**Statistical FLOOD StandarDS**

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

1. ***The use of historical data in developing the flood model shall be supported by rigorous methods published in current scientific and technical literature.***
2. ***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.***

 Purpose: Many aspects of flood model development and implementation involve fitting a probability distribution to historical data for use in generating stochastic floods. Such fitted models must be checked to ensure that the distributions are reasonable. The chi-square goodness-of-fit test may not be sufficiently rigorous for demonstrating the reasonableness of models of historical data.

 Relevant Forms: GF-4, Statistical Flood Standards Expert Certification

 HHF-1, Historical Event Flood Extent and Elevation or Depth

 Validation Maps

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

 SF-2, Examples of Flood Loss Exceedance Estimates (Coastal and

 Inland Combined)

**Disclosures**

1. Provide a completed Form SF-1, Distributions of Stochastic Flood Parameters (Coastal, Inland). Identify the form of the probability distributions used for each function or variable, if applicable. Identify statistical techniques used for estimation and the specific goodness-of-fit evaluations applied along with appropriate metrics. Describe whether the fitted distributions provide a reasonable agreement with available historical data. Provide a link to the location of the form [insert hyperlink here].
2. Provide the date of loss of the insurance claims data used for validation and verification of the flood model.
3. Provide an assessment of uncertainty in flood probable maximum loss levels and in flood loss costs for output ranges using confidence intervals or other scientific characterizations of uncertainty.
4. Justify any differences between the historical and modeled results using current scientific and statistical methods in the appropriate disciplines.
5. Provide graphical comparisons of modeled and historical data and goodness-of-fit evaluations. Examples to include are flood frequencies, flow, elevations or depths, and available damage.
6. Provide a completed Form SF-2, Examples of Flood Loss Exceedance Estimates (Coastal and Inland Combined). Provide a link to the location of the form [insert hyperlink here].

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

**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.***

Purpose: Sensitivity analysis involves the quantification of the magnitude and direction of the output (e.g., flood extent and depth, flood loss cost) as a function of the input variables in the flood model and provides critical insight into the behavior of the flood model.

Relevant Form: GF-4, Statistical Flood Standards Expert Certification

**Disclosures**

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

1. Identify other input variables that impact the magnitude of the output when the input variables are varied simultaneously. Describe the degree to which these sensitivities affect output results and illustrate with an example.
2. Describe how other aspects of the flood model may have a significant impact on the sensitivities in output results and the basis for making this determination.
3. Describe and justify action or inaction as a result of the sensitivity analyses performed.

**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.

**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.***

Purpose: Uncertainty analysis involves the quantification of the variability of the output (e.g., flood extent and depth, flood loss cost) as a function of the input variables in the flood model and provides critical insight into the behavior of the flood model.

Relevant Form: GF-4, Statistical Flood Standards Expert Certification

**Disclosures**

1. Identify the major contributors to the uncertainty in flood model outputs and the basis for making this determination. Provide a full discussion of the degree to which these uncertainties affect output results and illustrate with an example.
2. Describe how other aspects of the flood model may have a significant impact on the uncertainties in output results and the basis for making this determination.
3. Describe and justify action or inaction as a result of the uncertainty analyses performed.

**Audit**

1. The modeling organization’s 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.

**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.***

Purpose: The intent of this standard is to ensure that sufficient runs of the simulation have been made or a suitable sampling design invoked so that the contribution to the error of the flood loss cost estimates due to its probabilistic nature is negligible considering the computational effort involved. To be negligible, the standard error of flood loss cost estimator within each identified geographic zone should be less than 5% of the flood loss cost estimate unless otherwise justified.

Relevant Form: GF-4, Statistical Flood Standards Expert Certification

**Disclosures**

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

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

**Audit**

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

**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.***

Purpose: This standard applies to the combined effects of flood hazard, vulnerability functions, and loss estimation. Given a past flood event and a book of insured properties at the time of the flood event, the flood model is required to be able to provide expected flood losses.

 Relevant Forms: GF-4, Statistical Flood Standards Expert Certification

**Disclosure**

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

**Audit**

1. The following information for each flood event will be reviewed:
2. 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,
3. The version of the flood model used to calculate modeled flood losses for each flood event provided,
4. A general description of the data and its sources,
5. A disclosure of any material mismatch of exposure and flood loss data problems, or other material consideration,
6. The date of the exposures used for modeling and the date of the flood event,
7. An explanation of differences in the actual and modeled flood parameters,
8. A listing of the differences between the modeled and observed flood conditions used in validating a particular flood event,
9. 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,
10. The treatment of demand surge or loss adjustment expenses in the actual flood losses or the modeled flood losses, and
11. The treatment of wind losses in the actual flood losses or the modeled flood losses.
	1. The following documentation will be reviewed:
12. Publicly available documentation and data referenced in the flood model submission in hard copy or electronic form,
13. Modeling-organization-specific documentation and data used in validation of flood losses,
14. An analysis that identifies and explains anomalies observed in the validation data, and
15. User input data for each insurer and flood event detailing specific assumptions made with regard to exposed personal residential property.
16. The confidence intervals used to gauge the comparison between historical and modeled flood losses will be reviewed.
17. The results for more than one flood event will be reviewed to the extent data are available.

**Form SF-1: Distributions of Stochastic Flood Parameters**

**(Coastal, Inland)**

Purpose: This form identifies the probability distributions used in the coastal and inland flooding model and provides their justification.

Provide the probability distribution functional form used for each stochastic flood parameter in the flood model (one each for coastal and inland flooding). Provide a summary of the justification for each functional form selected for each general classification. Specify the relevant classification (coastal or inland) for each distribution.

Include Form SF-1, Distributions of Stochastic Flood Parameters (Coastal, Inland), in a submission appendix.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Justification for Functional Form** |  |  |  |  |  |  |  |  |  |
| **Year Range Used** |  |  |  |  |  |  |  |  |  |
| **Data Source** |  |  |  |  |  |  |  |  |  |
| **Functional Form of Distribution** |  |  |  |  |  |  |  |  |  |
| **Classification:****Coastal or Inland** |  |  |  |  |  |  |  |  |  |
| **Stochastic Flood Parameter:** **Function or Variable** |  |  |  |  |  |  |  |  |  |

**Form SF-2: Examples of Flood Loss Exceedance Estimates**

**(Coastal and Inland Combined)**

Purpose: This form provides the modeling organization’s flood loss exceedance estimates for coastal and inland losses combined.

Provide estimates of the annual aggregate personal residential insured flood losses for various probability levels using a modeling-organization-specified, predetermined, and comprehensive exposure dataset justified by the modeling organization. Provide the total average annual flood loss for the loss exceedance distribution. If the modeling methodology does not allow the flood model to produce a viable answer for certain return periods, state so and why.

Include Form SF-2, Examples of Flood Loss Exceedance Estimates (Coastal and Inland Combined), in a submission appendix.

 **Part A**

|  |  |  |
| --- | --- | --- |
| **Return****Period (years)** | **Annual****Probability of Exceedance** | **Estimated Flood Loss****Modeling Organization Exposure Dataset** |
| Top Event |  N/A  |   |
| 10,000 | 0.0001 |   |
| 5,000 | 0.0002 |   |
| 2,000 | 0.0005 |   |
| 1,000 | 0.0010 |   |
| 500 | 0.0020 |   |
| 250 | 0.0040 |   |
| 100 | 0.0100 |   |
| 50 | 0.0200 |   |
| 20 | 0.0500 |   |
| 10 | 0.1000 |   |
| 5 | 0.2000 |   |

 **Part B**

|  |  |
| --- | --- |
| Mean (Total AverageAnnual Flood Loss) |   |
| Median |   |
| Standard Deviation |   |
| Interquartile Range |   |
| Sample Size |   |