U.S. Flood Model

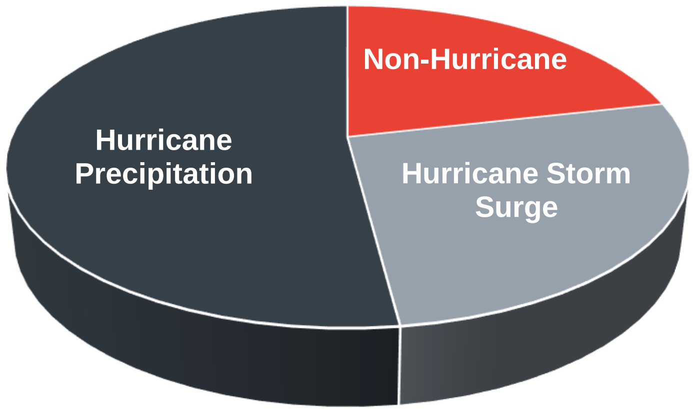
CAS RPM: U.S. Flood Insurance

David F. Smith

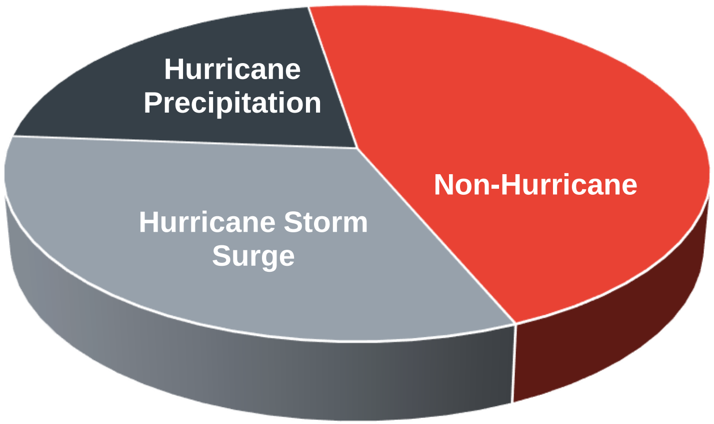
March 20, 2018

Flood Type Contributions to Nationwide NFIP Risk

100-year TVaR



AAL



- What metric you manage your book against matters

Storm Surge Model

Surge Height

- Storm tide
- Wind driven waves
- Astronomical tide level, independent of the storm

Width of High Velocity Zone

- Storm Intensity

Inundation Depth

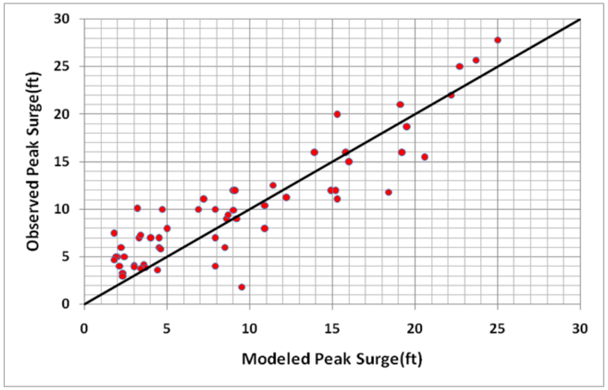
- Site Elevation
- Distance to Coast
- Inundation and depths calculated on 10m DEMs

Incorporates bathymetry and full time history of each hurricane (critical for events like Katrina)

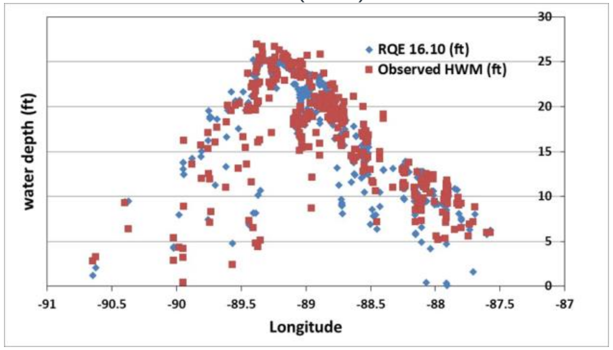
Uses 10m Digital Elevation Model for better risk differentiation

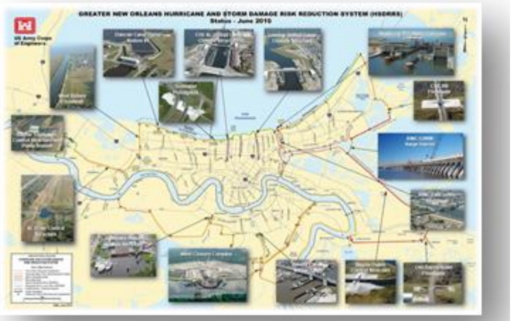
Considers the potential benefit from coastal flood protection systems, especially in New Orleans and Galveston

Camille (1969), Katrina (2005), Gustav (2008), and Ike (2008)



Katrina (2005)

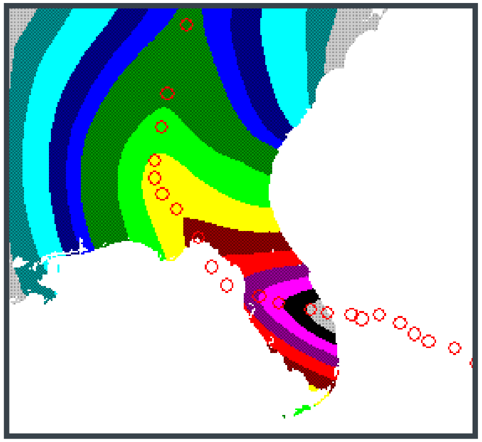


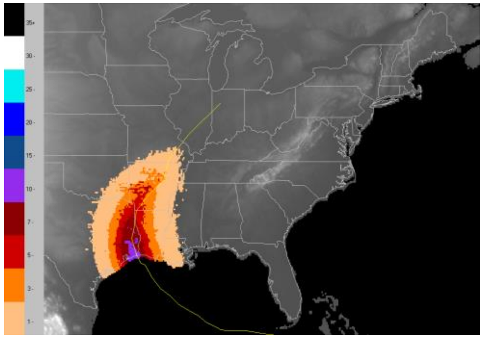


The early days of hurricane rainfall-induced flood modeling

(Pre-2016)

- Develop footprint model for total rainfall given a hurricane
  - Translational speed
  - Distance from storm track
  - Historical association of local station with hurricane rainfall
- Develop relationships between total rainfall and relative damage rate
  - Historical loss data
  - Numerically model flood propagation for representative subset of storms given rainfall input, topography, land use, etc.
  - Flood vulnerability functions
- Result: event by event load factors for additional contribution to loss from inland flooding

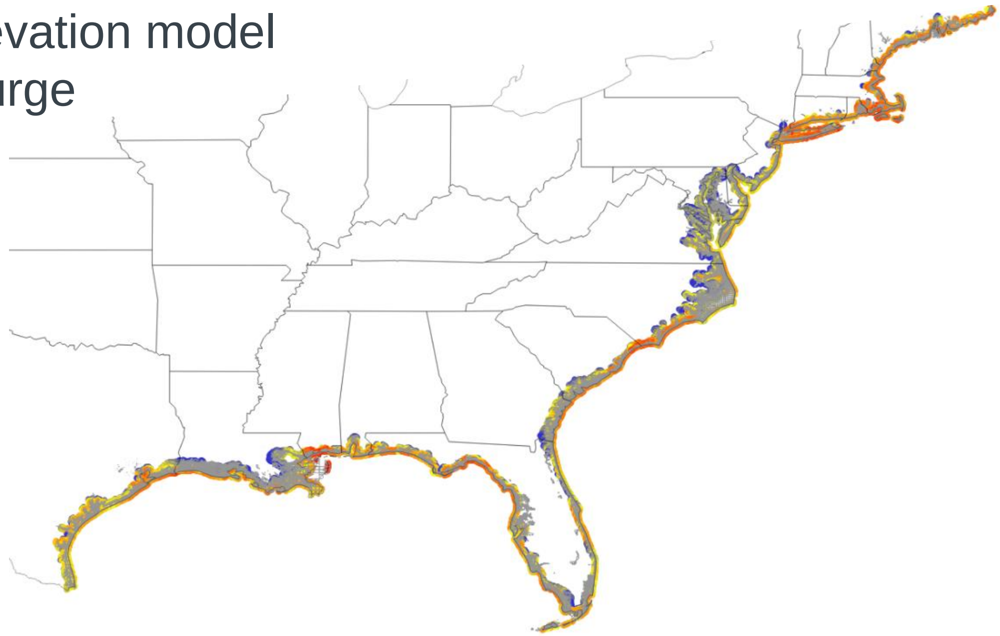




Storm surge and inland flooding: hurricanes produce both!

For proper OEP, a single hurricane event set must do it all

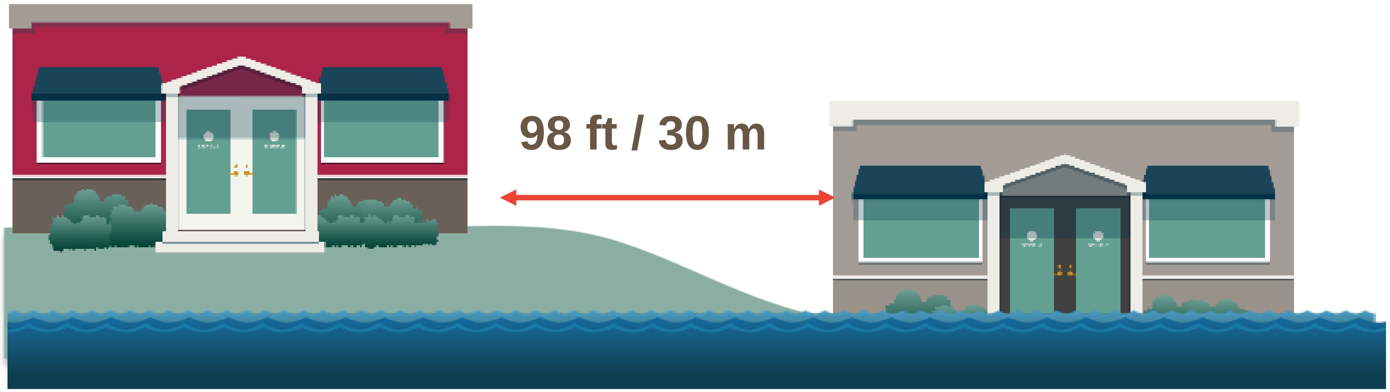
- Same hurricane event set used in both models
- Combine flooding results without double-counting
  - Storm surge flooding - North Atlantic Hurricane Model
  - Precipitation driven flooding - U.S. Inland Flood Model
- Application of 10-meter digital elevation model for both inland flood and storm surge
- Unified vulnerability model



Focus on granularity

High resolution modeling suitable for both single site and portfolio analyses

Increased Granularity = Accuracy and confidence in results



- **10m or finer resolution** digital elevation models
- High resolution hazard (**down to 0.3m**)
- **6 million** miles of river networks
- **500m** resolution precipitation climatology layer
- **300,000** simulations – critical for excess flood policies
- **2-D** vulnerability modeling (depth and velocity)

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Geocoding: close enough isn't good enough!

New standard in structure- and parcel-level geocoding

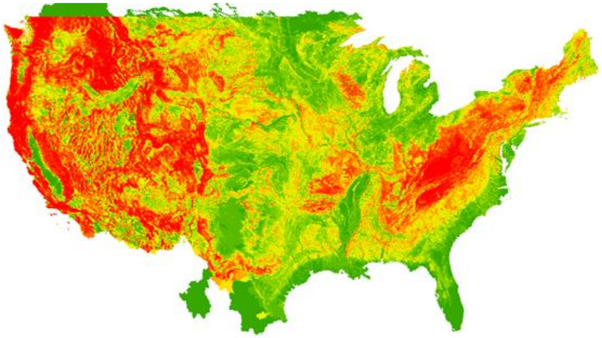
- PxPoint
  - Structure- and parcel-level geocoding engine
  - Precise address standardization for a variety of industries
  - Selected and is used by FEMA and many other government agencies
  - Drives CoreLogic's industry-leading Flood and Spatial business
- Largest parcel database:
  - Over 144 million parcels and growing
  - 98% of population
- Structure footprint database:
  - 44.7 million footprints and growing
  - 32% of population
- Directly integrated into RQE, or stand-alone via Web Services or on site

Hydrology: Climatological & Statistical Models

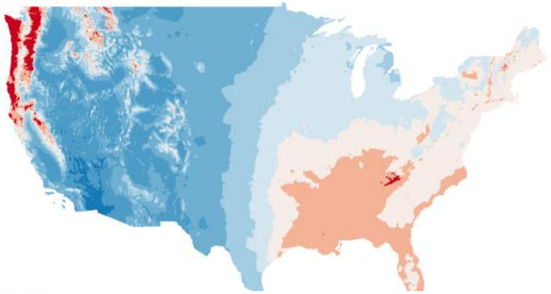
Reducing uncertainty introduced by precipitation based event modeling

- Watershed and climatic characteristics driving the hydrology
- Over 50 different data layers:
  - **Hydrological**: accumulation, basin shape, hydrological regions
  - **Topographic**: slope
  - **Meteorological**: rainfall
  - **Land Use**: percentage of forestry in catchment; urban vs. rural catchments
  - **Geological**: soil characteristics and rock types
- 6 M miles of river network data with over 300 M flood elevation features
- Accurate correlation of flooding between HUC-12 regions

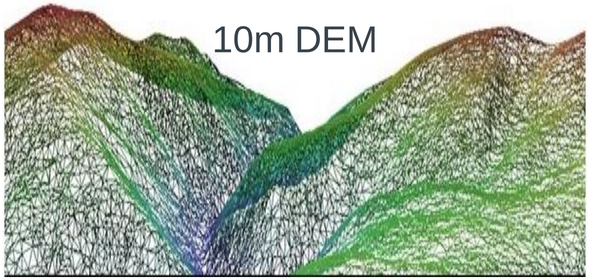
Catchment Slope



Average Annual Precipitation

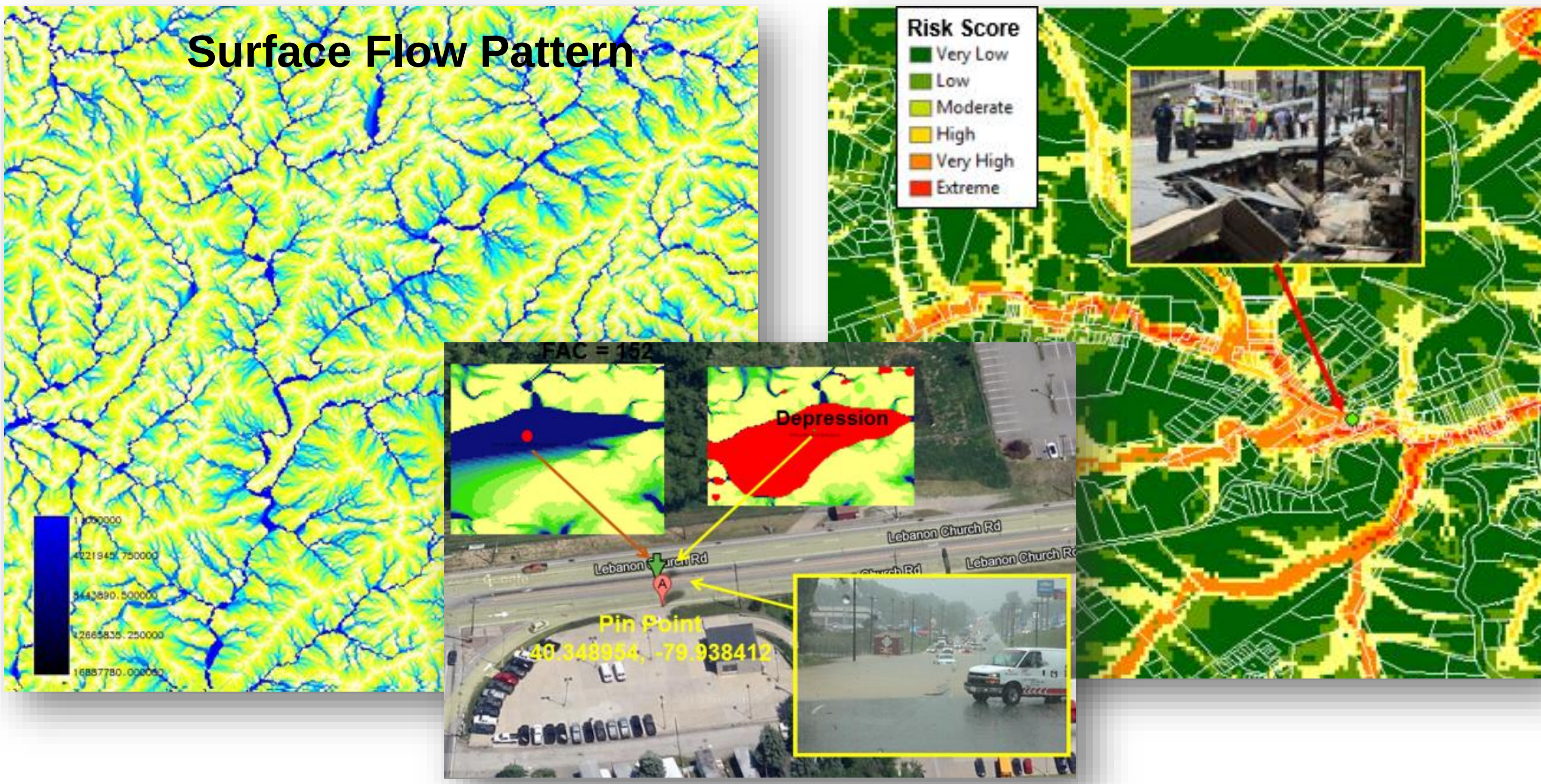


10m DEM



Flash Flood

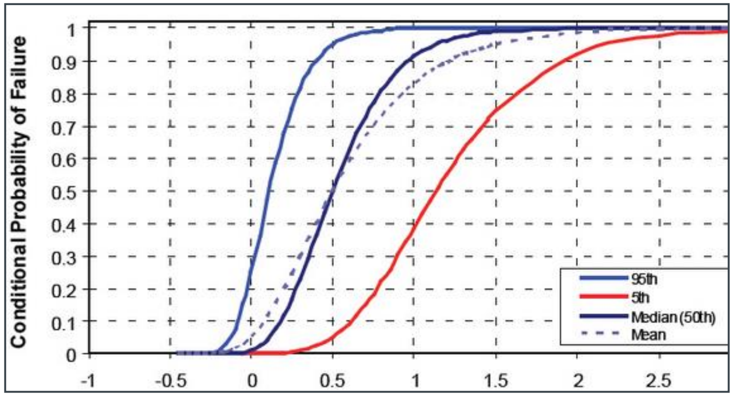
- Estimate flash flood losses based on flash flood risk classifications
- The model considers surface flow pattern in watersheds, rainfall, soil infiltration, vegetation interception, land imperviousness, drought condition, land slopes, land depression, flash flood observation and statistics



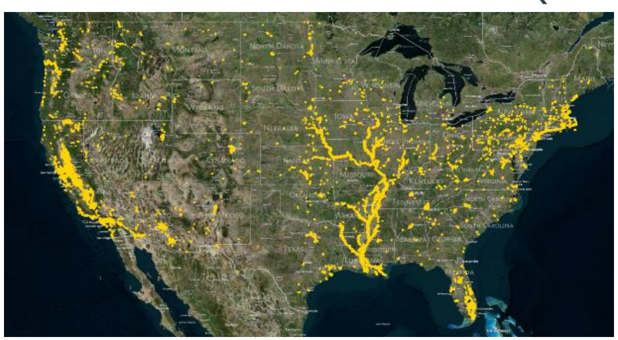
CoreLogic

Flood Defense Systems

Accurate capture of flood defenses and probability of breach or full failure

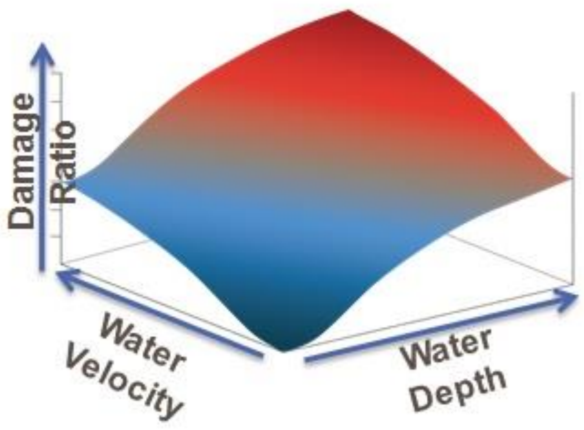


- National Levee Database (NLD) used to characterize flood defense systems



  - Custom Defense System
  - 10m DEM allows for capture of topographic features

Flood Vulnerability



- Foundation Type
- Basement Finished
- Waterproofing
- Wall-to-floor/foundation Anchorage
- Enclosure Type
- Flooring Type
- Wall Siding Type
- Exterior Wall Condition
- Exterior Door Type
- Utilities and Equipment Raised

Building

- Contents Vulnerability Above Ground
- Contents Vulnerability Below Ground
- Contents Waterproof
- Contents Perishable
- Contents Percent Raised

Contents

Structure Type

Occupancy

Number of Stories

Presence of Basement

Presence of Split Level

Year Built

First Floor Elevation (1st FE)

Secondary Structural Modifiers

Accurate Capture of Building Characteristics

Pre-FIRM (Flood Insurance Rate Map)

OCCUPANCY CLASS: Commercial

YEAR BUILT: 1965
(FIRM Year = 1971)

EXTERIOR WALL CONDITION: Poor

WALL TO FLOOR ANCHORAGE: No

UTILITIES EQUIPMENT RAISED: No

WATERPROOFING: Unknown

WALL TYPE: Common Brick

ENCLOSURE TYPE: Solid

FLOORING TYPE: Carpet

ENTRY WAY DOOR OPENINGS: Wood, Solid

FOUNDATION TYPE: Strip Foundation

Accurate Capture of Building Characteristics

Post-FIRM

YEAR BUILT: 2007
(FIRM Year = 1971)

OCCUPANCY CLASS: Commercial

EXTERIOR WALL CONDITION: Very Good

WALL TO FLOOR ANCHORAGE: Yes

UTILITIES EQUIPMENT RAISED: Yes

WATERPROOFING: Yes

WALL TYPE: Concrete Block

ENCLOSURE TYPE: Open, Breakaway Walls

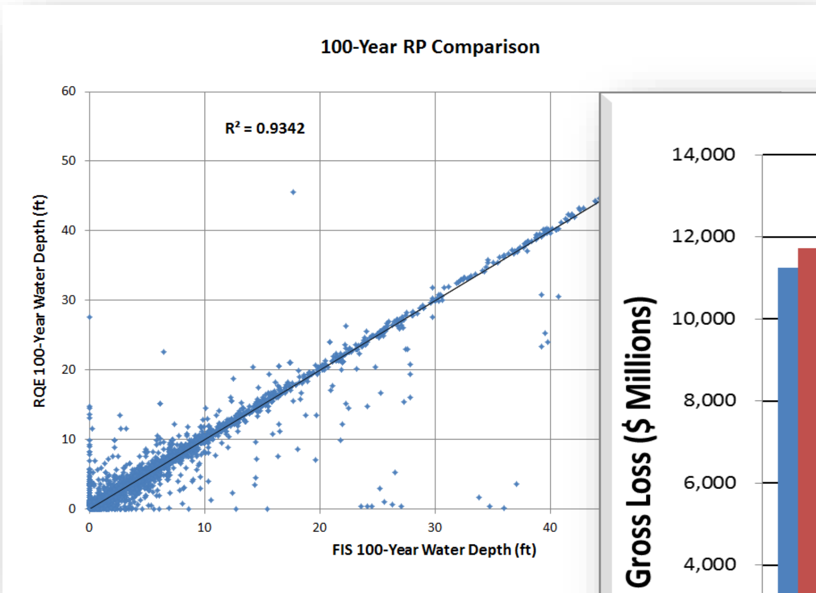
FLOORING TYPE: Concrete Tile / Stone

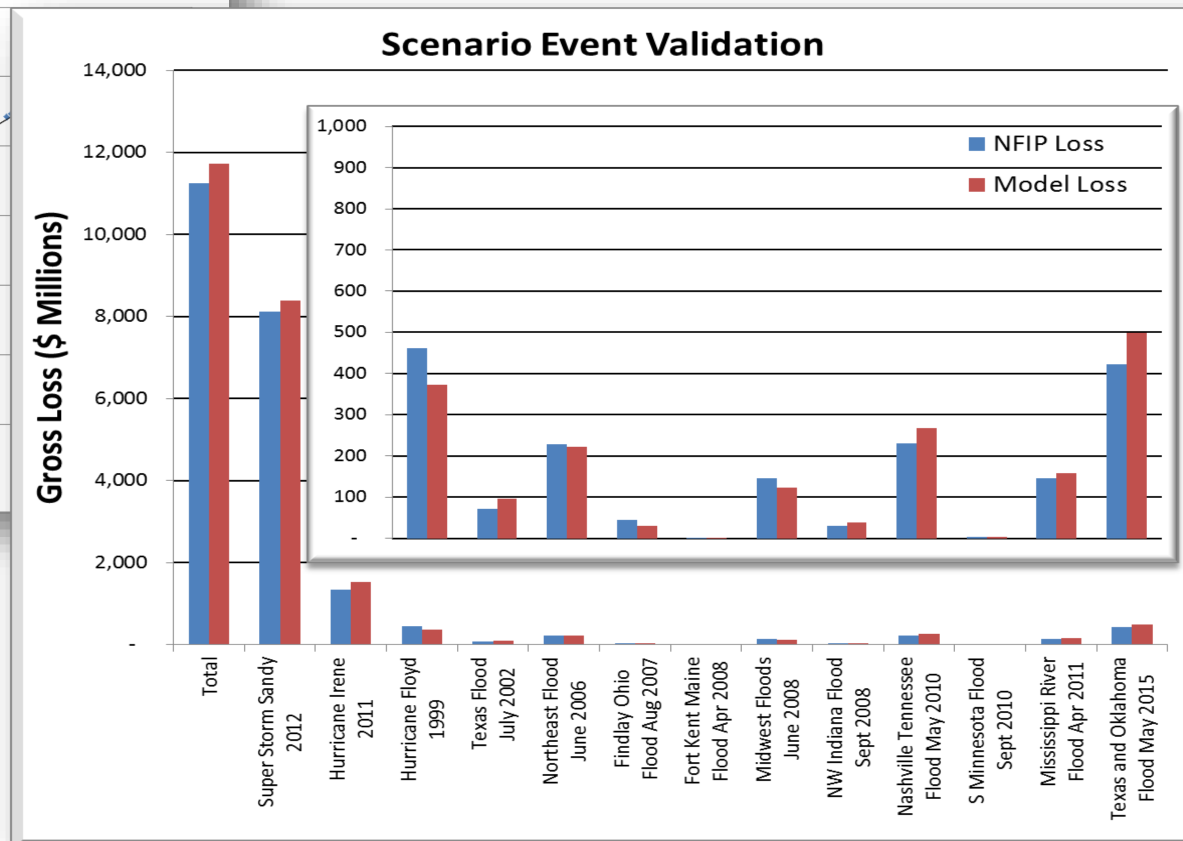
ENTRY WAY DOOR OPENINGS: Wood, Solid

FOUNDATION TYPE: Pile

Flood Model Validation

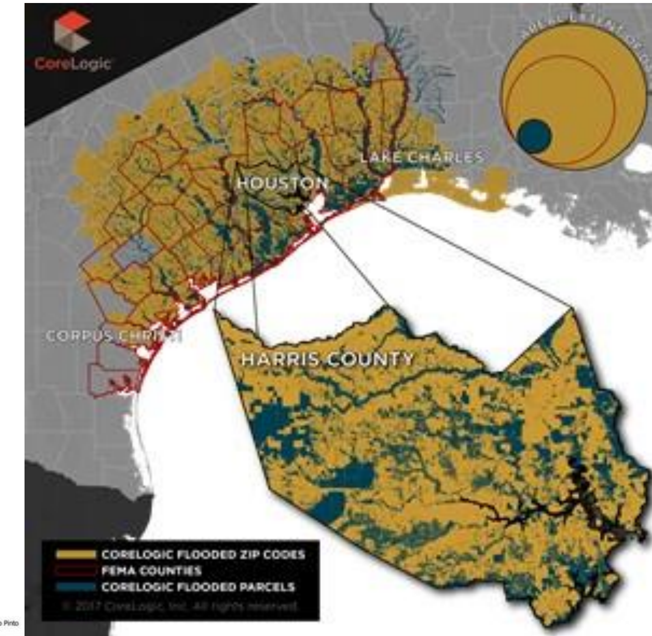
Model was validated by using hydraulic data from detailed FEMA Flood Insurance Studies (FIS) and with claims data

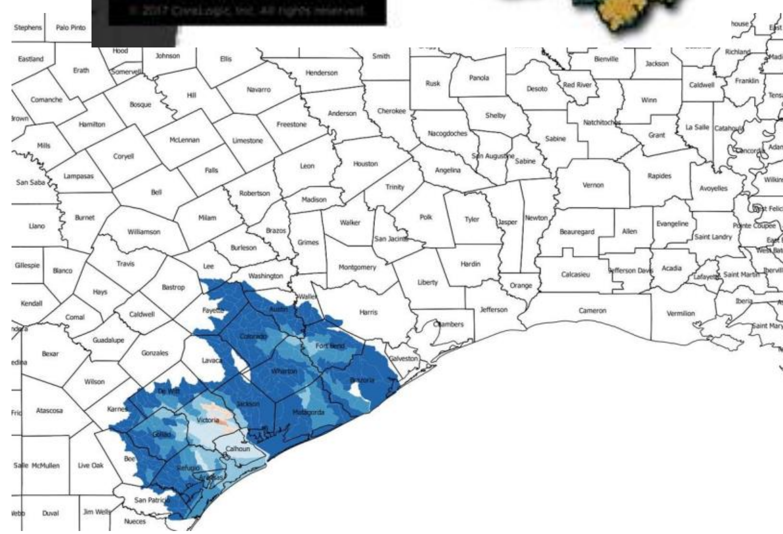




Harvey Loss Estimates

- CoreLogic (Aug. 31, 2017) estimates insured and uninsured flood losses for Hurricane Harvey:
  - NFIP = $6 - $9 Billion
  - Uninsured: $18 – $27 Billion
  - Private (after Aug. 31): $12 - $20 Billion
- Approximately 70% of flood damage is uninsured
- More than 50% of properties in Houston at high and moderate risk of flood are not in designated flood zones
- Return period of flood loss of this severity in Texas is ~250 years





Summary of model highlights

High resolution modeling suitable for accurate risk differentiation	• 10m DEM data with ability to model with 3m DEM data • CoreLogic developed high resolution hazard data • 300,000-year simulation-based modeling framework
Uniquely innovative combination of CoreLogic data and model methodology that delivers relevant results	• PxPoint™ parcel-based and structure geocoding • CoreLogic property characteristics used in model validation and smart default assignment
Vulnerability model that incorporates both water depth and water velocity damage	• Detailed hydrodynamic vulnerability functions
Easy differentiation and combination of sources of flood hazard and loss	• No double counting of hurricane storm surge and precipitation flooding • Easy to combine inland flooding with storm surge flooding
Accurate capture and modeling of site characteristics and flood policy terms	• Confirmation that historic event footprint losses align with EP curve • Validation against research data and available claims • Policy term capture from the coverage level through to the portfolio level