was given that subject matter experts reviewed all submitted materials for completeness and accuracy.

4. The modification history for flood model submission documentation will be reviewed.

   Discussed the process for preparing, reviewing, revising, and tracking revisions to the submission documentation. Reviewed the submission documentation modification history.

5. A flowchart defining the process for form creation will be reviewed.

   Reviewed a flowchart of the process for submission form creation.

6. Form GF-8, Editorial Review Expert Certification, will be reviewed.

   Reviewed Form GF-8.

Editorial items noted in the pre-visit letter and during the on-site review by the Professional Team were satisfactorily addressed during the audit. The Professional Team has reviewed the submission per Audit item 3, but cannot guarantee that all editorial difficulties have been identified. The modeling team is responsible for eliminating such errors.

September Additional Verification Review Comments:

Verified after review of revisions in the August 12, 2024, revised submission and revisions made during the additional verification review.

METEOROLOGICAL FLOOD STANDARDS – JIMMY BOOTH, LEADER

MF-1 Flood Event Data Sources*

*(*Significant Revision)*

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

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.

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.

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

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

12. MF-1.C, page 106: Discuss how the water elevation data downloaded from NOAA was converted from vertical datum mean sea level (MSL) to be consistent with the other model data. Explain what is meant by, "For the High Water Mark (HWM) data, data above North American Vertical Datum of 1988 (NAVD88) are used."

    Discussed that in earlier years, the time series water levels downloaded from NOAA were referred to the MSL and converted to NAVD88 by using NOAA's VERTCON tool. Currently, the option of NAVD88 vertical datum is available in the water level data from NOAA.

    Reviewed an example snapshot of the HWM data downloaded from USGS referred to NAVD88.

Audit

1. The modeling organization's data sources will be reviewed.

   Reviewed and discussed the following flood-event data sources used in the model.
   - NLCD 2016 from USGS for inland, and NLCD 2011 for waves
   - Bathymetry and topography from USGS, Florida Geographic Data Library (FGDL), and NOAA
   - High water marks from USGS, reports from NOAA and FEMA, and published articles
   - Water level time series from NOAA

   Discussed that the vintage of the DEM data used for exposures is 2022, and that the vintage of the DEM data used for the hazard models is 2021.

2. Changes to the modeling organization's data sources from the currently accepted flood model will be reviewed.

   Not applicable as this is the first submission of the Florida Public Flood Loss Model.

3. Justification for any modification, partitioning, or adjustment to historical data and the impact on flood model parameters and characteristics will be reviewed.

   Discussed that for historical hurricane calibration, not all cases are updated with new data. For example, when simulating Hurricane Andrew (1992), the historical data, such as land cover, bathymetry, and topography, were used and were not later updated.

   Discussed that the inland models used historical data with no change.

4. The method and process used for calibration and validation of the flood model, including adjustments to input parameters, will be reviewed.

   Discussed that water level time series from NOAA, high water marks, and debris lines were used for validating the CEST storm surge model.

   Reviewed validation of the CEST model from field surveys and comparisons of computed maximum surge versus historical surge observations from Hurricane Wilma (2005), Hurricane Andrew (1992), and Hurricane Ivan (2004).

   Discussed that model parameters such as Manning's coefficient and wind stress coefficient are deterministic and that no manual adjustments are made.

   Discussed that MRMS and Prism were used for calibration of EF5 and PLUV2D.

5. Any treatment of projected changes in sea level, precipitation, and storm characteristics will be reviewed.

   Discussed that no projected sea levels were considered in the current surge model.

MF-2 Flood Parameters (Inputs)*

*(*Significant Revision)*

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.

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

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

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

13. MF-2.2, page 113: Provide a plot for a location near Miami and a location near Jacksonville, of:
    a. Modeled maximum surge versus Vmax at time of maximum surge (one point in the plot per event),
    b. Modeled maximum surge versus central pressure minimum at time of maximum surge (one point in the plot per event),
    c. Modeled maximum surge versus modeled Rmax at time of maximum surge (one point in the plot per event), and
    d. Modeled maximum surge versus storm distance to coast at time of maximum surge (one point in the plot per event). In terms of the modeled storm center location relative to land, identify when modeling of storm surge begins.

    Reviewed plots for a location near Miami and a location near Jacksonville of maximum storm surge versus Vmax, central pressure, Rmax, and distance to coast. Reviewed how the model captures relationships and noise relevant to flooding from storm surge.

14. MF-2.7, page 114: Provide a map of the 116 subgrids used in the model.

    Reviewed map illustrating the 116 subgrids used in the flood model.

Audit

1. All flood parameters used in the flood model will be reviewed.

   Discussed that primary parameters for the storm surge model include the bottom friction coefficient, surface stress coefficient, and the tidal boundary parameters.

   Discussed that the primary parameters for PLUV2D are Manning's coefficients, infiltration parameters for non-impervious ground types, and Horton parameters for soil capacity.

2. For explicit representation of precipitation, data sources, calibration, and evaluation will be reviewed.

   Discussed that the core algorithm for the rain model is from the R-CLIPER (Rainfall CLImatology and PERsistence) model that was developed by NOAA Hurricane Research Division (HRD) and used by NHC.

   Regarding Standard MF-2.B, clarified with the modeling team that, by the definition in the ROA, parameters include inputs to the models. With this in mind, determined that the inputs for the historical and stochastics events differed in some cases. In particular, some historical events included cases with precipitation input from non-tropical cyclones, whereas the stochastic event set only includes precipitation generated by R-CLIPER (a tropical cyclone precipitation emulator).

3. For implicit representation of precipitation, justification, data sources, method, and implementation will be reviewed.

   Discussed how the model represents precipitation for non-tropical storms by comparing distributions from the stochastic model output with USGS gauge station data. Determined that additional information was needed in order to verify the standard.

4. Graphical depictions of flood parameters as used in the flood model will be reviewed. Descriptions and justification of the following will be reviewed:
   a. The dataset basis for any fitted distributions, the methods used, and any smoothing techniques employed,
   b. The modeled dependencies among correlated parameters in the flood model and how they are represented, and
   c. The dependencies between the coastal and inland flooding analyses.

   Reviewed map of the four CEST model basins covering Florida and a map of the basins with historical hurricane storm tracks.

   Reviewed the CEST governing equations: continuity equation, momentum equations, bottom friction forces using Manning's coefficient.

Reviewed topographical maps of the NLCD 2016 data in Florida and two selected basins. Reviewed the formula for converting NLCD 2016 to a Manning's coefficient value. Reviewed corresponding topographic maps of the Manning's coefficient for the two selected basins.

5. Scientific and technical literature cited in Flood Standard GF-1, Scope of the Flood Model and Its Implementation, may be reviewed to determine applicability.

   Meteorological references were available electronically and were reviewed as necessary.

6. The initial and boundary conditions for coastal flood events will be reviewed.

   Discussed that the spin-up and boundary conditions during CEST model evolution suffice.

   Determined that the surge model (CEST) uses 4 different numerical modeling regions to cover the Florida coastline and inland (to the extent needed for coastal flood). Asked that all elements in the submission be updated to include the 4 regions, when applicable.

7. The basis or dependence of flood model parameters on NFIP FIRM or other FIS data will be reviewed.

   Discussed that the flood model parameters do not depend on NFIP FIRM or other FIS data.

September Additional Verification Review Comments:

Justification for the use of NLCD 2011 in the wave model versus the use of NLCD 2016 as used for inland flooding could not be resolved during the May on-site review.

Reviewed additional comparisons of wave subgrids on both the east and west coasts demonstrating consistency of wave model results using the 2011 and 2016 NLCD datasets. The analyses determined the differences between the two datasets did not affect wave height estimates appreciably, and that the resulting impact to STWAVE calculations did not alter the expected damage and resulting modeled loss costs. The comparisons showed differences between 2011 and 2016 NLCD land cover classifications to be small to very small, with the changes due to new construction being inland where wave heights are small, and damage caused by waves is low. Wave heights are dominated by breaking which occurs close to the shoreline and is not affected by the LULC changes. The change in losses for the subgrids tested ranged from a decrease of 0.003% to 0.34%.

The process for modeling rainfall from non-tropical cyclone events and how non-tropical flooding is represented in the modeled loss costs was questioned during the May on-site review and could not be resolved during that audit.

Reviewed the new approach to estimating losses from rainfall due to non-tropical events. The historical record was used for simulating flood with the inland models to estimate the loss costs. Discussed the use of the NOAA Climate Prediction Center (CPC) unified gauge-based analysis of daily precipitation based on historical gauge station data from 1948 to 2023.

Reviewed map of Florida grid point locations where the daily maximum rain exceeds 4 inches and 6 inches.

Average annual losses (AAL) are calculated for each policy and coverage type and then added to the tropical cyclone AAL on the policy level.

Discussed how historical data is used to statistically model non-tropical precipitation.

Discussed how non-tropical events are incorporated in the stochastic set for calculating rainfall losses included in the AAL.

MF-3 Wind and Pressure Fields for Storm Surge*

*(*Significant Revision)*

A. Modeling of wind and pressure fields shall be employed to drive storm surge models due to tropical cyclones.

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

C. Physically-based simulation of atmosphere-ocean interactions resulting in storm surge shall be conducted over a sufficiently large domain that storm surge height has converged.

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

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

15. MF-3.9, page 126: Provide revised Figures 33 and 34 that include all five areas listed in the legend.

    Reviewed revised Figures 33 and 34 to confirm that the listed number of basins in the legends and plots match.

Audit

1. All external data sources that affect the modeled wind and pressure fields associated with storm surge will be identified and their appropriateness reviewed.

   Discussed that the storm surge model team used the wind and pressure information provided from the current accepted hurricane model for each simulated storm.

2. Calibration and evaluation of wind and pressure fields will be reviewed. Scientific comparisons of simulated wind and pressure fields to historical storms will be reviewed.

   Discussed that the wind model and pressure profile are the same as used in the current accepted hurricane model.

3. The sensitivity of flood extent and depth results to changes in the representation of wind and pressure fields will be reviewed.

   Refer to the Hurricane Michael (2018) sensitivity study report and comments under Standard SF-2.

4. The over-land evolution of simulated wind and pressure fields and its impact on the simulated flooding will be reviewed.

   See comments under Audit #3.

5. The derivation of surface water wind stress from surface windspeed will be reviewed. If a sea-surface drag coefficient is employed, how it is related to the surface windspeed will be reviewed. A comparison of the sea-surface drag coefficient to coefficients from current scientific and technical literature will be reviewed.

   Reviewed the equations for surface wind stresses.

6. The uncertainties in the factors used to convert from a reference windfield to a geographic distribution of surface winds and the impact of the resulting winds upon the storm surge will be reviewed and compared with current scientific and technical literature.

   Discussed that the conversion of the slab wind model mean wind to 10m surface wind is based on published literature and described in GF-1.2.

MF-4 Flood Characteristics (Outputs)*

*(*Significant Revision)*

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

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

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

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

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

16. MF-4.1, page 134: Clarify how the storm substitutions described here align with the data in Form HHF-1.

    Discussed that the data in Form HHF-1 correspond to the storm substitutions. See HHF-1 for more details.

17. MF-4.6, page 135: Discuss how differences in grid resolutions may affect the selection of the maximum inundation depth.

    Discussed that the grid resolutions do not affect selection, because selection of inundation depth is not relevant for coastal versus inland. For inland, the riverine versus pluvial selection is based on location of the claim relative to the location of the 800m buffer used in the riverine model.

18. MF-4.6, page 135: If the maximum inundation depth is selected when a location is flooded by both coastal and inland, discuss how the model accounts for larger losses for coastal depths that are slightly less than inland depths.

    Discussed that selection is actually based on the larger of the coastal and inland losses. The submission was updated accordingly.

Audit

1. The method and supporting material for determining flood extent and elevation or depth for coastal flooding will be reviewed.

   Discussed flood extent and elevation methodology.

2. The inland propagation of coastal flood and the effect of coastal flood propagation on inland flood will be reviewed.

   Reviewed animation of Hurricane Wilma (2005) storm surge.

3. Any modeling-organization-specific research performed to calculate the flood extent and elevation or depth and wave conditions will be reviewed, along with the associated databases.

   Discussed that overland wave heights were compared with measured values during Hurricane Ike (2008) for the STWAVE wave dissipation scheme used in the flood model and for the depth-limited cutoff. Reviewed wave height validation.

   Discussed that the pluvial flood model PLUV2D uses Atlas 14 (a dataset of historical precipitation probabilities) to create rainfall versus flood depth curves. These curves are then used as a lookup table to map precipitation to flood depth in the stochastic model.

   Discussed that as used in the FPFLM, STWAVE will not estimate wave heights from waves propagating from bays toward the back side of barrier islands.

4. Historical data used as the basis for the flood model flood extent and elevation or depth will be reviewed. Historical data used as the basis for the flood model flood velocity, as available, will be reviewed.

   Refer to Form HHF-1 historical hurricane events validation.

5. The comparison of the calculated characteristics with historical flood events will be reviewed. The selected locations and corresponding storm events will be reviewed to verify sufficient representation of the varied geographic areas. If a single storm is used for both coastal and inland flooding validation, then its appropriateness will be reviewed.

   Reviewed modeled flood extent and inundation depth corresponding to 100-year and 500-year return period maps for Bay, Dixie, Sarasota, Miami-Dade, and St. Lucie Counties.

6. Consistency of the flood model stochastic flood extent and elevation or depth with reference to the historical flood databases will be reviewed. Consistency of the flood model stochastic flood velocity, as available, with reference to the historical flood databases will be reviewed.

   Discussed that the historical storms are driven by historical precipitation, whereas the stochastic events all use R-CLIPER data. Discussed the implications of this difference for storms such as the May 2009 and July 2013 events, in which precipitation was not generated by a tropical storm.

7. Form HHF-2, Coastal Flood Characteristics by Annual Exceedance Probability, and Form HHF-3, Coastal Flood Characteristics by Annual Exceedance Probabilities (Trade Secret Item), will be reviewed.

   Refer to PVL #40 comments.

8. Modeled frequencies will be compared with the observed spatial distribution of flood frequencies across Florida using methods documented in current scientific and technical literature. The comparison of modeled to historical statewide and regional coastal flood frequencies as provided in Form HHF-2, Coastal Flood Characteristics by Annual Exceedance Probability, and Form HHF-3, Coastal Flood Characteristics by Annual Exceedance Probabilities (Trade Secret Item), will be reviewed.

   Refer to Forms HHF-2 and HHF-3 comments.

9. Comparison of 0.01 and 0.002 annual exceedance probability flood extents produced by the flood model with those from the Federal Emergency Management Agency (FEMA) will be reviewed.

   Refer to Forms HHF-2 and HHF-3 comments.

10. Temporal evolution of coastal flood characteristics will be reviewed. (Trade Secret Item to be provided during the closed meeting portion of the Commission meeting to review the flood model for acceptability.)

    Reviewed illustrations of coastal inundation depth for several locations along the coast of Florida.

11. Comparisons of the flood flow calculated in the flood model with records from United States Geological Survey (USGS) or Florida Water Management District (FWMD) gauging stations will be reviewed.

    Reviewed comparisons of flood flow from Hurricane Wilma (2005).

12. Calculation of relevant characteristics in the flood model, such as flood extent, elevation or depth, and waves, will be reviewed. The methods by which each flood model component utilizes the characteristics of other flood model components will be reviewed.

    Discussed that the wave model is the USACE STWAVE model. The wave model uses coastal water level output from the Surge Model, and wind outputs from the Wind Model, and the same winds as used by the Surge Model.

    Reviewed validation of overland wave heights during Hurricane Ike (2008).

    Discussed that the flood depth calculation for EF5 uses height above nearest drainage (HAND), and that "nearest" is not distance as the crow flies, but is instead based on where water flows.

    Reviewed the flood depth calculation for PLUV2D which relies primarily on Manning's equation.

    Discussed that NLCD 2011 was used for the wave model. Discussed similarities and differences between NLCD 2011 and NLCD 2016. Reviewed example maps comparing the differences between the two datasets. Determined that additional comparisons are needed for verification of the standard.

    September Additional Verification Review Comments:

    Reviewed additional comparisons of wave subgrids on both the east and west coasts demonstrating consistency of wave model results using the 2011 and 2016 NLCD datasets. The analyses determined the differences between the two datasets did not affect wave height estimates appreciably, and that the resulting impact to STWAVE calculations did not alter the expected damage and resulting modeled loss costs. The comparisons showed differences between 2011 and 2016 NLCD land cover classifications to be small to very small, with the changes due to new construction being inland where wave heights are small, and damage caused by waves is low. Wave heights are dominated by breaking which occurs close to the shoreline and is not affected by the LULC changes. The change in losses for the subgrids tested ranged from a decrease of 0.003% to 0.34%.

13. The modeled coincidence and interaction of inland and coastal flooding will be reviewed. If it is not modeled, justification will be reviewed.

    Discussed that there is no interaction of inland and coastal flooding, and the justification for not modeling the interaction.

14. The basis or dependence of modeled flood characteristics on NFIP FIRM or other FIS data will be reviewed.

    Discussed that the flood model characteristics do not depend on NFIP FIRM or other FIS data.

September Additional Verification Review Comments:

The process for modeling waves in the Florida Keys was questioned during the May on-site review which could not be resolved during that audit.

Discussed that the map of Florida with subgrids presented during the May on-site review was incorrect. Reviewed the correct map of Florida subgrids, including subgrids in the Florida Keys. Discussed that the incorrect map was never used for loss computations, that all computations include the Florida Keys subgrids, and that the Florida Keys subgrids are treated the same as all others.

Reviewed a revised Figure 41 updated to include a flowchart of the process for calculating waves in all computational basins. The Modeler confirmed that the Florida Keys are covered in the wave calculation.

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.***

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

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

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.***

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Audit

1. The consistency in accounting for similar flood parameters and characteristics across Florida and segments in adjacent states will be reviewed.

   Reviewed a map of the four CEST model basins and a map of the CEST basins with historical hurricane storm tracks.

2. The method and supporting material for generating stochastic coastal and inland flood events will be reviewed.

   Discussed that wave conditions arise from the same probability distribution as used for storm tide modeling.

   Discussed that the flood model uses the same set of tracks as used in the current accepted hurricane model.

   Discussed that for stochastic storm events that drive the surge model, the tide conditions are based on 2022 conditions and the initial tide conditions for a storm are chosen using a random sampling technique.

Discussed that the surge model (CEST) uses the domain region with the finer resolution for locations in which there are two overlapping regions.

3. Any modeling-organization-specific research performed to develop the functions used for simulating flood model characteristics or to develop flood databases will be reviewed.

   The Modeler referenced the CEST user manual, source code, and references.

4. Form SF-1, Distributions of Stochastic Flood Parameters (Coastal, Inland), will be reviewed.

   Discussed that there are no stochastic flood parameters in the flood model.

   Discussed that storm tracks are stochastic and are taken from the hurricane model.

5. Comparisons of modeled flood probabilities and characteristics for coastal and inland flooding against the available historical record will be reviewed. Modeled probabilities from any subset, trend, or fitted function will be reviewed, compared, and justified against this historical record. In the case of partitioning, modeled probabilities from the partition and its complement will be reviewed and compared with the complete historical record.

   Refer to Forms HHF-2 and HHF-3 comments.

   Reviewed maps that show comparisons of the pluvial model (PLUV2D) for 100-year flood extent as compared to FEMA 100-year flood zones for Lake City and Tallahassee.

   Reviewed maps of PLUV2D 100-year flood depths and NFIP claims for Miami.

September Additional Verification Review Comments:

The process for modeling rainfall from non-tropical cyclone events and how non-tropical flooding is represented in the modeled loss costs was questioned during the May on-site review and could not be resolved during that audit.

Reviewed the new approach to estimating losses from rainfall due to non-tropical events. The historical record was used for simulating flood with the inland models to estimate the loss costs. Discussed the use of the NOAA CPC unified gauge-based analysis of daily precipitation based on historical gauge station data from 1948 to 2023.

Discussed that modeling non-tropical events is challenging since there are a number of unique and diverse meteorological conditions that lead to the events.

Discussed that an analysis of losses using the unredacted NFIP claims data found that the top non-tropical losses were due to different meteorological conditions, some of which only occurred once.

Reviewed map of Florida grid point locations where daily maximum rain amounts exceed 4 inches and 6 inches.

HYDROLOGICAL AND HYDRAULIC FLOOD STANDARDS – DEL SCHWALLS, LEADER, BLAKE TULLIS, LEADER, SEPTEMBER ADDITIONAL VERIFICATION REVIEW

HHF-1 Flood Parameters (Inputs)*

*(*Significant Revision)*

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) 2016 or later. Use of alternate datasets shall be justified.

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

C. Treatment of watersheds and hydrologic basins shall be consistent with current scientific and technical literature.

D. Treatment of hydraulic systems, including conveyance, storage, and hydraulic structures, shall be consistent with current scientific and technical literature.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

20. HHF-1.A, page 157: Explain how the Manning coefficients are assigned and how they vary across the state.

    Discussed that the Manning’s coefficients are assigned based on a lookup table that maps the coefficient to the NLCD land cover code. The table is from the HEC-RAS 2D model. The MRLC NLCD 2016 data was used for land cover. Reviewed maps illustrating the variation of coefficients across the state.

21. HHF-1.1.b., page 158: Explain how river flows are routed through flat (no-depth) model lakes and how flood flow attenuation associated with lake storage is accounted for. If it is not, provide justification, and discuss the impact on model results.

    Discussed that flow direction is determined based on the Flow Direction tool in the Spatial Analyst toolbox of ArcGIS Pro software.

Reviewed an example of the flow direction and routing through a lake using the Flow Direction tool.

Discussed that storage effects on lakes are not accounted for in the model. Analysis of the NFIP riverine claims showed losses downstream of reservoirs and lakes were not significant. Discussed that data on reservoir stage-storage-discharge relationships are minimal.

22. HHF-1.1.c., page 158: Explain the difference between groundwater dynamics and subsurface flow as referenced in the response.

Discussed that subsurface flow in the model is comprised of flow from the unsaturated and saturated groundwater zone of the soil column. The riverine model does not model the unsaturated and saturated zones of the soil separately. Subsurface flow is modeled as one flow component overall.

23. HHF-1.3, pages 158-159: Provide justification for the average from 33 storms being used as the initial soil moisture content for the riverine model. Explain the temporal and spatial variability of the soil moisture content across the state. Provide the 33-storm average initial moisture content value and standard deviation across the data set depicted in Figure 53 (page 159).

Discussed that the fluvial analysis focused on initial soil moisture conditions of historical hurricane events. The NASA North American Land Data Assimilation System (NLDAS) soil moisture dataset provides information beginning in 1979. All hurricane events since 1979 were selected and reported in Form AF-2. Hurricane Ian (2022) and Hurricane Nicole (2022) were added to the NLDAS dataset to comprise the 33 storms analyzed.

Reviewed table of the 33 utilized storms.

Reviewed topographical maps of the spatial and temporal variability of initial soil moisture conditions for Hurricane Katrina (2005), Hurricane Rita (2005), and Hurricane Wilma (2005).

Reviewed state-wide maps of the mean and standard deviation of the initial soil moisture values for the 33 storms analyzed.

24. HHF-1.4, page 159: Figure 54 shows that the model is sensitive (gives a different result) for different initial moisture content values. Explain how these data support using the 33-storm average initial moisture content value in the model.

Discussed that the lowest and highest values of soil moisture used in the fluvial sensitivity test shown in Figure 54 correspond to extreme cases and are rather unrealistic to apply uniformly at a state-wide scale.

Reviewed the sensitivity test repeated using soil moisture values on a range from 34-54%, which captures more than 80% of the distribution as shown in Figure 53. Discussed that 44% was the value used for the riverine simulation, and that the distribution of flood depths is similar to the distribution of average values across the scenarios.

25. HHF-1.5, page 160: Explain the process for incorporating LiDAR (light detection and ranging) data into the topographic data.

    Discussed that the DEM was prepared by the University of Florida Geoplan Center. Approximately 26 domains were combined, with many LiDAR-based (Light Detection and Ranging), into a GIS (geographic information system) raster to cover the entire State of Florida and partially extending into adjacent states to cover all contributing watersheds.

26. HHF-1.11, page 161: Demonstrate the closeness of loss costs to the average of loss costs with the antecedent soil moisture parameter set at 0.5.

    Reviewed a chart illustrating losses for the pluvial flood model driven by observed precipitation for a 100-year rain event in the vicinity of Pensacola, Florida. The best loss match was for an antecedent soil moisture parameter of 0.5.

27. HHF-1.12, page 162: Demonstrate how the overland flow paths associated with the cells in the grid mimic watershed flow behavior.

    Discussed that in the riverine flood model, flow direction is determined based on the D8 algorithm available in the ArcGIS Pro software. The D8 flow method models flow direction from each cell to its steepest downslope neighbor. Reviewed schematic illustrating the methodology.

    Discussed that based on the D8 methods, the flow direction raster grid is one dimensional.

    Reviewed an example of the resulting stream network using the D8 algorithm.

    Reviewed the code implementing flood flow direction.

28. HHF-1.12, page 162: Demonstrate how watersheds with headwaters in adjoining states that flow into Florida are accounted for in the model.

    Reviewed an illustration of the spatial extent of the riverine flood model domain. The domain covers drainage basins that extend outside the state boundary, such as the Apalachicola basin. Reviewed a comparison map of the Apalachicola basin as given in USGS HUC06 (hydrologic unit code).

29. HHF-1.13, page 163: Given that bridges and culvert crossings are not represented in the model, yet can represent a significant part of the hydraulic connectivity for base flows and flood flows, explain how the hydraulic connectivity across roadways is handled in the model. Discuss how the inland flooding extents of large rivers (e.g., St. Johns River, Peace River) are affected by the presence of large roadway crossings of these rivers, and how the model treats these constrictions in flow.

    Discussed that the pluvial flood model provides two methods for handling unresolved hydraulic connections (e.g., sewers and culverts).

    1. The modeled flood depths for a given event are reduced by subtracting the two-year return period flood depth based on Florida Department of Transportation design goals where drainage pathways are constructed to alleviate flooding that can occur from a 2 or 5-year return period rain amount.
    2. A one-dimensional routing method where any given cell can be routed to another cell or reservoir, despite the presence of barriers in the DEM.

    Discussed that the DEM used by both the pluvial and riverine flood models has major bridges removed.

Audit

1. The initial and boundary conditions for flood events will be reviewed.

   Discussed that tides are not considered as boundary conditions in the riverine model. The riverine model considers the entire upslope drainage area at each grid point and thus river confluences are included and are not needed as boundary conditions. In the pluvial model, lake level boundary corresponds to elevation from DEM.

   Discussed that for both the riverine and pluvial models, initial soil moisture conditions are considered. The riverine model has zero flux boundaries at the watershed boundaries. The pluvial model considers the lake level defined by the DEM as a boundary.

2. The topographic representation will be reviewed.

   Discussed that the 1-arcsec National Elevation Dataset was used for pluvial flooding which was aggregated to 3-arcsec for the riverine model.

3. Any modeling-organization-specific methodology used to incorporate LULC information into the flood model will be reviewed.

   Discussed that riverine parameters are calibrated.

Discussed that roughness is based on MRLC 2016 NLCD land use and land cover for all portions of the flood model except for STWAVE which utilizes NLCD 2011. The Manning's coefficient is assigned based on a HEC-RAS 2D table that assigns a valued based on NLCD classification.

4. Any modeling-organization-specific research performed to develop the soil infiltration and percolation rates or soil moisture conditions used in the flood model will be reviewed, if applicable.

   Discussed that for the riverine model, infiltration is modeled using the VIC (Variable Infiltration Capacity) approach from Flamig et al. (2020).

   Discussed that for the pluvial model, a modified Horton equation is used for infiltration.

   Reviewed the equation for soil capacity from a modified Horton method for infiltration.

5. The watershed and hydraulic basin boundaries in the flood model, and the methods for developing these boundaries, or any equivalent assumptions, will be reviewed.

   See comments under PVL #28.

6. The hydraulic network and treatment of hydraulic structures in the flood model will be reviewed.

   Discussed that hydraulic structures are not accounted for unless explicitly represented in the DEM.

   Reviewed examples in the DEM for a St. Johns River bridge and the Mexico Beach Highway 98 canal.

   See additional comments under PVL #29.

7. The hydrologic and hydraulic mathematical models used will be reviewed.

   Reviewed detailed equations for the riverine model taken from Flamig et al. (2020).

   Reviewed Manning's equation for flow velocity in PLUV2D.

8. Any modeling-organization-specific research performed to develop hydrologic and hydraulic equations used in the flood model, and the variables and constants used in these equations, will be reviewed.

   See comments under GF-1.

9. The input files for the hydrologic and hydraulic components of the inland flood model will be reviewed.

   Reviewed and discussed the Inland flood model data sources with release dates and time periods as provided in Table 12.

10. The relationships between time steps used in the hydrologic and hydraulic components of the flood model will be reviewed, if applicable.

    See comments under PVL #30.

11. The basis or dependence of flood parameters on NFIP FIRM or other FIS data will be reviewed, if relevant.

    Discussed that there is no dependence of flood parameters on NFIP FIRM or other FIS data.

September Additional Verification Review Comments:

Justification for the use of NLCD 2011 in the wave model versus the use of NLCD 2016 as used for inland flooding could not be resolved during the May on-site review.

Reviewed additional comparisons of wave subgrids on both the east and west coasts demonstrating consistency of wave model results using the 2011 and 2016 NLCD datasets. The analyses determined the differences between the two datasets did not affect wave height estimates appreciably, and that the resulting impact to STWAVE calculations did not alter the expected damage and resulting modeled loss costs. The comparisons showed differences between 2011 and 2016 NLCD land cover classifications to be small to very small, with the changes due to new construction being inland where wave heights are small and damage caused by waves is low. Wave heights are dominated by breaking which occurs close to the shoreline and is not affected by the LULC changes. The change in losses for the subgrids tested ranged from a decrease of 0.003% to 0.34%.

HHF-2 Flood Characteristics (Outputs)*

*(*Significant Revision)*

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

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

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

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

30. HHF-2.C, page 164: Discuss the time step used in the hydraulic portion of the inland flood model, and how the selected time step is appropriate to capture flood elevation peaks.

    Discussed that the time step used for the riverine flood model is 1 hour. The modeling team made comparisons of the simulated hydrographs with streamflow observations from USGS stations that demonstrated the model adequately represents flood peaks.

    Discussed that the time step used for the pluvial flood model is 15 seconds.

31. HHF-2.7, page 173: Provide plots and/or data to illustrate the following comparisons:
    a. The pluvial flood model versus other model data, reports, and flood maps,
    b. The riverine model simulations versus observed flow record, and
    c. Storm Surge model results versus the three data sets used for validation.

    Discussed for the storm surge model, the three datasets include high water marks, time series of water level at NOAA tide gauges, and debris lines. Reviewed comparisons of each dataset to observations from Hurricane Andrew (1992) and Hurricane Ivan (2004).

    Reviewed comparisons of the modeled riverine flood flow to recorded flow data for Hurricane Irma (2017), Hurricane Jeanne (2005), Hurricane Ivan (2004), and Tropical Storm Fay (2008).

35. Form HHF-1, pages 294-295: Explain the flow depth legends as related to the captions for Figures 93-96.

    Discussed that the elevation value refers to the NAVD88 datum. Below NAVD88, the elevation is denoted as a positive value. Above NAVD88, the elevation is denoted as a negative value. Discussed that this methodology aligns with the CEST storm surge model.

36. Form HHF-1, pages 294-325: Provide Figures 93-117 with the storm tracks plotted. Provide Figures 118-136 with the vertical datum.

    Reviewed maps of coastal flooding in West North Florida, West Florida, South Florida, and East North Florida basins with the storm tracks plotted.

    Reviewed maps of coastal flooding for Hurricane Andrew (1992), Hurricane Frances (2004), Hurricane Ivan (2004), Hurricane Katrina (2005), Hurricane Wilma (2005), Hurricane Hermine (2016), Hurricane Matthew (2016), Hurricane Irma (2017), Hurricane Michael (2018), and Hurricane Dorian (2019) with the storm tracks plotted.

37. Form HHF-1, pages 296-305: Provide Figures 97-106 with the coastline overlaid.

    Reviewed Figures 97-106 with the coastline overlaid.

38. Form HHF-1, pages 296-305: Remove the open-water coverage on each map in Figures 97-106 to provide clarity of storm impacts.

    Reviewed the open-water coverage on the maps in Figures 97-106.

39. Form HHF-1, pages 294-329: Provide mapped model results (e.g., interactive GIS (geographic information system)) capable of being reviewed at higher resolution.

    Reviewed interactive GIS maps of coastal flooding at high resolution for a selection of locations.

40. Form HHF-3, pages 337-343: Provide mapped model results (e.g., interactive GIS) capable of being reviewed at higher resolution.

    Reviewed interactive GIS maps of inland flooding at high resolution for a selection of locations.

41. Form HHF-5.B, pages 366-370: Provide Figures 188-192 adjusted to move the inset and legend to not block impacted coastal areas.

    Reviewed the updated Figures 188-192 that were revised to move the insets and legends to not block the impacted coastal areas. The original figures were replaced in the submission document with the revised figures.

Audit

1. The method and supporting material for determining flood extent and elevation or depth for inland flooding will be reviewed.

   Discussed that the EF5 implementation uses the CREST model for the water balance component, kinematic wave for overland and channel routing, and linear reservoirs scheme for subsurface routing.

   Discussed that soil moisture and surface/subsurface runoff are simulated at ~90m spatial and 1 hour temporal resolution at ~1.3 million grid points.

   Reviewed schematic of processes resolved at each grid point.

   Discussed that infiltration is modeled using the VIC model from Flamig et al. (2020).

   Reviewed flow diagram from streamflow to flood stage.

   Discussed the input data and parameters required in the inland flood model.

   Reviewed the spatial extent of the riverine model domain that covers drainage basins that extend into adjacent states.

   Reviewed calibration and validation of modeled riverine flooding to historical observations for Hurricane Michael (2018), Hurricane Sally (2020), and Hurricane Irma (2017).

   Reviewed comparison of modeled riverine flood flow to recorded flow data for Hurricane Irma (2017) and Hurricane Jeanne (2004).

   Reviewed comparison between modeled flood depth and USGS observations for Hurricane Ian (2022), Hurricane Wilma (2005), and Hurricane Jeanne (2004).

   Reviewed validation maps of modeled flood extent and depth compared to NFIP flood extents in Desoto County.

   Reviewed the computational aspects of the pluvial flood model.

   Reviewed return period flood maps for the entire State of Florida created for the 1, 2, 5, 10, 25, 50, 100, 200, 500, and 1,000-year return periods at 30m resolution based on NOAA Atlas 14 Data.

   Reviewed validation comparing return period flood depths with those published on FloodFactor.com which were produced by First Street Foundation (FSF) using the LISFLOOD model. The LISFLOOD model used NOAA intensity and duration data and the Horton method for infiltration. The FPFLM uses the same data but with a small modification.

Reviewed comparison of 100-year flood depths with FSF LISFLOOD for Gretna in Gadsden County.

Reviewed comparison of 100-year flood depths with FSF LISFLOOD and FEMA flood zones for Lake City in Columbia County.

Reviewed validation comparisons of 100-year flood maps produced by the model with FEMA flood zones in Tallahassee (Leon County).

Discussed that overall, there is agreement in flood extent. The flood model sometimes shows flooding in locations that are not mapped as FEMA flood zones. Most of these cases are where there are holding ponds or natural depressions and channels where water accumulation is expected to occur.

Reviewed flood depth validation comparisons with locations of FEMA claims data. Reviewed comparison of 100-year flood depths and NFIP claims data for the Miami area in Miami-Dade County.

2. Any modeling-organization-specific research performed to calculate the inland flood extent and elevation or depth will be reviewed along with the associated databases.

   See comments under Audit 1.

3. Any modeling-organization-specific research performed to derive the hydrological characteristics associated with the topography, LULC distributions, soil conditions, watersheds, and hydrologic basins for the flood extent and elevation or depth will be reviewed.

   See comments under Audit 1.

4. Historical data used as the basis for the flood model flood extent and elevation or depth will be reviewed. Historical data used as the basis for the flood model flood flow and velocity, if applicable, will be reviewed.

   Discussed that USGS observations were used to estimate rating curve parameters.

5. The comparison of the calculated characteristics with historical inland flood events will be reviewed. The selected locations and corresponding storm events will be reviewed to verify sufficient representation of the varied geographic areas.

   Discussed that the USGS gauging stations selected by the modeling team were located in a reported area affected by inland flooding, and that there were no flags from USGS indicating missing data or potential error for the duration of the modeled storm event.

Reviewed comparison of the modeled riverine flood flow to recorded flow data for Hurricane Irma (2017).

Reviewed empirical cumulative distribution functions (CDFs) of simulated riverine flooding.

Reviewed map of USGS station locations chosen for the analysis.

Reviewed map illustrating pluvial flooding from a 500mm flood event in Ft. Lauderdale.

6. Consistency of the flood model stochastic flood extent and elevation or depth with reference to the historical flood databases will be reviewed. Consistency of the flood model stochastic flood flow and velocity, if applicable, with reference to the historical flood databases will be reviewed.

   Reviewed examples of the CDF of simulated streamflow values based on the stochastic rain model input. Discussed that observed streamflow values for different events are identified on the CDF demonstrating that distribution of simulated values encapsulates observations.

7. Form HHF-1, Historical Event Flood Extent and Elevation or Depth Validation Maps, will be reviewed.

   Reviewed Form HHF-1.

8. For the historical flood events given in Form HHF-1, Historical Event Flood Extent and Elevation or Depth Validation Maps, the flood characteristics, including temporal and spatial variations contributing to modeled flood damage, will be reviewed.

   Reviewed the spatial variations in Form HHF-1 maps. Additional maps with the storm tracks plotted were provided and reviewed under PVL #30.

   Discussed that temporal variations do not contribute to modeled damage and are therefore not applicable.

9. Form HHF-4, Inland Flood Characteristics by Annual Exceedance Probability, and Form HHF-5, Inland Flood Characteristics by Annual Exceedance Probabilities (Trade Secret Item), will be reviewed.

   Reviewed Forms HHF-4 and HHF-5.

   Reviewed comparison of the modeled flood extent and depth and NFIP flood extents corresponding to a 100-year return period in Leon County.

10. Modeled frequencies will be compared with the observed spatial distribution of flood frequencies across Florida using methods documented in current scientific and technical literature. The comparison of modeled to historical statewide and regional inland flood frequencies as provided in Form HHF-4, Inland Flood Characteristics by Annual Exceedance Probability, and Form HHF-5, Inland Flood Characteristics by Annual Exceedance Probabilities (Trade Secret Item), will be reviewed.

    Reviewed inland flood maps in Form HHF-4 for different annual exceedance probabilities.

11. Comparison of 0.01 and 0.002 annual exceedance probability flood extents produced by the flood model, including both inland and coastal flood, with the flood extents from FEMA will be reviewed.

    Reviewed coastal flooding 100-year and 500-year return period maps as provided in Form HHF-2.

    Reviewed inland flooding 100-year and 500-year return period maps as provided in Form HHF-4.

    Reviewed the revised maps for the 500-year return period comparison provided in response to the deficiencies.

12. The basis or dependence of flood characteristics on NFIP FIRM or other FIS data will be reviewed, if relevant.

    Discussed that there is no dependence of flood parameters on NFIP FIRM or other FIS data.

13. Temporal evolution of inland flood characteristics will be reviewed, if applicable. (Trade Secret Item to be provided during the closed meeting portion of the Commission meeting to review the flood model for acceptability.)

    Discussed that the model does not account for temporal evolution and therefore does not contribute to modeled damage.

14. Calculation of relevant characteristics in the inland flood model, such as flood extent and elevation or depth, will be reviewed. The methods by which each flood model component utilizes the characteristics of other flood model components will be reviewed.

    Discussed that the flood model components run independently from each other.

    See comments under Audit 1.

15. The selected time steps representing peak flood extents and elevations or depths referenced in Flood Standard HHF-1, Flood Parameters (Inputs), Disclosure 14, will be reviewed, if applicable. Any assumptions used to account for peak flood extents and elevations or depths for flood events with shorter durations than the selected time steps will be reviewed.

    See comments under PVL #30.

September Additional Verification Review Comments:

The process for modeling rainfall from non-tropical cyclone events and how non-tropical flooding is represented in the modeled loss costs was questioned during the May on-site review and could not be resolved during that audit.

Reviewed the new approach to estimating losses from rainfall due to non-tropical events. The historical record was used for simulating flood with the inland models to estimate the loss costs. Discussed the use of the NOAA CPC unified gauge-based analysis of daily precipitation based on historical gauge station data from 1948 to 2023.

Reviewed map of Florida grid point locations where daily maximum rain amounts exceeds 4 inches and 6 inches.

Reviewed the list of historical inland storms that was added to Form HHF-1 during the additional verification review for clarification.

Reviewed correction made during the additional verification review in Form HHF-1 to the statements on the initial water levels for Hurricane Hermine (2016), Hurricane Matthew (2016), Hurricane Michael (2018), and Hurricane Dorian (2019).

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.***

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.***

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.***

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

32. HHF-3.1, pages 174-175, Table 25: Explain why the "begin" and "end" latitudes are identical for the levees.

    Discussed that there was an error with the ArcGIS tool used to calculate the start and end coordinates of the levees. Table 25 was revised to report centroid coordinates instead.

33. HHF-3.4, page 175: Provide more detail regarding how flood control structure failure is accounted for in the model through Digital Elevation Model (DEM) modification and the limits for that method.

    Reviewed map illustrating the location of a levee used for a failure scenario and the 500m flood extent of the levee break.

    Discussed the process for modifying the DEM using Quantum Geographic Information System (QGIS) tools. Within the levee break extent, the elevation of west and east levee sides was modified to remove elevation barriers.

Audit

1. Treatment of major flood control measures incorporated in the flood model will be reviewed.

   See comments under PVL #33.

2. The documented procedure addressing the updating of major flood control measures as necessary will be reviewed.

   Discussed that the procedure for updating representation of flood control measures in the flood model is directly tied to the updating of the DEM.

3. The methodology and justification used to account for the potential failure or alteration of major flood control measures in the flood model will be reviewed.

   See comments under PVL #33.

4. Examples of flood extent and depth showing the potential impact of major flood control measure failures will be reviewed.

   Reviewed an example of the flood extent and depth showing the impact of levee failure.

5. If the flood model incorporates major flood control measures that require human intervention, the methodology used in the flood model will be reviewed.

   Discussed that the flood model does not incorporate flood control measures that require human intervention.

HHF-4 Logical Relationships Among Flood Parameters and Characteristics*

*(*Significant Revision)*

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

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

C. Rate of discharge shall increase with increase in imperviousness of LULC, all other factors held constant.

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

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

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

34. HHF-4.2, page 183: Provide the degree of modification used to demonstrate the logical relationships as represented in Figures 65-68 (pages 179-182).

    For Figure 65 illustrating the impact of increased roughness, discussed that the alpha parameter in the stage-discharge relationship was increased by 20%.

    For Figure 66 illustrating the impact of increased steepness, discussed that the multiplier parameter of the relationship between cross sectional area and discharge of the kinematic wave equation was reduced by 50%.

    For Figure 67 illustrating the impact of increased imperviousness, discussed that the impervious factor of EF5 corresponding to the percentage of impervious area was increased by 10%.

    For Figure 68 illustrating the impact of increased discharge, discussed that the amount of rainfall was increased by 50%.

    Reviewed revised graphs for increased imperviousness to replace Figure 67 in the submission document.

Audit

1. The analysis performed to demonstrate the logical relationships will be reviewed.

   See comments under PVL #34.

2. Methods (including any software) used in verifying the logical relationships will be reviewed.

   See comments under PVL #34.

   Reviewed graphical representations of the analysis of logical relationships between model parameters and water surface level in which the modeling organization changes terrain roughness, steepness, imperviousness, and discharge in the Panhandle, North Florida, East Florida, Southwest Florida, and Southeast Florida.

September Additional Verification Review Comments:

Reviewed the parameter adjustment values used to achieve the sensitivity in Figures 66-69 (previously Figures 65-68). Reviewed submission pages revised during the additional verification review to include discussion on the different parameter adjustment values for clarification.

STATISTICAL FLOOD STANDARDS – MARK JOHNSON, LEADER

SF-1 Modeled Results and Goodness-of-Fit*

*(*Significant Revision)*

A. The use of historical data in developing the flood model shall be supported by rigorous methods published in 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.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Audit

1. Forms SF-1, Distributions of Stochastic Flood Parameters (Coastal, Inland), and SF-2, Examples of Flood Loss Exceedance Estimates (Coastal and Inland Combined), will be reviewed. Justification for the distributions selected, including for example, citations to published literature or analyses of specific historical data, will be reviewed. Justification for the goodness-of-fit tests used will also be reviewed.

   Reviewed each of the distributions given in Form SF-1 with respect to selection, estimation, goodness-of-fit, and basis in the scientific literature.

   Reviewed examples of flood loss exceedance estimates for coastal and inland losses combined.

2. The modeling organization characterization of uncertainty for damage estimates, annual flood loss, flood probable maximum loss levels, and flood loss costs will be reviewed.

   Reviewed confidence intervals for selected PML levels.

   Reviewed confidence intervals for frame and masonry loss costs for several counties.

3. Regression analyses performed will be reviewed, including for example parameter estimation, graphical summaries and numerical measures of the quality of fit, residual analysis and verification of regression assumptions, outlier treatment, and associated uncertainty assessment.

September Additional Verification Review Comments:

The process for modeling rainfall from non-tropical cyclone events and how non-tropical flooding is represented in the modeled loss costs was questioned during the May on-site review and could not be resolved during that audit.

Reviewed the new approach to estimating losses from rainfall due to non-tropical events. The historical record was used for simulating flood with the inland models to estimate the loss costs. Discussed the use of the NOAA CPC unified gauge-based analysis of daily precipitation based on historical gauge station data from 1948 to 2023.

Reviewed map of Florida grid point locations where daily maximum rain amounts exceeds 4 inches and 6 inches.

Discussed the new methodology for estimating the PML of the combined tropical and non-tropical losses. Non-tropical event losses are fitted to a probability distribution function (PDF). The PDF considers the number of events in a given year, and are sampled for each year in the stochastic event set. The results are combined with the tropical PML results as appropriate for aggregate or annual occurrence.

Reviewed a two-sample Kolmogorov-Smirnov test and a Welch two-sample t-test comparing simulated historical observations and PML fitted model runs.

Reviewed CDFs of simulated historical losses versus PML fitted model.

Reviewed goodness-of-fit test statistics for the PML distribution.

Reviewed the *p*-values of the statistical tests on the PML distributions.

Reviewed the sample variance of the number of events per year.

Discussed that errors were discovered in Form SF-2 and Form AF-8 due to an incorrect number of events used in the calculation of losses. More details on the error are provided under CIF-4.

Reviewed corrected forms using the correct number of events including both tropical and non-tropical events.

Reviewed the percentage changes between the original Form SF-2 using tropical only events and the corrected Form SF-2 using both tropical and non-tropical events.

Discussed that the PML values and mean losses increased, and that relative changes were small in the upper quantiles and were most pronounced for the lower quantiles.

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.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. The modeling organization's sensitivity analysis for the flood model will be reviewed in detail. Statistical techniques used to perform sensitivity analysis will be reviewed. The results of the sensitivity analysis displayed in graphical format (e.g., contour or high-resolution plots with temporal animation) will be reviewed.

   Reviewed the sensitivity analysis for the fluvial model that examined three input parameters: maximum soil water capacity, initial value of soil moisture, and precipitation under three scenarios, a reasonable estimate of the low, moderate, and high values of each parameter. The domain was downstream of the Caloosahatchee River in Glades County. Twenty-seven runs were completed varying each parameter and each scenario one at a time with losses computed for each component. The losses were modeled as a function of the three input variables. The analysis showed that losses are most sensitive to rainfall in the fluvial model.

   Reviewed details of the regression analysis.

   Reviewed the sensitivity analysis for the pluvial model that examined three input variables on loss costs: rainfall for return periods of 50, 100, and 200 years; duration for short, medium, and long; and antecedent soil moisture condition for dry, medium, and wet. The domain was Pensacola, Florida. The analysis showed that losses are most sensitive to rainfall in the pluvial model.

   Residual analyses were reviewed.

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.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

42. SF-3.3, page 195: Elaborate on the improved methods to estimate first floor elevation (FFE) in older homes.

    Discussed that the initial assumption created for inland structures presented a large overestimation of losses in coastal regions, since many old structures were assigned a FFE that was unrealistically low. To resolve this problem, current FFE assumptions were replaced with the results of an analysis of NFIP data of properties that are pre-FIRM and lowest floor elevation as reported in the NFIP data. The subset was further stratified into elevated or on grade (NFIP data) and coastal or inland using the Surge Maximum of Maximum value. Reviewed the calculation of the mean FFE of each group (coastal/inland and elevated/on grade).

    Discussed the FFE assumptions and distributions for property assigned to coastal and inland zones that are closest to the target location.

    Reviewed map of coastal and inland zones with corresponding properties from the comprehensive exposure dataset.

Audit

1. The modeling organization uncertainty analysis for the flood model will be reviewed in detail. Statistical techniques used to perform uncertainty analysis will be reviewed. The results of the uncertainty analysis displayed in graphical format (e.g., contour or high-resolution plots with temporal animation) will be reviewed.

   Reviewed the uncertainty analysis for the fluvial model using the same criteria as the sensitivity analysis. Precipitation is the largest contributor to the uncertainty in loss costs for the fluvial model.

Discussed that to compute the contribution of each input variable to the uncertainty in the losses, the proportion of the total variability in the losses was computed via the expected percentage reduction. The variable with the highest expected percentage reduction was the largest contributor to the uncertainty. Reviewed the expected percentage reduction values for the input variables.

Reviewed the uncertainty analysis for the pluvial model using the same criteria as the sensitivity analysis. Reviewed the expected percentage reduction values for the input variables. Rainfall is the largest contributor and duration contributes significantly to the uncertainty in loss costs for the pluvial model.

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.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. An exhibit of the standard error by each geographic zone will be reviewed.

   Discussed the convergence test methodology.

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.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

43. SF-5.1, page 198, Table 30: Explain why the modeled Hurricane Irma (2017) losses are low.

Discussed that the data used for validation and verification of the flood model is the unredacted NFIP exposure and claims data up to 2014. Exposure sets were prepared for 2004 and 2012 using NFIP exposure data. For Hurricane Irma (2017), losses were based on NFIP publicly available aggregated loss data. The analysis originally included non-residential losses and claims. Non-residential policies were also found in other NFIP claims data. These non-residential policies were removed, leading to a lower actual loss for Hurricane Irma (2017) and some other storms.

Reviewed comparison of total claims losses versus modeled total losses for several events.

Reviewed scatter plot of total actual losses versus total modeled losses.

Audit

1. The following information for each flood event in Form HHF-1, Historical Event Flood Extent and Elevation or Depth Validation Maps, will be reviewed:
   a. The validity of the flood model assessed by comparing projected flood losses produced by the flood model to available flood losses incurred by insurers at both the state and county level,
   b. The version of the flood model used to calculate modeled flood losses for each flood event provided,
   c. A general description of the data and its sources,
   d. A disclosure of any material mismatch of exposure and flood loss data problems, or other material consideration,
   e. The date of the exposures used for modeling and the date of the flood event,
   f. An explanation of differences in the actual and modeled flood parameters,
   g. A listing of the differences between the modeled and observed flood conditions used in validating a particular flood event,

   h. The type of coverage applied in each flood event to address:
      1. Personal residential structures
      2. Manufactured homes
      3. Condominiums
      4. Contents
      5. Time element,
   i. The treatment of demand surge or loss adjustment expenses in the actual flood losses or the modeled flood losses, and
   j. The treatment of wind losses in the actual flood losses or the modeled flood losses.

Discussed that losses were computed for selected events and that the total losses for the events are provided in Table 30.

Discussed that the data used for validation and verification of the flood model are the unredacted NFIP exposure and claims data up to 2014. Exposure sets were prepared for 2004 and 2012 using NFIP exposure data.

Discussed that the model has conditions corresponding to one snapshot in time, but different historical events may have different characteristics which may not be captured by the model (e.g., bathymetry, landcover data).

Discussed that the flood model does not include wind losses.

2. The following documentation will be reviewed:
   a. Publicly available documentation and data referenced in the flood model submission in hard copy or electronic form,
   b. Modeling-organization-specific documentation and data used in validation of flood losses,
   c. An analysis that identifies and explains anomalies observed in the validation data, and
   d. User input data for each insurer and flood event detailing specific assumptions made with regard to exposed personal residential property.

Reviewed NFIP claims and exposure data.

Discussed the revision to Hurricane Irma (2017) losses that had incorrectly included non-residential losses.

Discussed that no other exposure and claims data were used other than the NFIP data.

3. The confidence intervals used to gauge the comparison between historical and modeled flood losses will be reviewed.

Reviewed plot of modeled versus observed losses. Reviewed the Pearson’s correlation coefficient and the Wilcoxon signed rank test showing agreement between the two losses.

4. The results for more than one flood event will be reviewed to the extent data are available.

    Reviewed a table with results for more than one flood event.

September Additional Verification Review Comments:

Discussed the reasons for the large changes in values for Hurricane Irma (2017), Tropical Storm Debby (2012), Tropical Storm Fay (2008), and Hurricane Irene (2011) when there was no change in values for other events given in Table 30 of the August 12, 2024, revised submission. The changes in values were related to a problem with the datasets used for validation in the original submission. Table 30 was originally completed using the redacted NFIP dataset for some storms and the unredacted NFIP dataset for other storms.

Reviewed a new Table 30 revised during the additional verification review where filtered losses were used for Hurricane Irma (2017) and unfiltered losses were used for all the other events.

VULNERABILITY FLOOD STANDARDS – CHRIS JONES, LEADER

VF-1 Derivation of Building Flood Vulnerability Functions*

*(*Significant Revision)*

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

B. The derivation of building flood vulnerability functions and the treatment of associated uncertainties shall be theoretically sound and consistent with fundamental engineering principles.

C. Residential building stock classification shall be representative of Florida construction for personal residential buildings.

D. The following flood characteristics shall be used or accounted for in the derivation of building flood vulnerability functions: depth above ground, and in coastal areas, damaging wave action.

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

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

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

44. VF-1.D, page 201: Clarify how "inundation depth" is determined when waves are present.

Discussed that the modeling team defines inundation depth as the water depth absent waves. This depth is determined by the storm surge hazard model, and for inland flooding, by the inland models.

45. VF-1.2, page 202, Figure 78: Starting with “Tsunami Fragility Curves,” step through the derivation of coastal flood vulnerability functions for reference structures 3 and 4 in Form VF-1.

Reviewed examples of vulnerability functions versus fragility functions.

Discussed that fragility and vulnerability functions are either 1) empirical models derived from post-disaster damage assessments or insurance claims data, 2) engineering-based models derived from structural behavior principles, 3) models based on expert option, or 4) some combination of the three.

Discussed the use of Peng (2015) as a basis to translate tsunami fragility functions into coastal flood fragility functions using a force equivalency.

Reviewed the process for converting damage state tsunami fragilities into corresponding flood fragilities, and into a single coastal flood vulnerability function.

Reviewed the water force equations.

Reviewed the coastal flood fragility mapping procedure.

Reviewed example of coastal fragility curves for a 1-story on-grade masonry structure.

Discussed that damage ratios are quantified per storm surge damage state. Cost analyses were performed for different structures and the probability of damage assigned to each building major component. Components considered were foundation, walls, interiors, openings, and roof. Reviewed the qualitative description of six coastal flood damage states provided in Table 6 of the submission.

Discussed the detailed cost analysis of 72 different building types and components for developing cost ratios between the cost to repair or replace a component and the original cost of the entire building.

Reviewed example of expected damage ratios for different damage states for a one-story masonry on-grade structure.

Reviewed conversion of a coastal flood fragility to vulnerability equation, and a plot of the resulting vulnerability curve for a reinforced masonry structure.

Reviewed the coastal flood vulnerability functions for reference structures 3 and 4 in Form VF-1.

46. VF-1.2, page 203, Figure 79: Starting with USACE vulnerability functions, step through the derivation of inland flood vulnerability functions for reference structures 3, 4, and 7 in Form VF-2.

    Discussed that inland flood vulnerability functions for personal residential structures are based on USACE (2015), and for manufactured homes, on USACE (1992, 2006). USACE data is shifted to reflect the FFE relative to the ground. A lognormal cumulative distribution function (CDF) is used to fit the empirical points. Reviewed an inland flood building vulnerability curve for a 2-story masonry house with 2ft FFE.

    Reviewed the inland flood vulnerability functions for reference structures 3, 4, and 7 in Form VF-2.

    Discussed the development of vulnerability functions for tied-down and untied-down manufactured homes.

47. VF-1.7, pages 206-207: Clarify how "flood depth" is determined when waves are present and how this compares to inundation depth.

    Discussed that flood depth and inundation depth have the same meaning, and that flood depth is determined by the flood hazard model, not vulnerability/engineering.

    Discussed that the flood (no waves) vulnerability curves in USACE (2015) represent saltwater flooding. Discussed that the model applies the no-wave saltwater vulnerability curve to inland flooding.

48. VF-1.9, page 208: Justify use of 2002 as the date separating weak from strong construction for flood resistant design.

    Discussed that the Modeler determined implementation of the statewide Florida Building Code is a reasonable separation point to initiate the model; that there is a lack of validation data to test finer gradations of strength eras; and that the model is designed to accommodate future enhancements in building strength.

    Discussed that the base flood elevation (BFE) is determined using the FEMA National Flood Hazard Layer.

49. VF-1.12, page 211: Justify using personal residential building flood vulnerability functions for condo unit owners.

    Discussed that using personal residential building flood vulnerability functions for condo unit owners is due to only including individual condo units owned by a unit owner or a condominium association in the exposure dataset.

50. VF-1.13, page 212: Explain the rules used to resolve building input conflicting characteristics.

    Discussed that the sentence in question was a carry-over from the wind model submission, does not apply to the flood model, and was removed in the revised flood model submission.

53. Form VF-1, pages 374-388: Provide plots of the building, contents, and time element vulnerability functions for each of the 8 reference structures.

    Reviewed plots of the building, contents, and time element vulnerability functions for each of the 8 reference structures in Form VF-1, coastal flood with waves.

    Reviewed plots of coastal flood with waves building vulnerability functions for wood frame reference structures combined, masonry reference structures combined, and manufactured homes reference structures combined.

54. Form VF-2, pages 389-403: Provide plots of the building, contents, and time element vulnerability functions for each of the 8 reference structures.

    Reviewed plots of the building, contents, and time element vulnerability functions for each of the 8 reference structures in Form VF-2, inland flood.

    Reviewed plots of inland flood building vulnerability functions for wood frame reference structures combined, masonry reference structures combined, and manufactured homes reference structures combined.

Audit

1. All building and manufactured home flood vulnerability functions will be reviewed. The magnitude of logical changes among these for given flood events and validation materials will be reviewed.

    Reviewed comparisons of modeled vulnerability curves with USACE (2015) for a 1-story slab on-grade weak wood frame 0.3m FFE and a 1-story slab on-grade strong masonry 0m FFE.

    Reviewed coastal and inland vulnerability curves for the 8 reference structures in Forms VF-1 and VF-2.

    Reviewed vulnerability functions for tied-down and untied-down manufactured homes.

    Reviewed vulnerability functions for different mitigation measures, as shown in Form VF-3: elevation of the structure, elevating utilities, wet floodproofing, dry floodproofing, and a combination of mitigation measures. Discussed that the mitigation measures are limited in the flood model to FFE + 3ft and that changing this limit in the future would be simple.

Discussed that an inland flood vulnerability curve is never used for a coastal surge event and that storm surge flooding will always be accompanied by waves (minor, moderate, or severe).

See comments under PVLs #45, #46, #53, and #54.

2. Comparison of building flood vulnerability functions for Form VF-1, Coastal Flood with Damaging Wave Action, reference structures will be reviewed. Comparison of building flood vulnerability functions for Form VF-2, Inland Flood by Flood Depth, reference structures will be reviewed.

   See comments under PVLs #53 and #54.

3. If the flood model uses component-based vulnerability functions, comparisons of the overall building flood vulnerability functions and the individual component-based vulnerability functions will be reviewed for each of the reference structures in Form VF-1, Coastal Flood with Damaging Wave Action, and Form VF-2, Inland Flood by Flood Depth (16 comparisons total, eight for each form).

   Discussed that the flood model does not use component-based vulnerability functions.

4. Modifications to the building vulnerability component of the flood model since the currently accepted flood model will be reviewed in detail, including the rationale for the modifications, the scope of the modifications, the process, the resulting modifications, and their impacts on the building vulnerability functions.

   Not applicable as this is the first submission of the Florida Public Flood Loss Model.

5. Comparisons of the building flood vulnerability functions with the currently accepted flood model will be reviewed.

   Not applicable as this is the first submission of the Florida Public Flood Loss Model.

6. Building vulnerability functions that incorporate waves or wave proxies will be reviewed. Thresholds for damaging wave action will be reviewed. The area over which building flood vulnerability functions for damaging waves or wave proxies are applied will be reviewed.

   Discussed the process for selecting a vulnerability function if the surge in a subgrid is less than 0.75m and does not trigger the wave model.

   Verified in the source code that the STWAVE model starts to run at ≥ 0.75m in a subgrid.

Reviewed the flood model's minor, moderate, and severe wave vulnerability curves as compared to those given in Peng (2015). Discussed that Peng (2015) results used a different minor wave characterization. Discussed that, in addition to some modifications, Peng's curves have also been shifted in the flood model to be closer to USACE (2015) wave curves.

7. Validation of the building flood vulnerability functions and the treatment of associated uncertainties will be reviewed.

   Reviewed uncertainty discussion in Standard VF-1, Disclosure 17.

8. Historical data in the original form will be reviewed with explanations for any changes made and descriptions of how missing or incorrect data were handled. For historical data used to develop building flood vulnerability functions, the goodness-of-fit of the data will be reviewed. Complete reports detailing flooding conditions and damage suffered for any laboratory or field-testing data used will be reviewed. A variety of different personal residential building construction classes will be selected from the complete rational structural analyses and calculations to be reviewed. Laboratory or field tests and original post-event site investigation reports will be reviewed. Other scientific and technical literature and expert opinion summaries will be reviewed. Insurance claims data will be reviewed.

   See comments under PVLs #6, #45, #46, and #51.

9. All scientific and technical literature, reports, and studies used in the continual development of the building flood vulnerability functions must be available for review in hard copy or electronic form.

   All references were available electronically and were reviewed as necessary.

10. Justification for the personal residential building construction classes and characteristics used will be reviewed.

    Reviewed Table 34 detailing the different building flood vulnerability functions used for various building classes of personal residential building structures and manufactured homes.

11. Documentation and justification for the effects on the building flood vulnerability functions due to local and regional construction practices, and statewide and local building codes, floodplain management regulations, and their enforcement will be reviewed. If year of construction or geographical location of the building is used as a surrogate for building code, floodplain management regulation, and their enforcement, complete supporting information for the number of year of construction groups used as well as the year-bands and geographical regions of construction that separate particular groups will be reviewed.

    Discussed that FFE = BFE + 1 is the assumption for post-FIRM construction.

See comments under PVLs #42 and #48.

12. Describe in detail the breakdown of new flood claims data into number of policies, number of insurers, dates of flood loss, amount of flood loss, and amount of dollar exposure; separated into personal residential and manufactured homes. Indicate whether or not the new flood claims datasets were incorporated into the flood model. Describe research performed and analyses on the new flood claims datasets and the impact on flood vulnerability functions.

    Discussed the NFIP claims dataset used for validation. The dataset contained 150,000+ claims between 1975 and 2014 for 126 events. The data included information on the date of loss, year of construction, physical address, cause of damage, total property value, building and content coverages, and financial damage to the building and contents. The data did not include information on water height at time of event, the property's structural material, number of stories, FFE, or the total value of contents.

    Discussed validation by creating a hybrid dataset to enhance the NFIP dataset. Tax appraisals and Florida Office of Insurance Regulation information were used to obtain additional information about the properties. FEMA field observations were used for hazard information, where available.

    Reviewed NFIP claims data for personal residential structures and manufactured homes for 12 major hurricanes included in Tables 32 and 33.

13. How the claim practices of insurance companies are accounted for when flood claims data for those insurance companies are used to develop or to verify building flood vulnerability functions will be reviewed. Examples include the level of damage the insurer considers a loss to be a total loss, claim practices of insurers with respect to concurrent causation, the impact of public adjusting, or the impact of the legal environment.

    Discussed that the only insurance company interacted with is the NFIP, and that no adjustments were made for any of the items listed in the audit item.

14. The percentage of damage at or above which the flood model assumes a total building loss will be reviewed.

    Discussed that there is not a threshold where the flood model assumes a total building loss.

15. The treatment of law and ordinance in building flood vulnerability functions will be reviewed.

    Discussed that law and ordinance is not treated through the building flood vulnerability functions.

16. Documentation and justification for the method of derivation and data on which the building flood vulnerability functions are based will be reviewed.

    See comments under PVLs #45 and #46.

17. If modeled, the treatment of water intrusion in building flood vulnerability functions will be reviewed.

    Discussed that water intrusion is not explicitly modeled. Water intrusion is addressed implicitly via the vulnerability functions.

18. The basis or dependence of building flood vulnerability functions on NFIP FIRM or other FIS data will be reviewed.

    Discussed that the development of the flood vulnerability functions was not dependent upon NFIP FIRM or other FIS data.

19. The process to account for FEMA's change in flood insurance premium rating to Risk Rating 2.0 will be reviewed, if applicable.

    Discussed that FEMA Risk Rating 2.0 is not taken into account in the vulnerability flood model.

20. Form VF-1, Coastal Flood with Damaging Wave Action, will be reviewed.

    Reviewed Form VF-1. See comments under PVL #53.

21. Form VF-2, Inland Flood by Flood Depth, will be reviewed.

    Reviewed Form VF-2. See comments under PVL #54.

September Additional Verification Review Comments:

The process for modeling waves in the Florida Keys and how the minor, moderate, and severe wave vulnerability functions are assigned in the Florida Keys was questioned during the May on-site review and could not be resolved during that audit.

Discussed that the map of Florida with subgrids presented during the May on-site review was incorrect. Reviewed the correct map of Florida subgrids, including subgrids in the Florida Keys. Discussed that the incorrect map was never used for loss computations, that all computations include the Florida Keys subgrids, and that the Florida Keys subgrids are treated the same as all others.

Reviewed an updated Figure 41 flowchart illustrating the CEST storm surge model and the damage ratio computation model, that was revised during the additional verification review to conform to ISO 5807 standards.

The Modeler confirmed that the Florida Keys are covered in the wave calculation.

VF-2 Derivation of Contents Flood Vulnerability Functions*

*(*Significant Revision)*

A. Development of the contents flood vulnerability functions shall be based on some combination of the following: (1) post-event site investigations, (2) scientific and 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.

B. The relationship between building and contents flood vulnerability functions shall be reasonable.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

51. VF-2.4, page 220, Figure 85: Explain how contents damage is less than 100% when the building damage is 100%.

Reviewed example of NFIP claims data used to develop contents vulnerability functions.

Reviewed the relationship between building and contents damage ratios.

Reviewed the building vulnerability, contents transfer function, and resulting contents vulnerability curves.

Reviewed plot of contents vulnerability functions.

Audit

1. Modifications to the contents vulnerability component of the flood model since the currently accepted flood model will be reviewed in detail, including the rationale for the modifications, the scope of the modifications, the process, the resulting modifications and their impact on the contents vulnerability functions.

   Not applicable as this is the first submission of the Florida Public Flood Loss Model.

2. Comparisons of the contents flood vulnerability functions with the currently accepted flood model will be reviewed.

   Not applicable as this is the first submission of the Florida Public Flood Loss Model.

3. All contents flood vulnerability functions will be reviewed.

   See comments under PVLs #51, #53, and #54.

4. Contents flood vulnerability functions that incorporate waves or wave proxies will be reviewed. Thresholds for damaging wave action will be reviewed. The area over which contents flood vulnerability functions for damaging waves or wave proxies are applied will be reviewed.

   Discussed that the contents vulnerability is derived from the building vulnerability. See comments under VF-1, Audit 2.

5. Validation of the contents flood vulnerability functions and the treatment of associated uncertainties will be reviewed.

   See comments under PVL #51.

6. Documentation and justification of the method of derivation and underlying data or assumptions related to contents flood vulnerability functions will be reviewed.

   See comments under PVL #51.

7. Historical data in the original form will be reviewed with explanations for any changes made and descriptions of how missing or incorrect data were handled. For historical data used to develop contents flood vulnerability functions, the goodness-of-fit of the data will be reviewed. Complete reports detailing flood conditions and damage suffered for any test data used will be reviewed. Original post-event site investigation reports will be reviewed. Other scientific and technical literature and expert opinion summaries will be reviewed. Insurance claims data will be reviewed.

   See comments under PVL #51.

8. Justification for changes from the currently accepted flood model in the relativities between flood vulnerability functions for building and the corresponding flood vulnerability functions for contents will be reviewed.

   Not applicable as this is the first submission of the Florida Public Flood Loss Model.

9. Documentation and justification of the method of derivation and underlying data or assumptions related to contents flood vulnerability functions will be reviewed.

   See comments under PVL #51 and Standard VF-2, Disclosure 4.

10. The basis or dependence of contents flood vulnerability functions on NFIP FIRM or other FIS data will be reviewed.

    Discussed that the development of the contents flood vulnerability functions was not dependent upon NFIP FIRM or other FIS data.

11. All scientific and technical literature, reports, and studies used in the continual development of the contents flood vulnerability functions must be available for review in hard copy or electronic form.

    All literature, reports, and studies were available electronically and were reviewed as necessary.

VF-3 Derivation of Time Element Flood Vulnerability Functions*

*(*Significant Revision)*

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

B. The relationship among building, contents, and time element flood vulnerability functions shall be reasonable.

C. Time element flood vulnerability functions derivations shall consider the estimated time required to repair or replace the property.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

52. VF-3.A, page 223: Justify using wind claims data to inform flood time element losses.

Discussed that NFIP does not cover time related expenses; therefore, there are no time-element NFIP flood claims data for validation.

Discussed that the Modeler has extensive time-element claims data for wind. Repair time, delay time, and utilities downtime used to predict overall recovery time are the same regardless of the cause of the damage. The flood model uses the wind claims data to inform the time-element model.

Audit

1. Modifications to the time element vulnerability component of the flood model since the currently accepted flood model will be reviewed in detail, including the rationale for the modifications, the scope of the modifications, the process, the resulting modifications and their impact on the time element vulnerability functions.

   Not applicable as this is the first submission of the Florida Public Flood Loss Model.

2. Comparisons of the time element flood vulnerability functions with the currently accepted flood model will be reviewed.

   Not applicable as this is the first submission of the Florida Public Flood Loss Model.

3. All time element flood vulnerability functions will be reviewed.

   See comments under PVLs #53 and #54.

4. Time element flood vulnerability functions that incorporate waves or wave proxies will be reviewed. Thresholds for damaging wave action will be reviewed. The area over which time element flood vulnerability functions for waves or wave proxies are applied will be reviewed.

   Discussed that the time element vulnerability uses the same fragilities as the building vulnerability.

   See comments under PVLs #45, #46, #53, and #54.

5. Validation of the time element flood vulnerability functions and the treatment of associated uncertainties will be reviewed.

   Discussed that the time element flood vulnerability functions were indirectly validated against the time element vulnerability functions of the wind model since there is no time element claims data related to flood.

6. Documentation and justification of the method of derivation and underlying data or assumptions related to time element flood vulnerability functions will be reviewed.

   Reviewed the underlying data and assumptions related to time element flood vulnerability functions.

7. Historical data in the original form will be reviewed with explanations for any changes made and descriptions of how missing or incorrect data were handled. To the extent historical data are used to develop time element flood vulnerability functions, the goodness-of-fit of the data will be reviewed. Complete reports detailing flooding conditions and damage suffered for any test data used will be reviewed. Original post-event site investigation reports will be reviewed. Other scientific and technical literature and expert opinion summaries will be reviewed. Insurance claims data will be reviewed.

   Discussed the Modeler does not have historical claims data related to time element losses for flood.

8. If included, the methodology and validation for determining the extent of infrastructure flood damage and governmental mandate and their effect on time element flood vulnerability will be reviewed.

   Discussed that infrastructure flood damage and governmental mandates are not included in the flood model.

9. Justification for changes from the currently accepted flood model in relativities between flood vulnerability functions for building and the corresponding flood vulnerability functions for time element will be reviewed.

   Not applicable as this is the first submission of the Florida Public Flood Loss Model.

10. Documentation and justification of the method of derivation and underlying data or assumptions related to time element flood vulnerability functions will be reviewed.

    See Audit 6.

VF-4 Flood Mitigation Measures*

*(*Significant Revision)*

A. Modeling of flood mitigation measures to improve flood resistance of buildings, and the corresponding effects on flood vulnerability and 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 buildings.

B. The modeling organization shall justify all flood mitigation measures considered by the flood model.

C. Application of flood mitigation measures that affect the performance of personal residential buildings and the damage to contents shall be justified as to the impact on reducing flood damage whether done individually or in combination.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

55. Form VF-3, pages 404-408: Explain the results contained in the form.

Discussed the methodology and assumptions made for completing Form VF-3 for coastal flooding and for inland flooding.

Audit

1. Flood mitigation measures used by the flood model, whether or not referenced in Form VF-3, Flood Mitigation Measures, will be reviewed for theoretical soundness and reasonability.

   See comments under PVL #55.

   Discussed the behavior of mitigated vulnerability functions for:
   - Elevated structures
   - Elevating utilities
   - Wet floodproofing
   - Dry floodproofing
   - Combined mitigation

Reviewed illustration of mitigated versus unmitigated vulnerability.

2. Modifications to flood mitigation measures in the flood model since the currently accepted flood model will be reviewed in detail, including the rationale for the modifications, the scope of the modifications, the process, the resulting modifications, and their impacts on the flood vulnerability component.

   Not applicable as this is the first submission of the Florida Public Flood Loss Model.

3. Comparisons of flood mitigation measures in the flood model with the currently accepted flood model will be reviewed.

   Not applicable as this is the first submission of the Florida Public Flood Loss Model.

4. Procedures, including software, used to calculate the impact of flood mitigation measures will be reviewed.

   See comments under PVL #55.

5. Form VF-3, Flood Mitigation Measures, Range of Changes in Flood Damage, and Form VF-4, Differences in Flood Mitigation Measures, will be reviewed.

   Reviewed Forms VF-3 and VF-4. See comments under PVL #55.

6. Implementation of flood mitigation measures will be reviewed as well as the effect of individual flood mitigation measures on flood damage. Any variation in the change in flood damage over the range of flood depths above ground for individual flood mitigation measures will be reviewed. Historical data, scientific and technical literature, expert opinion, or insurance company claims data used to support the assumptions and implementation of flood mitigation measures will be reviewed. How flood mitigation measures affect the uncertainty of the vulnerability will be reviewed.

   See comments under PVL #55.

7. Implementation of multiple flood mitigation measures will be reviewed. The combined effects of these flood mitigation measures on flood damage will be reviewed. Any variation in the change in flood damage over the range of flood depths above ground for multiple flood mitigation measures will be reviewed.

   See comments under PVL #55.

ACTUARIAL FLOOD STANDARDS – STU MATHEWSON, LEADER

AF-1 Flood Model Input Data and Output Reports*

*(*Significant Revision)*

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.

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.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. Quality assurance procedures, including methods to assure accuracy of flood insurance or other input data, will be reviewed. Compliance with this standard will be readily demonstrated through documented rules and procedures.

   Reviewed the pre-processing of exposure input data as given in Disclosure 8, Table 40.

2. All flood model inputs and assumptions will be reviewed to determine that the flood model output report appropriately discloses all modifications, adjustments, assumptions, and defaults used to produce the flood loss costs and flood probable maximum loss levels.

   Reviewed the model inputs as given in Disclosure 4, Table 38 and the output report given in Disclosure 5, Table 39.

3. Explanation of the differences in data input and flood model output for coastal and inland flood modeling will be reviewed.

   Discussed that there is no difference in data input for coastal and inland flood modeling. Losses are modeled with a set of stochastic events that produce either coastal or inland flooding, or both from a single event. When an exposure is impacted by both coastal and inland flooding from a single event, the greater of the two damage estimates is used. The output report does not distinguish between coastal and inland flood loss costs or PMLs.

4. The human-computer interface relevant to input data and output reports and corresponding nomenclature used in Florida rate filings will be reviewed.

   Discussed that input data testing and model runs are executed by the Computer Science team.

AF-2 Flood Events Resulting in Modeled Flood Losses*
*(*Significant Revision)*

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.

B. The modeling organization shall have a documented procedure for distinguishing flood-related losses from other peril losses.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

56. AF-2.B, page 247: Provide an electronic copy of the documented procedure for distinguishing flood losses from other peril losses.

    Reviewed the documented procedure for distinguishing flood losses from other peril losses.

Audit

1. The flood model will be reviewed to evaluate whether the determination of flood losses in the flood model is consistent with this standard.

   Discussed that wind losses do not influence the calculation of flood losses.

2. The flood model will be reviewed to determine that meteorological or hydrological and hydraulic events originating either inside or outside of Florida are modeled for flood losses occurring in Florida and that such effects are considered in a manner which is consistent with this standard.

   Reviewed validation comparisons.

3. The flood model will be reviewed to determine whether and how the flood model takes into account any damage resulting directly and solely from wind and water infiltration.

   Discussed that there is no consideration of wind damage or wind-driven water infiltration in the flood model.

4. The flood model will be reviewed to determine how flood losses from water intrusion are identified and calculated.

   Discussed that water intrusion is handled by the damage ratios for building and contents damage. For flooding with no waves, damage from intrusion is assumed to occur whenever the flooding depth exceeds the FFE of the structure. For flooding with minor, moderate, or severe waves, damage from intrusion starts occurring where the flood level is below the FFE, due to the presence of waves.

5. The documented procedure for distinguishing flood-only losses from other peril losses will be reviewed.

   Reviewed the documented procedure for distinguishing flood losses from other peril losses.

6. The effect on flood loss costs and flood probable maximum loss levels arising from flood events that are neither inland nor coastal flooding will be reviewed.

   Discussed that the model treats water intrusion other than flood as described in s. 627.715, F.S., as an optional coverage that can be provided under the Preferred and Flexible policies defined by statute. Losses for this option are not included in the submission's modeled loss costs or PMLs.

AF-3 Flood Coverages*
*(*Significant Revision)*

A. The methods used in the calculation of personal residential structure flood loss costs, including the effect of law and ordinance coverage, shall be actuarially sound.

B. The methods used in the calculation of personal residential appurtenant structure flood loss costs shall be actuarially sound.

C. The methods used in the calculation of personal residential contents flood loss costs shall be actuarially sound.

D. The methods used in the calculation of personal residential time element flood loss costs shall be actuarially sound.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. The methods used to produce personal residential structure, appurtenant structure, contents, and time element flood loss costs will be reviewed.

   Reviewed the methods as described in Disclosures 1-4.

   Discussed with Gail Flannery, Actuarial Flood Standards signatory, her review of the actuarial portion of the submission document. Discussed how she attested the model results to be actuarially sound.

2. The treatment of law and ordinance coverage will be reviewed, including the 25% and 50% coverage options for personal residential policies.

   Discussed that the model includes the NFIP coverage Increased Cost of Compliance (ICC) as an option. Losses for this option are not included in the submission's modeled loss costs or PMLs.

   When a building covered by a Standard Flood Insurance Policy (SFIP) suffers a flood loss and is declared to be damaged by more than 50%, ICC pays up to $30,000 to bring the building into compliance with State or community floodplain management laws or ordinances. However, the SFIP caps possible ICC payments such that the policy limit is not exceeded.

Reviewed a needed correction to the source code that was made during the on-site review to set a cap on the loss limit when the optional ICC coverage is selected.

AF-4 Modeled Flood Loss Cost and Flood Probable Maximum Loss Level Considerations*

*(*Significant Revision)*

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.

B. Flood loss cost projections and flood probable maximum loss levels shall not make a prospective provision for economic inflation.

C. Flood loss cost projections and flood probable maximum loss levels shall 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.

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.

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.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

57. AF-4.1, page 252: Provide, in Excel, tables of 1,000 years descending from the Top Event corresponding to Form AF-8. For each year, show the value of each event separately.

    Reviewed the tables of 1,000 years descending from the Top Event which showed agreement to Form AF-8.

58. AF-4.3, page 253: Explain in detail the demand surge model. Provide a copy of the documented procedure, and its implementation in the code.

    Reviewed the documented procedure for the demand surge model.

The flood model applies the same demand surge model developed for the wind model with the industry loss from flood. The demand surge functions were developed from the behavior of construction cost and consumer price indices before and after hurricanes. Discussed that the minimum threshold for applying demand surge factors is $2 Billion.

Reviewed the formula for calculating demand surge factors for each storm.

Audit

1. How the flood model handles expenses, risk load, investment income, premium reserves, taxes, assessments, profit margin, economic inflation, and any criteria other than direct property flood insurance claim payments will be reviewed.

   Discussed that no assumptions for expenses, risk load investment income, premium reserves, taxes, assessments, profit margin, economic inflation, or any other criteria other than direct property flood insurance claims payments are made.

2. The method of determining flood probable maximum loss levels will be reviewed.

   Discussed that the PMLs are percentiles of the ordered set of modeled losses, either on an occurrence or annual basis.

3. The uncertainty in the estimated annual flood loss costs and flood probable maximum loss levels will be reviewed.

   Reviewed the PML confidence intervals as given in Form AF-8.

4. The data and methods used to incorporate individual aspects of demand surge on personal residential coverages for coastal and inland flooding, inclusive of the effects from building material costs, labor costs, contents costs, and repair time will be reviewed.

   See comments under PVL #58.

5. How the flood model accounts for economic inflation associated with past insurance experience will be reviewed.

   Discussed that validation with NFIP 2004 and 2012 exposures with claims from a mix of years from 2004-2012 without adjustment for inflation matched. Vulnerability calibration also matched NFIP claims with adjuster-based property values for the same year.

6. The treatment of wind losses in the determination of flood losses will be reviewed.

   Discussed that there is no consideration of wind losses in determining flood losses.

7. How the flood model determines flood loss costs associated with coastal flooding will be reviewed.

   Discussed that the model does not determine separate loss costs for coastal versus inland flooding.

8. How the flood model determines flood probable maximum loss levels associated with coastal flooding will be reviewed.

   Discussed that the model does not determine separate PMLs for coastal versus inland flooding.

9. How the flood model determines flood loss costs associated with inland flooding will be reviewed.

   Discussed that the model does not determine separate loss costs for coastal versus inland flooding.

10. How the flood model determines flood probable maximum loss levels associated with inland flooding will be reviewed.

    Discussed that the model does not determine separate PMLs for coastal versus inland flooding.

11. The methods used to ensure there is no systematic over-estimation or under-estimation of flood loss costs and flood probable maximum loss levels from coastal and inland flooding will be reviewed.

    Reviewed validation comparisons.

12. All referenced scientific and technical literature will be reviewed, in hard copy or electronic form, to determine applicability.

    All references were available electronically and were reviewed as necessary.

    Reviewed the Wilkinson paper, Estimating Probable Maximum Loss with Order Statistics.

September Additional Verification Review Comments:

Discussed the method used to compute the total PML that adds non-tropical events to the tropical cyclone events.

AF-5 Flood Policy Conditions*

*(*Significant Revision)*

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.

B. The relationship among the modeled deductible flood loss costs shall be reasonable.

C. Deductible flood loss costs shall be calculated in accordance with s. 627.715, F.S.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

59. AF-5.1, page 254: Explain in detail the method used to treat deductibles.

Discussed that the model follows the NFIP approach of applying separate deductibles to building and contents losses. An exposure's damages are calculated for building and for contents for every event in the stochastic set. Demand surge factors are applied to the damages for each event. Losses are limited to the coverage limits. The deductibles for building and contents are subtracted from limited losses. Increased Cost of Compliance (ICC) allowance is added, if appropriate, without application of any deductible, consistent with NFIP coverage.

Audit

1. The extent that historical data are used to develop mathematical depictions of deductibles, policy limits, policy exclusions, and loss settlement provisions for flood coverage will be reviewed.

   Discussed that historical data was not used to develop mathematical depictions of deductibles, policy limits, policy exclusions or loss settlement provisions in the model.

2. The extent that historical data are used to validate the flood model results will be reviewed.

   Reviewed validation comparisons.

3. Treatment of annual deductibles will be reviewed, if applicable.

   Discussed that annual deductibles are not modeled.

4. Justification for the changes from the currently accepted flood model in the relativities among corresponding deductible amounts for the same coverage will be reviewed.

   Not applicable as this is the first submission of the Florida Public Flood Loss Model.

AF-6 Flood Loss Outputs and Logical Relationships to Risk*

(Significant Revision)

A. The methods, data, and assumptions used in the estimation of flood loss costs and flood probable maximum loss levels shall be 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.

C. Flood loss costs cannot increase as the structure flood damage resistance increases, all other factors held constant.

D. Flood loss costs cannot increase as flood hazard mitigation measures incorporated in the structure increase, all other factors held constant.

E. Flood loss costs shall be consistent with the effects of major flood control measures, all other factors held constant.

F. Flood loss costs cannot increase as the flood resistant design provisions increase, all other factors held constant.

G. Flood loss costs cannot increase as building code enforcement increases, all other factors held constant.

H. Flood loss costs shall decrease as deductibles increase, all other factors 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.

J. Flood output ranges shall be logical for the type of risk being modeled and apparent deviations shall be justified.

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.

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.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

60. Form AF-1, pages 410-414: Explain the large number of zero loss costs, especially in the Panhandle, North Florida, and East Florida.

    Discussed that the model is not structured with rating areas as required in Form AF-1. To create losses by rating area, the loss costs for coastal ZIP Codes are split between higher and lower risk areas, resulting in zero loss costs in some cases for inland areas. This split was applied in testing for convergence in the stochastic storm set.

    Reviewed a version of Form AF-1 with the “rating area” redefined by county code. In the county code version, the loss costs are summarized to the ZIP Code level and the number of zero loss costs was greatly reduced.

61. Form AF-1, pages 410-414: Explain the difference in Frame Owners rates between the low of 0.001 (e.g., 33449, 32439, 33073, 33971, 33972, 34638, 33647, 34786) and the high of 229.9 (34139).

    Discussed that low loss cost ZIP Codes are not coastally impacted and have a maximum inland flood depth less than 1ft above assumed FFE of 1ft above grade. High loss cost ZIP Codes are coastal and impacted by both coastal and inland flooding.

62. Form AF-1, pages 410-414: Explain the difference in Manufactured Homes rates, by ZIP Code, between the low of 0.004 (33974) and the high of 481.4 (34139).

    Discussed that the low loss cost ZIP Code has no coastal flooding and maximum inland flooding depth of 0.04ft. The high ZIP Code has both coastal and inland flooding with significant depths.

63. Form AF-1, pages 410-414: Explain the difference in Frame Owners rates, by County, between the low of about 0.008 in Liberty County and the high of about 43.0 in Monroe County.

    Discussed that there is more than one exposure in each ZIP Code, so the countywide loss cost is not the average of the loss costs shown in Form AF-1. Liberty County is non-coastal with a low frequency and a maximum inland flood of 0.49ft above the assumed FFE of 1ft. Monroe County has a high frequency and maximum coastal flooding of 15.1ft above an assumed FFE of 1ft.

64. Form AF-1, pages 410-414: Explain the difference in Manufactured Homes rates, by County, between the low of 0.08 in Liberty County and the high of about 118.0 in Monroe County.

    See the response for PVL #63.

65. Form AF-1, pages 410-414: Explain why the ratio of Manufactured Homes rates to Frame Owners rates ranges from 1.44 in Miami-Dade County (34786) to 2,294.00 in Orange County (34786).

    Discussed that the lowest ratio of Manufactured Homes to Frame Owners in Miami-Dade County is in ZIP Code 33116 which is a point ZIP Code in Coconut Grove.

    The Orange County ZIP Code had low levels of inland flooding which resulted in minimal damage to Frame Owners and more significant damage to Manufactured Homes, thus the large relativity.

66. Form AF-2, pages 415-416: Describe in detail the modeling-organization-specified, predetermined and comprehensive exposure dataset. Provide the total value of the exposures and the number of exposures by type (frame, masonry, manufactured homes).

    Discussed that the exposures for Form AF-2 were sourced from the NFIP 2012 exposure file for Florida, the 2019 exposures of a manufactured home insurer whose policies included flood coverage, and post-2012 construction for frame and masonry owners policies located in coastal ZIP Codes as reported to the Modeler by the Florida Office of Insurance Regulation for 2019 stress testing.

    Reviewed a summary of the exposure data by construction type.

67. Form AF-2, pages 415-416: Explain the Great Miami Hurricane (1926) losses compared to other storms, especially Tampa Bay (1921).

    Discussed that coastal areas on the Gulf side of Florida are more susceptible to storm surge and sea level rise than the Atlantic side.

    Discussed that Tampa Bay has a wider and shallower continental shelf than Miami Beach, hence the potential for larger storm surge and higher loss when the Great Miami Hurricane (1926) and the Tampa Bay Hurricane (1921) have similar characteristics.

68. Form AF-4, pages 445-462: Explain the zeros for Frame Owners (e.g., Glades and Liberty Counties Average) and Renters (e.g., Alachua and Clay Counties Average). Explain the propensity of zeros for Low.

    Discussed that no inland flood depth in the stochastic storm set exceeded the FFE of the exposures. Discussed that for a county with at least one ZIP Code with no flooding event exceeding the FFE of the exposures, the low loss cost will be zero.

Reviewed examples of policies in Glades, Liberty, Alachua, and Clay Counties with FFE and maximum coastal and inland ground level.

69. Form AF-4, pages 445-462: Explain why there are “NAs” for Renters and Condo Units (e.g., Bradford County Average).

Discussed that there are no exposures for Renters and Condo Units where “NA” is shown.

70. Form AF-4, pages 445-462: Explain the differences in Average Frame Owners loss costs between the highest counties (Monroe, Dixie, Citrus) and the lowest county (Baker). The high counties show loss costs over 14.80 with the low about 0.026.

Discussed that only 8% of Baker County exposures have modeled losses. There is no coastal flooding, and the maximum inland flooding inundations ranged between 0.3 and 2.1ft.

Discussed that 91% of Monroe County exposures have modeled losses with coastal flooding inundations as high as 12ft.

Discussed that 67% of Dixie County exposures have modeled losses with both coastal and inland flooding and maximum inundations greater than 10ft.

Discussed that 78% of Citrus County exposures have modeled losses. Flooding is primarily coastal with maximum inundations ranging from 5-20ft.

71. Form AF-4, pages 445-462: Explain the differences in Average Manufactured Homes loss costs between the highest county (Monroe) and the lowest counties (Liberty, Union). The high county shows loss costs around 83.0 while the low counties are around 0.001.

Discussed that there were only 7 exposures in Monroe County, but all 7 produced modeled losses with inundations as high as 7ft.

Discussed that there was only 1 exposure in Liberty County and only 1 exposure in Union County that have modeled losses, out of 20-30 exposures. Both exposures have minor flooding depths.

72. Form AF-4, pages 445-454, 0% Deductible: Explain, in general, the wide swings in relativities for Average loss costs as shown below:
    a. The ratio of Masonry Owners to Frame Owners rates that range from 0.03 to 235.88,
    b. The ratio of Manufactured Homes to Frame Owners rates that range from 0.03 to 8.91, and the majority of the Manufactured Homes ratios are less than Frame Owners,
    c. The ratio of Masonry Renters to Frame Renters rates that range from 0.01 to 5.92, and about half of the Masonry Renters ratios are greater than Frame Renters, and

d. The ratio of Masonry Condo Owners to Frame Condo Owners rates that range from 0.01 to 35.5, and about half of Masonry Condo Owners ratios are greater than Frame Condo Owners.

Discussed that the extreme ranges in the average loss cost relationships between frame and masonry are driven by the trivial number of policies that incurred modeled losses in the affected counties.

Discussed that Manufactured Homes exposures all assume an FFE of 3ft which is higher than the average FFE for Owners Frame in most counties. This can reverse the relationship.

Discussed that within a county, exposure characteristics such as the distance from the immediate coast for coastal ZIP Codes, proximity to lakes/rivers, the ground elevation and the FFE have a more significant impact on loss costs than the construction type. Loss cost relationships between frame and masonry will not be consistent within or across counties due to the impact of these primary characteristics.

Discussed that loss costs in this exhibit were calculated at the exposure level and will not agree exactly to the weighted ZIP Code average loss costs in Form AF-4.

73. Form AF-4, page 446: With Form AF-1 having only two ZIP Codes for Glades County (note that both are labeled 33471, one in territory 16 and one in territory 25 with presumably one should have been labeled 33944), explain the values given in Form AF-4 in Glades County Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.

Discussed that there are no exposures in ZIP Code 33944 and that ZIP Code 33471 is split between two rating zones in Form AF-1. Since there is only one ZIP Code with exposure, the Low/High/Average loss costs in Form AF-4 are all equal for each construction type.

Discussed that the Frame Owners average loss cost for ZIP Code 33471 is zero because no inland flooding exceeded the FFE of the exposures.

74. Form AF-4, page 446: With Form AF-1 having only two ZIP Codes for Gulf County (32456 and 32465), explain the values given in Form AF-4 in Gulf County Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.

Discussed that there are 3 ZIP Codes for Gulf County in Form AF-1, but only one ZIP Code, 33457, shows zero losses. There is a single Frame Owners exposure in ZIP Code 33457 with no losses.

75. Form AF-4, page 447: With Form AF-1 having only one ZIP Code in Lafayette County (32066), explain the values given in Form AF-4 in Lafayette County Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.

Followed the same process as for PVL #73.

76. Form AF-4, page 448: With Form AF-1 having only two ZIP Codes for Okeechobee County (34972 and 34974) with similar loss costs, explain the values given in Form AF-4 in Okeechobee County Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.

    Discussed that the FFE assumptions in Form AF-1 and Form AF-4 are not the same and consequently the loss costs by ZIP Code are different in the forms.

77. Form AF-6.E, page 510: Explain the unusual relativity values of Franklin County compared to all other counties in Figure 238.

    Discussed that at low flood levels, building loss costs are lower than personal property loss costs. At high flood levels, the reverse is true. The stochastic storm set only produced flooding in Franklin County greater than 6ft above ground elevation. At these flood levels, personal property loss costs are lower than building loss costs which results in the relativity values observed.

78. Form AF-8, pages 527-528: Explain why most of the annual occurrence estimates exceed the corresponding annual aggregates.

    Discussed that the annual aggregate distribution includes years where there are no storms, whereas the occurrence distribution only includes storms, and most storms result in losses. 43% of all years in the stochastic storm set have no storms and zero losses, which results in lower percentiles.

    Reviewed a comparison of the occurrence distributions including years with no storms and excluding years with no storms.

Audit

1. The data and methods used for flood probable maximum loss levels for Form AF-8, Flood Probable Maximum Loss for Florida, will be reviewed. The Top Event and Conditional Tail Expectations will be reviewed.

   Discussed that the data used for PMLs are the ranked modeled loss by storm and by year. The PMLs are percentiles of those distributions.

   Reviewed the top event and the conditional tail expectations.

2. The frequency distribution and the individual event severity distribution, or information about the formulation of events, underlying Form AF-8, Flood Probable Maximum Loss for Florida, will be reviewed.

   See comments under PVL #78.

   Discussed that the events underlying the PMLs are the 69,310 storms generated from the 73,200-year simulation. The modeled losses from those events are ranked to compute the PMLs.

3. All referenced scientific and technical literature will be reviewed, in hard copy or electronic form, to determine applicability.

   All references were available electronically and were reviewed as necessary.

4. Graphical representations of flood loss costs by rating areas and geographic zones (consistent with the modeling-organization grid resolution) will be reviewed.

   Reviewed the Form AF-1 maps.

5. The procedures used by the modeling organization to verify the individual flood loss cost relationships will be reviewed. Methods (including any software) used in verifying Flood Standard AF-6, Flood Loss Outputs and Logical Relationships to Risk, will be reviewed. Forms AF-1, Zero Deductible Personal Residential Standard Flood Loss Costs; AF-2, Total Flood Statewide Loss Costs; AF-3, Personal Residential Standard Flood Losses by ZIP Code; and AF-6, Logical Relationships to Flood Risk (Trade Secret Item); and AF-7, Percentage Change in Logical Relationships to Flood Risk, will be reviewed to assess flood coverage relationships.

   Reviewed the Form AF-6 relationships.

6. The flood loss cost relationships among deductible, policy form, construction type, coverage, year of construction, foundation type, number of stories, and lowest floor elevation will be reviewed. For coastal flooding, the flood loss cost relationship with distance to the closest coast will be reviewed.

   Reviewed Form AF-6 graphical representations of the flood loss costs relationships.

   Discussed the explanations provided in Disclosure 14 for the relationships that are not consistent.

   Discussed the results shown for Franklin and Dixie Counties.

   Discussed that there were no losses in the counties where the graphs show zero.

Reviewed Figure 265 graph plotting loss costs against distance to the coast.

7. The total personal residential insured flood losses provided in Forms AF-2, Total Flood Statewide Loss Costs, and AF-3, Personal Residential Standard Flood Losses by ZIP Code, will be reviewed.

   See comments under PVL #67.

8. Form AF-4, Flood Output Ranges, and Form AF-5, Percentage Change in Flood Output Ranges, will be reviewed, including geographical representations of the data where applicable.

   Not applicable as this is the first submission of the Florida Public Flood Loss Model.

9. Justification for all changes in flood loss costs from the currently accepted flood model will be reviewed.

   Not applicable as this is the first submission of the Florida Public Flood Loss Model.

10. Form AF-4, Flood Output Ranges, will be reviewed to ensure appropriate relativities among deductibles, coverages, and construction types.

    See comments under PVLs #68-76.

11. Apparent reversals in the flood output ranges and their justification will be reviewed.

    See comments under PVL #72.

12. Details on the calculation of uncertainty intervals and their justification will be reviewed.

    Reviewed the calculation of uncertainty intervals as described in Disclosure 10. The interval is an approximate 80% confidence interval.

    Reviewed testing of Form AF-8, Part A intervals.

September Additional Verification Review Comments:

Reviewed revised Forms AF-1, AF-4, AF-6, and AF-8 updated with the inclusion of non-tropical flood losses.

Reviewed Form AF-5 created to quantify the change in output ranges between the original and revised submissions.

Reviewed testing of the revised forms.

Discussed that the change in annual aggregate PML was due to using the correct number of events and the inclusion of non-tropical losses.

Reviewed a satellite image of the notional dataset location in Highlands County that had a large non-tropical contribution to the losses in Form AF-6.

COMPUTER/INFORMATION FLOOD STANDARDS – PAUL FISHWICK, LEADER

CIF-1 Flood Model Documentation*

*(*Significant Revision)*

A. Flood model functionality and technical descriptions shall be documented formally in an archival format separate from the use of correspondence including emails, presentation materials, and unformatted text files.

B. A primary document repository shall be maintained, 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.

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.

D. The following shall be maintained: (1) a table of all changes in the flood model from the currently accepted flood model to the initial submission this year, and (2) a table of all substantive changes in the flood model since this year's initial submission.

E. Documentation shall be created separately from the source code.

F. A list of all externally acquired currently used flood model-specific software and data assets shall be maintained. 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.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

79. CIF-1.F, page 261: Provide the list of all externally acquired flood model-specific software and data assets as described and required by Standard CIF-1, Audit item 6.

    Reviewed the list of externally acquired flood-model-specific software and data.

Audit

1. The primary document repository, containing or referencing full documentation of the software in either electronic or physical form, and its maintenance process will be reviewed.

   Discussed that the model functionality and technical descriptions are documented in a primary document repository in archival format.

   Discussed the use of source versioning system (SVN) for maintaining documentation.

2. All documentation should be easily accessible from a central location in order to be reviewed.

   Discussed that all documentation is maintained and can be accessed from a central location.

3. Complete user documentation, including all recent updates, will be reviewed.

   Reviewed the EF5 control file for creating flow direction in the riverine flood model.

   Reviewed the process for determining if pluvial or riverine flooding is used based on the location of the policy relative to the riverine 800m buffer.

4. Modeling organization personnel, or their designated proxies, responsible for each aspect of the software (i.e., user interface, quality assurance, engineering, actuarial, verification) should be present when the Computer/Information Flood Standards are being reviewed. Internal users of the software will be interviewed.

   Model team members and internal users of the flood model software were available in-person or virtually during the review.

5. Verification that documentation is created separately from, and is maintained consistently with, the source code and data will be reviewed.

   Discussed that documentation was created separately from the source code and data.

6. The list of all externally acquired flood model-specific software and data assets will be reviewed.

   Reviewed the list of externally acquired software and datasets.

7. The tables specified in Flood Standard CIF-1.D that contain the items listed in Flood Standard GF-1, Scope of the Flood Model and Its Implementation, Disclosure 8 will be reviewed. The tables should contain the item number in the first column. The remaining five columns should contain specific document or file references for affected components or data relating to the following Computer/Information Flood Standards: CIF-2, Flood Model Requirements, CIF-3, Flood Model Organization and Component Design, CIF-4, Flood Model Implementation, CIF-5, Flood Model Verification, and CIF-7, Flood Model Maintenance and Revision.

   Not applicable as this is the first submission of the Florida Public Flood Loss Model.

8. Tracing of the flood model changes specified in Flood Standard GF-1, Scope of the Flood Model and Its Implementation, Disclosure 8 and Audit 9 through all Computer/Information Flood Standards will be reviewed.

   Not applicable as this is the first submission of the Florida Public Flood Loss Model.

September Additional Verification Review Comments:

The need for improvements in 1) coding guidelines, 2) legacy code, and 3) coordination, communication, and documentation of workflow among the different modeling teams was recognized during the May on-site review. An improvement plan, with a time schedule, on upgrades and changes to the coding guidelines, legacy code, and processes for coordination, communication, and documentation was required and provided. Upon review of the 3 reports provided for the improvement plans, additional changes were necessary to improve clarity and to include specific timelines for completing all 3 improvement items. This requirement could not be resolved during the May on-site review.

Reviewed a Communication and Documentation Improvement Plan of actionable items to foster seamless communication, to ensure standardized and accessible documentation, and to create an environment for effective team collaboration. Reviewed a Gantt chart with timeline for implementation of the actionable items.

Reviewed a Coding Guideline Improvement Plan with a Gantt chart of timeline of action items. The plan outlines how to enhance current coding guidelines to make them universally applicable to all programming languages to be followed by the software development team.

Reviewed a Legacy Code Improvement Plan designed to enhance the existing codebase's quality, maintainability, and functionality. The plan outlines a series of strategic actions to address common issues associated with legacy code such as lack of clarity, potential errors, and outdated practices. Reviewed Gantt chart timeline for legacy code improvement.

Discussed the importance of project management software that integrates modeling organization personnel.

CIF-2 Flood Model Requirements*

*(*Significant Revision)*

A complete set of requirements for each software component, as well as for each database or data file accessed by a component, shall be maintained. Requirements shall be updated whenever changes are made to the flood model.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Audit

1. Maintenance and documentation of a complete set of requirements for each software component, database, and data file accessed by a component will be reviewed.

   Discussed that the requirements for each module, database, and data file are documented using standard software practices. Discussed that other documents are maintained as part of project management requirements, including a quality assurance document, a system hardware and software specification document, a training document, a model maintenance document, a testing document, and a user manual.

September Additional Verification Review Comments:

Verified after verification of other standards.

CIF-3 Flood Model Organization and Component Design*

*(*Significant Revision)*

A. The following shall be maintained and documented: (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, (4) network organization, and (5) system model representations associated with (1)-(4) above. Documentation shall be to the level of components that make significant contributions to the flood model output.

B. All flowcharts (e.g., software, data, and system models) in the submission or in other relevant documentation shall be based on (1) a referenced industry standard (e.g., UML, BPMN, SysML), or (2) a comparable internally-developed standard which is separately documented.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

80. CIF-3.B, page 263: Provide the documents for flowcharting standards.

    Reviewed the flowchart standards ISO 5807, BMPN 2, and UML 2 followed for creating flowcharts and diagrams.

Audit

1. The following will be reviewed:
    a. Detailed control and data flowcharts, completely and sufficiently labeled for each component,
    b. Interface specifications for all components in the flood model,
    c. Documentation for schemas for all data files, along with field type definitions,
    d. Each network flowchart including components, sub-component flowcharts, arcs, and labels,
    e. Flowcharts illustrating flood model-related information flow among modeling organization personnel or consultants (e.g., BPMN, UML, SysML, or equivalent technique including a modeling organization internal standard), and
    f. If the flood model is implemented on more than one platform, the detailed control and data flowcharts, component interface specifications, schema documentation for all data files, and detailed network flowcharts for each platform.

Reviewed the revised flowchart for applying demand surge factors that was corrected during the on-site review.

Discussed the Neural Net Model and USGS Data architecture.

Reviewed flowchart for execution of the CEST storm surge model.

Reviewed the process for calculating the mean FFE for coastal and inland elevated or non-elevated structures.

Reviewed the revised flowchart of the coastal surge model that was revised during the on-site review to show how characteristics for surge and wave results are used to estimate flood damage.

Reviewed dependency graph for capturing and visualizing a software trail.

Reviewed flowchart for developing the coastal flood and inland flood vulnerability functions for different personal residential building structural types.

Discussed that the FPFLM is implemented in a single platform.

Reviewed a UML state diagram for testing processes.

Reviewed the flowchart for form completion processes.

2. A flood model component custodian, or designated proxy, should be available for the review of each component.

   Discussed that the flood model component custodian is documented in the primary repository documents. Modeling team members were available throughout the review.

3. The flowchart reference guide or industry standard reference will be reviewed.

   Discussed that flowcharts are created according to ISO 5807, BPMN 2, and UML 2 standards.

September Additional Verification Review Comments:

During the May on-site review clarification on the process for modeling waves in the Florida Keys in the Figure 40 flowchart could not be resolved during that audit.

Reviewed an updated Figure 41 (previous Figure 40) flowchart illustrating the CEST storm surge model and the damage ratio computation model, revised during the additional verification review to conform to ISO 5807 standards.

Reviewed the corrections made during the additional verification review to the flowcharts in Figures 79, 80, 84, 89, and 90 to conform to ISO 5807 standards.

CIF-4 Flood Model Implementation*

(Significant Revision)

A. A complete procedure of coding guidelines consistent with current software engineering practices shall be maintained.

B. Network organization documentation shall be maintained.

C. A complete procedure used in creating, deriving, or procuring and verifying databases or data files accessed by components shall be maintained.

D. All components shall be traceable, through explicit component identification in the flood model representations (e.g., flowcharts) down to the code level.

E. A table of all software components affecting flood loss costs and flood probable maximum loss levels shall be maintained 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.

F. 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.

G. The following documentation shall be maintained for all components or data modified by items identified in Flood Standard GF-1, Scope of the Flood Model and Its Implementation, Disclosure 8 and Audit 9:

1. A list of all equations and formulas used in documentation of the flood model with definitions of all terms and variables.

2. A cross-referenced list of implementation source code terms and variable names corresponding to items within G.1 above.

H. Flood model code and data shall be accompanied by documented maintenance, testing, and update plans with their schedules. The vintage of the code and data shall be justified.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

81. CIF-4.H, page 265: Provide the information as noted.

Reviewed the flood model code and data maintenance, update, and testing plan, including legacy code and data.

Audit

1. Sample code and data implementations will be selected and reviewed, for at least the meteorology, hydrology and hydraulics, vulnerability, and actuarial components.

   Reviewed code revised during the on-site review for implementation of ICC optional coverage capped at the policy limit.

   Reviewed code for computing the wind stress drag coefficient.

   Reviewed code for applying flow direction in the riverine flood model.

   Reviewed code for the STWAVE model verifying that the model starts to run when surge is ≥ 0.75m in a subgrid.

   Reviewed code for selecting vulnerability functions for a given inundation depth and wave height.

   Reviewed selected code from the PLUVD2 model.

   Reviewed script for completing Form AF-2.

   Reviewed code for determining pluvial versus riverine flooding for each policy location.

2. The documented coding guidelines, including procedures for ensuring readable identifiers for variables, constants, and components, and confirmation that these guidelines are uniformly implemented will be reviewed.

   Reviewed the coding guidelines. Discussed the need for more robust coding guidelines and improvements needed in coordination, communication, and documentation among the different modeling teams.

   Reviewed an improvement plan with an established timeframe for implementation that was created during the on-site review.

3. The procedure used in creating, deriving, or procuring and verifying databases or data files accessed by components will be reviewed.

   Reviewed the procedure related to creating and verifying datasets.

4. The traceability among components at all levels of representation will be reviewed.

   Reviewed the process used to ensure traceability among model components.

5. The following information will be reviewed for each component, either in a header comment block, source control database, or the documentation:
   a. Component name,
   b. Date created,
   c. Dates modified, modification rationale, and by whom,
   d. Purpose or function of the component, and
   e. Input and output parameter definitions.

   Discussed that all source code is under source control and revision software.

6. The table of all software components as specified in Flood Standard CIF-4.E will be reviewed.

   Reviewed the table of software components.

7. Flood model components and the method of mapping to elements in the computer program will be reviewed.

   Reviewed the equation mapping table for calculation of surface wind stresses in the coastal flood model.

8. Comments within components will be reviewed for sufficiency, consistency, and explanatory quality.

   Reviewed code comments throughout the audit. Discussed the need for improving comments in legacy code.

9. Unique aspects within various platforms with regard to the use of hardware, operating system, and essential software will be reviewed.

   Discussed the hardware and operating system requirements for the flood model.

10. Network organization implementation will be reviewed.

    Reviewed the network organization diagram in Figure 1.

11. Code and data maintenance plans, testing plans, update plans, and schedules will be reviewed. Justification for the vintage of code and data will be reviewed.

    Reviewed the flood model code and data maintenance plan, the update plan, and the testing plan, including legacy code and data.

    Discussed with the Modeler the need to improve coordination between researchers and the computer science team consistent with Standard GF-1.B and C, including variable naming and sufficient commenting.

September Additional Verification Review Comments:

The need for improvements in 1) coding guidelines, 2) legacy code, and 3) coordination, communication, and documentation of workflow among the different modeling teams was recognized during the May on-site review. An improvement plan, with a time schedule, on upgrades and changes to the coding guidelines, legacy code, and processes for coordination, communication, and documentation was required and provided. Upon review of the 3 reports provided for the improvement plans, additional changes were required to improve clarity and to include specific timelines for completing all 3 improvement items. This requirement could not be resolved during the May on-site review.

Reviewed a Communication and Documentation Improvement Plan of actionable items to foster seamless communication, to ensure standardized and accessible documentation, and to create an environment for effective team collaboration. Reviewed a Gantt chart with timeline for implementation of the actionable items.

Reviewed a Coding Guideline Improvement Plan with a Gantt chart of timeline of action items. The plan outlines how to enhance current coding guidelines to make them universally applicable to all programming languages to be followed by the software development team.

Reviewed a Legacy Code Improvement Plan designed to enhance the existing codebase's quality, maintainability, and functionality. The plan outlines a series of strategic actions to address common issues associated with legacy code such as lack of clarity, potential errors, and outdated practices. Reviewed Gantt chart timeline for legacy code improvement.

Reviewed the script for generating Form AF-8.

CIF-5 Flood Model Verification*

(Significant Revision)

A. General

For each component, procedures shall be maintained 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.

B. Component Testing

1. ***Testing software shall be used to assist in documenting and analyzing all components.***
2. ***Unit tests shall be performed and documented for each updated component.***
3. ***Regression tests shall be performed and documented on incremental builds.***
4. ***Integration 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.***

C. Data Testing

1. ***Testing software shall be used to assist in documenting and analyzing all databases and data files accessed by components.***
2. ***Integrity, consistency, and correctness checks shall be performed and documented on all databases and data files accessed by the components.***

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Audit

1. Procedures for unit conversion verification will be reviewed.

   Reviewed procedures for unit conversion.

2. The components will be reviewed for containment of sufficient logical assertions, exception-handling mechanisms, and flag-triggered output statements to test the correct values for key variables that might be subject to modification.

   Software was reviewed for sufficient logical assertions and flag-triggered statements.

3. The testing software used by the modeling organization will be reviewed.

   Testing software was reviewed for different types of testing, including unit testing and regression testing.

4. The component (unit, regression, integration) and data test processes and documentation will be reviewed including compliance with independence of the verification procedures.

   Reviewed the Insurance Loss Model test reports.

   Reviewed the wave model test reports.

5. Fully time-stamped, documented cross-checking procedures and results for verifying equations, including tester identification, will be reviewed. Examples include mathematical calculations versus source code implementation, or the use of multiple implementations using different languages.

   Examples of testing and verification were reviewed.

6. Flowcharts defining the processes used for manual and automatic verification will be reviewed.

   Reviewed flowchart of testing processes.

7. Verification approaches used for externally acquired data, software, and models will be reviewed.

   Discussed the process for ensuring external software packages are working as expected.

   Discussed the process the modeling team uses to perform internal verifications to verify the accuracy and timeliness of datasets.

September Additional Verification Review Comments:

Discussed the error detected in Forms SF-2 and AF-8 which was discovered while checking the calculation of PML levels.

Discussed that the loss computation distributes the entire stochastic set events onto multiple servers and then the losses are combined for further post-processing. Due to a rare server glitch the event losses were not fully combined.

Reviewed the revised function with a validation step added to check the number of storms in the combined results against the hazard input. Reviewed the test case reports for the revised function.

Reviewed the subversion (SVN) log of the software revisions.

CIF-6 Human-Computer Interaction*
*(*New Flood Standard)*

A. Interfaces shall be implemented as consistent with accepted principles and practices of Human-Computer Interaction (HCI), Interaction Design, and User Experience (UX) engineering.

B. Interface options used in the flood model shall be unique, explicit, and distinctly emphasized.

C. For a Florida rate filing, interface options shall be limited to those options found acceptable by the Commission.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

82. CIF-6.C, page 270: Provide and explain the analysis options related to Florida rate filings.

Reviewed the analysis options related to Florida rate filings.

Discussed the process used for selecting the corresponding folder in the rate filing configuration file directory for data processing. Reviewed the available interface options.

Reviewed the code for running the model for a Florida rate filing.

Audit

1. External and internal user interfaces will be reviewed.

   Reviewed the configuration interface with pre-defined parameters.

2. Documentation related to HCI, Interaction Design, and UX engineering will be reviewed.

   Reviewed the flood model setup guide.

3. The decision process specifying the logic of interface option selections, when an acceptable flood model is selected, will be reviewed.

   Reviewed the decision process documentation specifying the logic of interface option selections.

CIF-7 Flood Model Maintenance and Revision*

*(*Significant Revision)*

A. A clearly written policy shall be implemented for review, maintenance, and revision of the flood model and network organization, including verification and validation of revised components, databases, and data files.

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.

C. Tracking software shall be used to identify and describe all errors, as well as modifications to code, data, and documentation.

D. A list of all flood model versions since the initial submission for this year shall be maintained. Each flood model description shall have an unique version identification and a list of additions, deletions, and changes that define that version.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. All policies and procedures used to review and maintain the code, data, and documentation will be reviewed. For each component in the system decomposition, the installation date under configuration control, the current version identification, and the date of the most recent change(s) will be reviewed.

   Reviewed the procedures for reviewing and maintaining code and data.

2. The policy for flood model revision and management will be reviewed.

   Reviewed the flood model revision and management plan.

3. Portions of the code will be reviewed.

   Reviewed in SVN the ICC optional coverage code before and after the code revision to cap the losses at the policy limit.

   See additional comments under CIF-4 Audit 1.

4. The tracking software will be reviewed and checked for the ability to track date and time.

   Discussed that SVN is used to identify and describe all errors and modifications to code, data, and documentation.

5. The list of all flood model revisions as specified in Flood Standard CIF-7.D will be reviewed.

   Reviewed the list of all flood model revisions since the initial submission.

CIF-8 Flood Model Security*

*(*Significant Revision)*

Security procedures shall be implemented and fully documented 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.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. The written policy for all security procedures and methods used to ensure the security of code, data, and documentation will be reviewed.

   Reviewed the procedures for security of code, data, and documentation.

   Discussed the use of different authorization levels, special network security enforcement, and regular backups.

2. Documented security procedures for access, client flood model use, anti-virus software installation, and off-site procedures in the event of a catastrophe will be reviewed.

   Reviewed the security procedures for flood model access and off-site procedures in the event of a catastrophe.

3. Security aspects of each platform will be reviewed.

   Discussed that the FPFLM runs on only one platform.

4. Network security documentation and network integrity assurance procedures will be reviewed.

   Reviewed network security documentation and procedures for network integrity assurance.

   Discussed that there have been no known security breaches of the flood model implementation.