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United States Nuclear Regulatory Commission

Protecting People and the Environment

US Nuclear Regulatory Commission (USNRC) Staff Needs In Probabilistic Flood Hazard Assessment (PFHA)

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Workshop on Probabilistic Flood Hazard Assessment (PFHA)
January 29, 2013

Presentation Outline

- Provide a brief overview of NRC’s mission, flooding-related guidance
- Discuss risk assessment concepts commonly used at the NRC
- Present examples of risk criteria used in NRC licensing and oversight activities
- Present issues of interest in the area of flooding risk to NRC licensed facilities

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NRC's Mission and Functions

License and regulate the Nation's civilian use of byproduct, source, and special nuclear materials to ensure the adequate protection of public health and safety, promote the common defense and security, and protect the environment.

REGULATIONS

code of federal regulations

OPERATIONAL EXPERIENCE

ANALYSIS
RESEARCH
HEARINGS

LICENSING ACTIONS

OVERSIGHT

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NRC Regulations Overview

- Natural phenomena must be identified and assessed for potential effects on safe operation ***10 CFR 72.92***
- Designed to withstand effects of natural phenomena, such as floods ***10 CFR 50 App. A***
- Appropriate consideration of most severe of the natural phenomena that have been historically reported ***10 CFR 50 App. A***
- With sufficient margin for limited accuracy, quantity, and period of time for accumulated historical data ***10 CFR 50 App. A***
- Proximity of man-related hazards (e.g., dams) for potential hazards ***10 CFR 100.20***

STREAM FLOODING
LOCAL FLOODING
DAM FAILURES
TSUNAMI
ICE FLOODING
SURGES
SEICHES
COMBINED EVENTS

Risk Analysis at the NRC

- NRC has a policy to increase the use of risk analysis in regulatory matters
  - To extent supported by the state-of-art
  - Complementary to deterministic approaches
  - Supports defense-in-depth philosophy
- Various methodologies, tools, approaches
  - Varying levels of detail, qualitative/quantitative
- Large resources/effort applied by NRC/industry on systematic risk assessments for nuclear reactors, i.e., Reactor Probabilistic Risk Assessments (PRAs)
- Risk triplet: *What can go wrong (s)? How likely is it (p)? What are the consequences (c)?*

$$R = \{(s_i, p_i, c_i)\}, \quad i = 1, 2, \ldots, N$$

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Great Tōhoku Earthquake

Source: Tokyo Electric Power Company

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NRC PRA Framework

EVENT FREQUENCY =

$\sum$ [(HAZARD FREQUENCY) x (CONDITIONAL PROBABILITY OF FAILURE)]

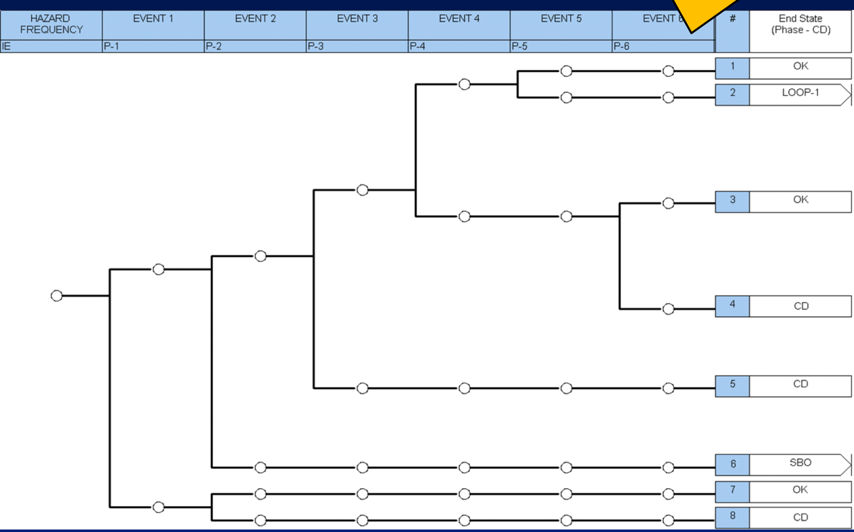
- Events that challenge plant safety, e.g., loss of cooling, loss of power
- Multiple potential "initiators"
  - System/operator failures
  - Internal Fire
  - Natural hazards
    - Earthquakes
    - High Winds
    - Floods…

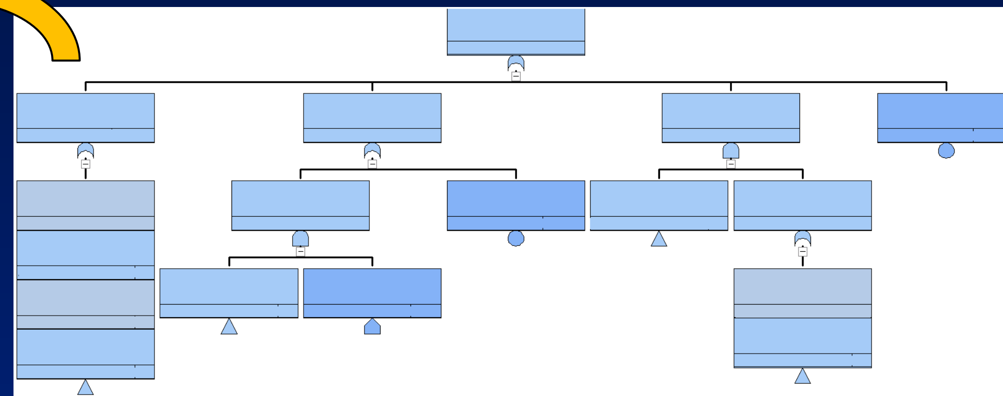
- Measure of mitigation capability
- System analysis
- Human reliability analysis
- Consideration of dependencies
- Probability of recovery
- Uncertainty/sensitivity analysis
- Risk ranking of contributors

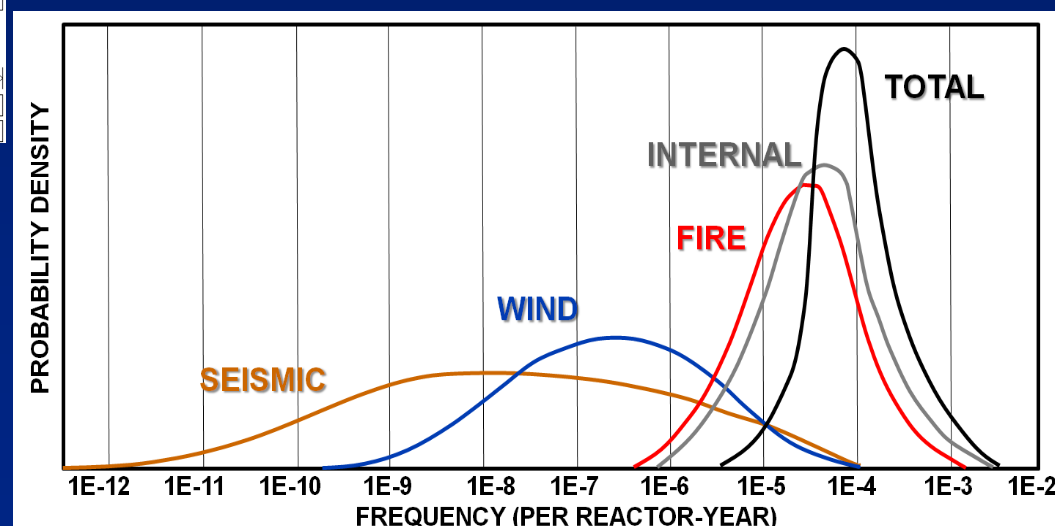
NRC PRA Reactor Framework

CORE DAMAGE FREQUENCY (CDF) =

∑ [(HAZARD FREQUENCY) x (CONDITIONAL CORE DAMAGE PROBABILITY)]







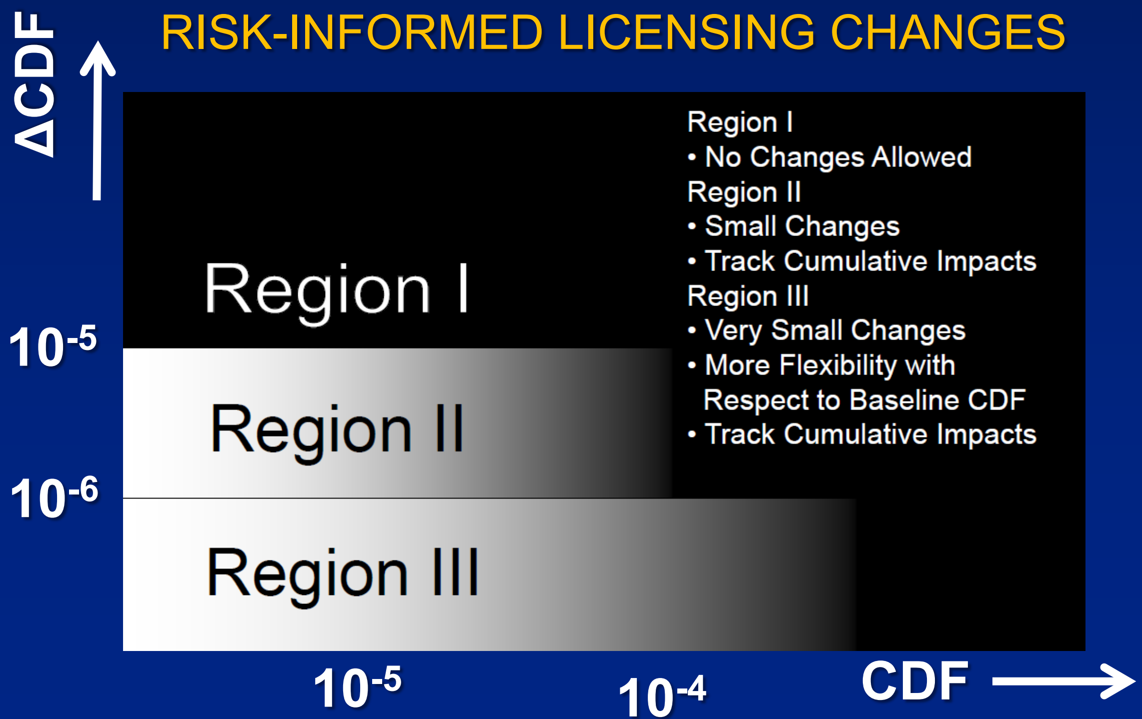
<u>For operating reactors:</u>
CDF ≈ 10^{-4} to 10^{-5}/year with contributors in the range of 10^{-5}/year to 10^{-9}/year

1982 PRA RESULTS

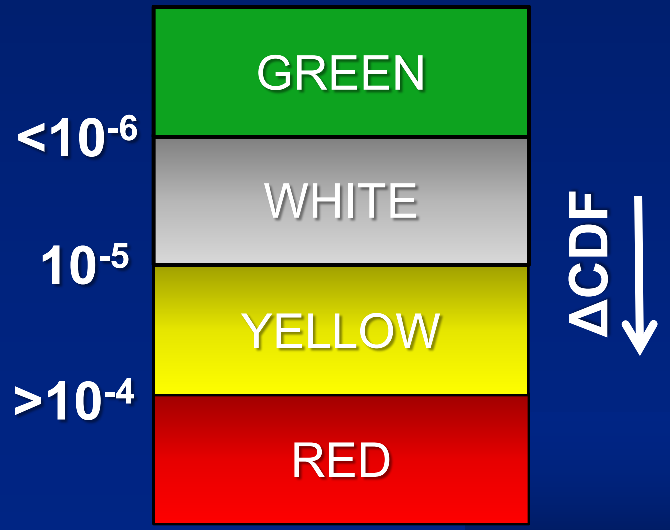
NRC Risk Criteria for Reactors

- NRC has adopted probabilistic safety goals for reactors
- Risk criteria defined for multiple regulatory activities, e.g.,
  - Risk-Informed licensing decisions
  - Risk significance of findings and events

ACCEPTANCE GUIDELINES FOR RISK-INFORMED LICENSING CHANGES



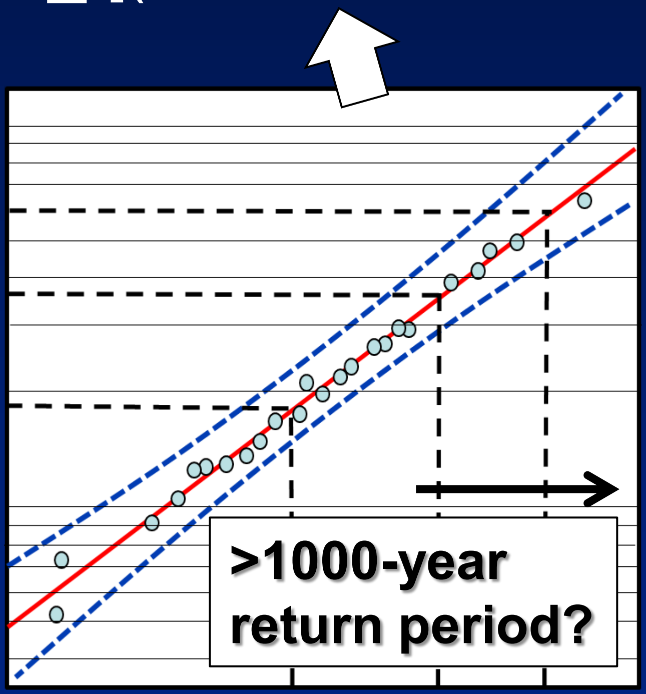
SIGNIFICANCE DETERMINATION PROCESS



NRC Staff Needs – Severe Flood Frequencies

EVENT FREQUENCY =

$\sum$ [(HAZARD FREQUENCY) x (CONDITIONAL PROBABILITY)]



- Flood intensity, duration, <u>AND</u> frequency in the NRC ranges of interest
  - Defensible extrapolation methods even with wide uncertainties
  - Need to capture wider risk spectrum, including more frequent/less severe floods
  - Obtain risk as a function of flood elevation, graded impact to plant activities
  - Applicability of advanced methods
- Potential screening methods
  - Screening out mechanisms or thresholds for flood contributors
  - Applicable to multiple sites across US

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NRC Staff Needs – Dams/Flooding Protection

EVENT FREQUENCY =

∑ [(HAZARD FREQUENCY) x (CONDITIONAL PROBABILITY)]

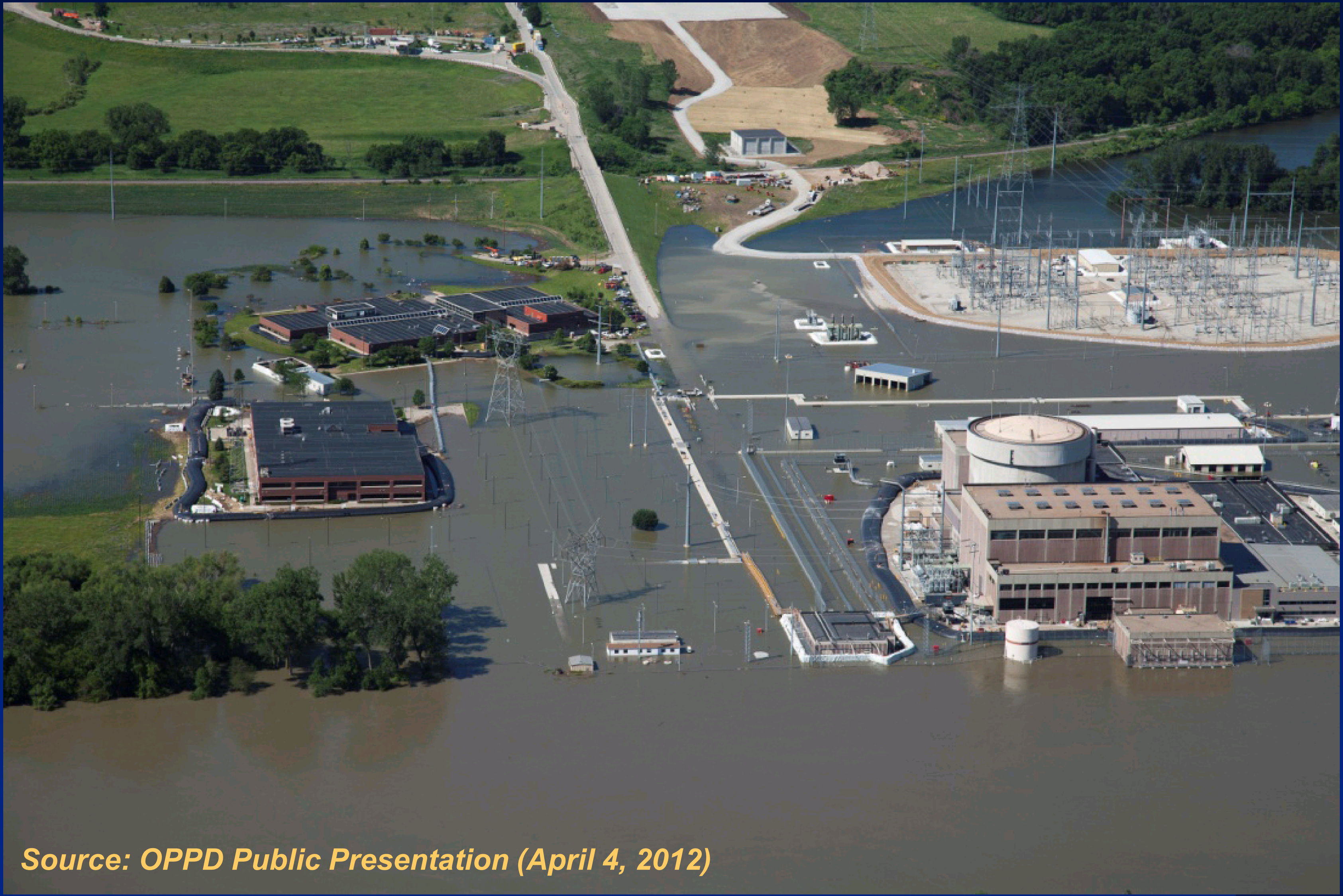
- Impact due to upstream, downstream dams
  - Dam failure rates (with uncertainty)
  - Combined events (e.g., seismic)
  - Uncertainty in flood timing
  - Failure of appurtenant structures (i.e., spillways and hydro-turbines)
  - Internal piping failures
  - Probabilistic treatment of long embankments, levees

- Probability of failure of flood protection structures and barriers (debris impact, degradation, erosion)
- Fragility curves for mechanical/electrical systems, components
- Feasibility of manual actions during extreme events

Ft. Calhoun 2010 Finding

Source: OPPD Public Presentation (April 4, 2012)

Missouri Flooding 2011



Source: OPPD Public Presentation (April 4, 2012)

Conclusions

- Recent events indicate the importance of characterizing low probability/high consequence events with respect to USNRC activities
- Current complementary use of deterministic and probabilistic methods at the USNRC can be significantly expanded by state-of-art flood hazard analysis
- Immediate needs exist in the area of licensing and oversight of commercial nuclear reactors
- Recognized expertise of multiple federal agencies is needed to bridge gaps in improving treatment of flooding hazard within USNRC applications