NRC Probabilistic Flood Hazard Assessment Research Program Update

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7th Annual PFHA Research Workshop
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February 15 – 18, 2022

Outline

- Objectives, key challenges, approach
- Phase 1 Overview (Technical Basis)
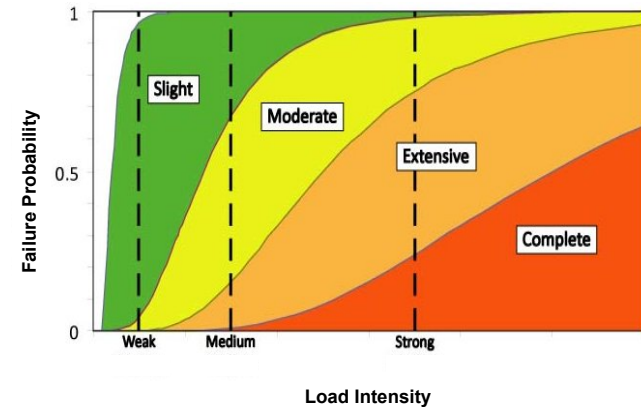- Phase 2 Projects (Pilot Studies)
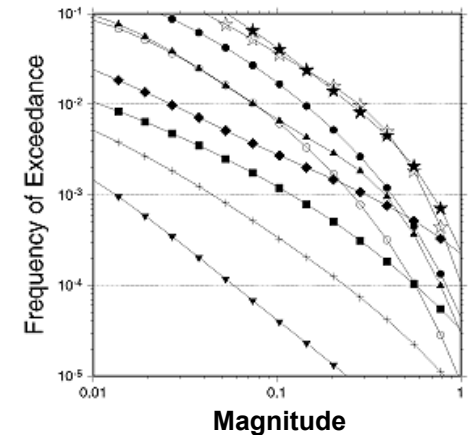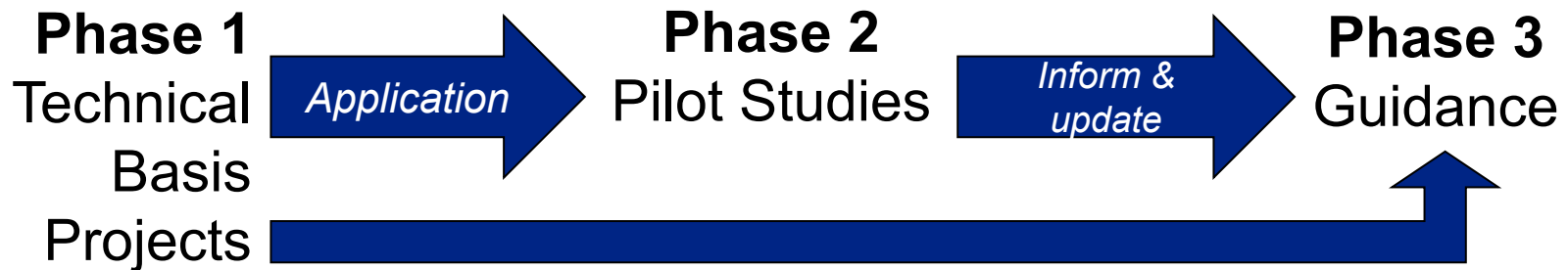- Thoughts on Phase 3 (Guidance)

- Develop resources, tools and selected guidance to:
  - Address significant gap in the technical basis for guidance for probabilistic assessment of external hazards
    - Probabilistic: seismic, high winds
    - Deterministic: flooding
  - Support risk-informed licensing and oversight activities involving assessment of flooding hazards and potential consequences
    - Licensing and oversight in operating reactor program
    - Design basis flood hazard assessments for new facilities
      - Readiness for licensing of advanced reactors

Key Challenges

- ## Hazard Estimation
  - ### Range of annual exceedance probabilities (AEPs)
    - Moderately rare to extreme floods
  - ### Multiple flooding mechanisms
    - Coincident and correlated mechanisms
  - ### Uncertainty characterization and estimation
    - Aleatory (e.g., storm recurrence rates)
    - Epistemic (e.g., model structure, parameters)

- ## Fragility
  - ### Information on reliability of flood protection features and procedures is sparse
  - ### Cliff-edge effects

Phased Research Approach

Phase 1 → Application → Phase 2 → Inform & update → Phase 3

Phase 1 Technical Basis Projects

Phase 2 Pilot Studies

Phase 3 Guidance

- Phase 1 – Technical Basis Research - *Complete*
  - *Climate and precipitation*
  - *Mechanistic, statistical and probabilistic modeling of flooding processes*
  - *Reliability of flood protection features and procedures*
  - *Modeling Frameworks*
  - *Natural Hazard Information Digest (NHID)*
- Phase 2 – Pilot Studies - *In Progress*
  - *Local Intense Precipitation (LIP) Flooding*
  - *Riverine Flooding - Complete*
  - *Coastal Flooding*
- Phase 3 – Develop Guidance - *In Progress*

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- **Climate**
  - *Historical trends and future projections for U.S. regions*
- **Mechanistic, statistical and probabilistic modeling of flooding processes**
  - *Extreme precipitation*
  - *Riverine flooding*
  - *Coastal flooding*
- **Methods for Estimating Joint Probabilities of Coincident and Correlated Flooding Mechanisms**
  - *Riverine flooding*
  - *Coastal flooding*
- **Reliability of flood protection features and procedures**
  - *Flood barriers (seals, etc.)*
  - *Environmental effects on manual actions*
- **Modeling Frameworks**
  - *Structured hazard assessment committee process for flooding (SHAC-F)*
  - *Dynamic analysis of flooding events*
  - *USACE HEC-WAT*
- **Natural hazards information digest (for internal NRC staff use)**
  - *Collect and organize natural hazard information for operating reactors*

For more details on Phase 1 completion see Digital Exhibit #11 at the 34th Annual Regulatory Information Conference (RIC), March 8-10, 2022:
https://www.nrc.gov/public-involve/conference-symposia/ric/index.html

Objective: **Synthesize results from technical basis research**

– **Multiple flooding mechanism contribution to hazard curves**

– **Quantify key aleatory variabilities and epistemic uncertainties**

- **LIP Flooding PFHA Pilot**
  – **PNNL**
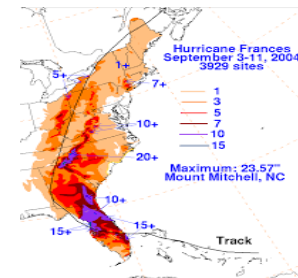 – *In Progress; completion expected in March 2022*

- **Riverine Flooding PFHA Pilot**
  – **USACE/HEC**
  – *Completed in January 2022*

- **Coastal Flooding Pilot PFHA Pilot**
  – **USACE/ERDC/CHL**
  – *In Progress; completion expected in June 2022*

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- **Objectives**
  - *Inform guidance development for probabilistic assessment of site-scale flooding hazards due to local intense precipitation*
  - *Synthesize results from technical basis research*
  - *Incorporate site-scale features (curbs, buildings, drains)*
- **Key elements**
  - *Point rainfall (aleatory variability) based on NOAA Atlas 14*
  - *Sensitivity study to identify key epistemic uncertainties wrt site features*
  - *Propagation of uncertainties to construct hazard curve families for selected flood hazard metrics (e.g., depth, velocity, duration)*
  - *Monte Carlo simulation with stratified sampling*
- **More detailed information:**
  - *Presentation 2A-5 (Wednesday at 12:00)*

Phase 2: Riverine Pilot Study

- **Objectives**
  - *Inform guidance development for probabilistic assessment of riverine flooding hazards*
  - *Synthesize results from technical basis research*
  - *Incorporate multiple flooding mechanism contributions to hazard curves*
- **Key elements**
  - *Stochastic rainfall model (aleatory variability)*
  - *Epistemic uncertainties in hydrologic (runoff and routing), reservoir, and hydraulic models*
  - *Multiple dam failure scenarios*
  - *Propagation of uncertainties to construct hazard curve families for selected flood hazard metrics (e.g., elevation, velocity, duration)*
  - *Monte Carlo simulation approach using HEC-WAT*
- **More detailed information:**
  - *Presentation 2B-4 (Wednesday at 15:20)*
  - *Posters 3A-4 and 3A-5 (Thursday at 10:00)*
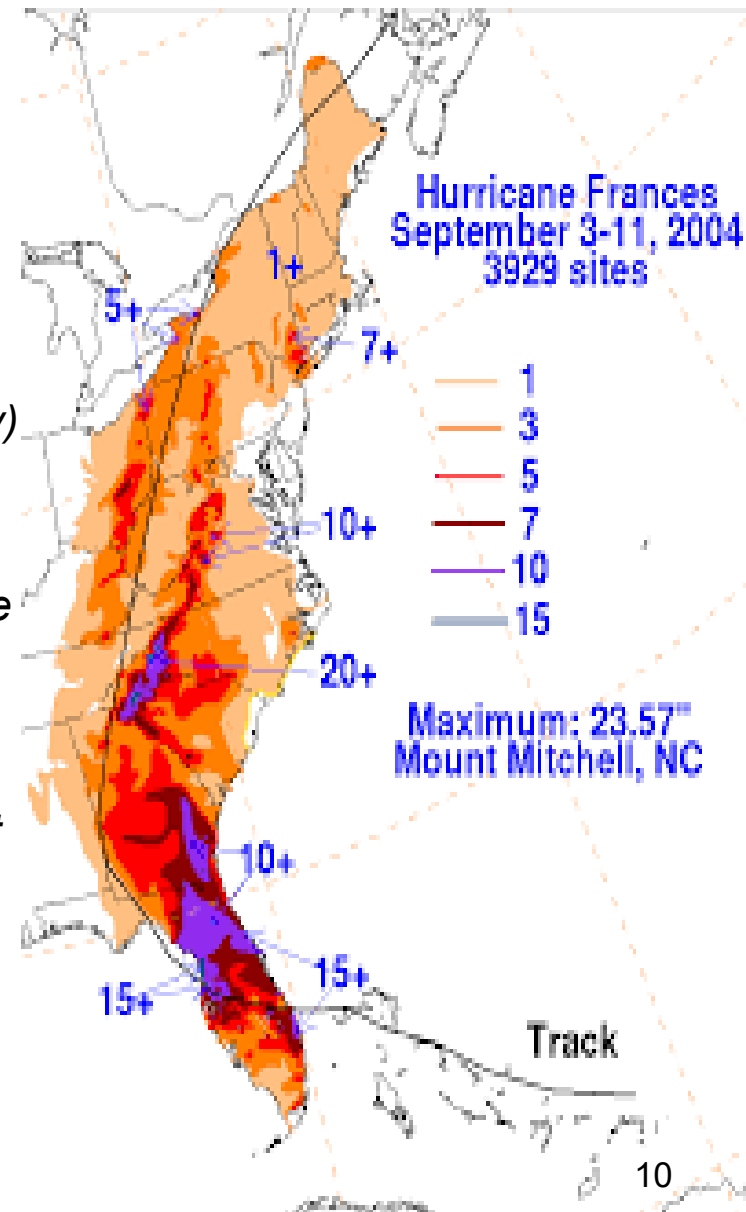
Phase 2: Coastal Pilot Study

- **Objectives**
  - *Inform guidance development for probabilistic assessment of coastal flooding hazards*
  - *Synthesize results from technical basis research*
  - *Incorporate multiple flooding mechanism contributions to hazard curves*

- **Key elements**
  - *Tropical cyclone rainfall model (aleatory variability)*
  - *Epistemic uncertainties in hydrodynamic (surge), hydrologic (runoff and routing), and hydraulic models*
  - *Flooding due to surge and rainfall-induced riverine discharge*
  - *Propagation of uncertainties to construct hazard curve families for selected flood hazard metrics (e.g., elevation, velocity)*
  - *USACE Probabilistic Coastal Hazard Assessment (PCHA) framework*

- **More detailed information:**
  - *Presentation 3B-3 (Thursday at 12:05)*

Hurricane Frances
September 3-11, 2004
3929 sites

1	
3	
5	
7	
10	
15	

Maximum: 23.57"
Mount Mitchell, NC

Track

Phase 3: PFHA Guidance

- **FY 22/FY23: Develop draft guidance based on:**
  - *Technical basis research*
  - *Pilot projects*
  - *User office needs*
  - *Stakeholder & public interests*

- **FY23: Publish draft guidance for public comment**
- **FY23: Finalize guidance based on public comment**

Past Workshops

- **Proceedings of 1ˢᵗ-4ᵗʰ Annual NRC PFHA Research Workshops**
  - *NRC Research Information Letter (RIL) 2020-01*
- **Proceedings of 5ᵗʰ Annual NRC PFHA Research Workshop**
  - *RIL 2021-01*
- **Proceedings of 6ᵗʰ Annual NRC PFHA Research Workshop**
  - *RIL 2022-02*

NRC Research Information Letters are available at:

https://www.nrc.gov/reading-rm/doc-collections/index.html#ril

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RIL2021-01

PROCEEDINGS OF THE FIFTH ANNUAL PROBABILISTIC FLOOD HAZARD ASSESSMENT WORKSHOP

Questions?

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