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# NRC Lessons Learned - External Events

Rebecca Karas
Office of New Reactors
U.S. Nuclear Regulatory Commission
February 8, 2012

# Outline

- Experience with North Anna Power Station Restart after 23-8-2011 Virginia Earthquake
- Experience with Fort Calhoun Nuclear Station after 2011 Flooding
- NRC Actions in Response to Fukushima Lessons Learned

❖ *This presentation is drawn from various presentations and documents made by the staff and management of NRC, Dominion (VEPCO) and Omaha Public Power District (OPPD)*

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# Experience with North Anna Power Station Restart after 23-8-2011 Virginia Earthquake

- Virginia Earthquake
- Events at the North Anna Power Station (NAPS)
- Actions taken by NRC and Dominion
- Regulations and Guidance for Restart

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# North Anna Power Station

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# August 23, 2011 . . . 1:51 p.m.

- Magnitude 5.8 quake strikes the east coast
- Epicenter was ~18km from the plant, 6km depth
- PGA at North Anna ~0.26g
- Fault type - reverse
- 12 Nuclear Plants felt quake; one tripped (North Anna)
- Largest recorded quake east of the Rocky Mountains since 1897
- USGS reported that this was the most widely-felt earthquake in U.S. history (Alabama to Canada and the East Coast to Illinois)

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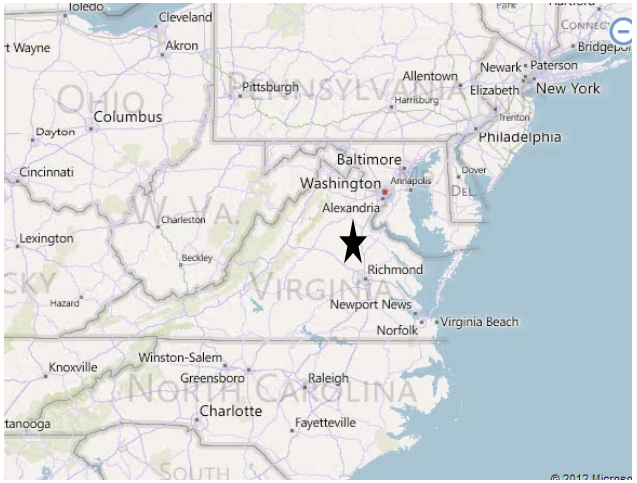
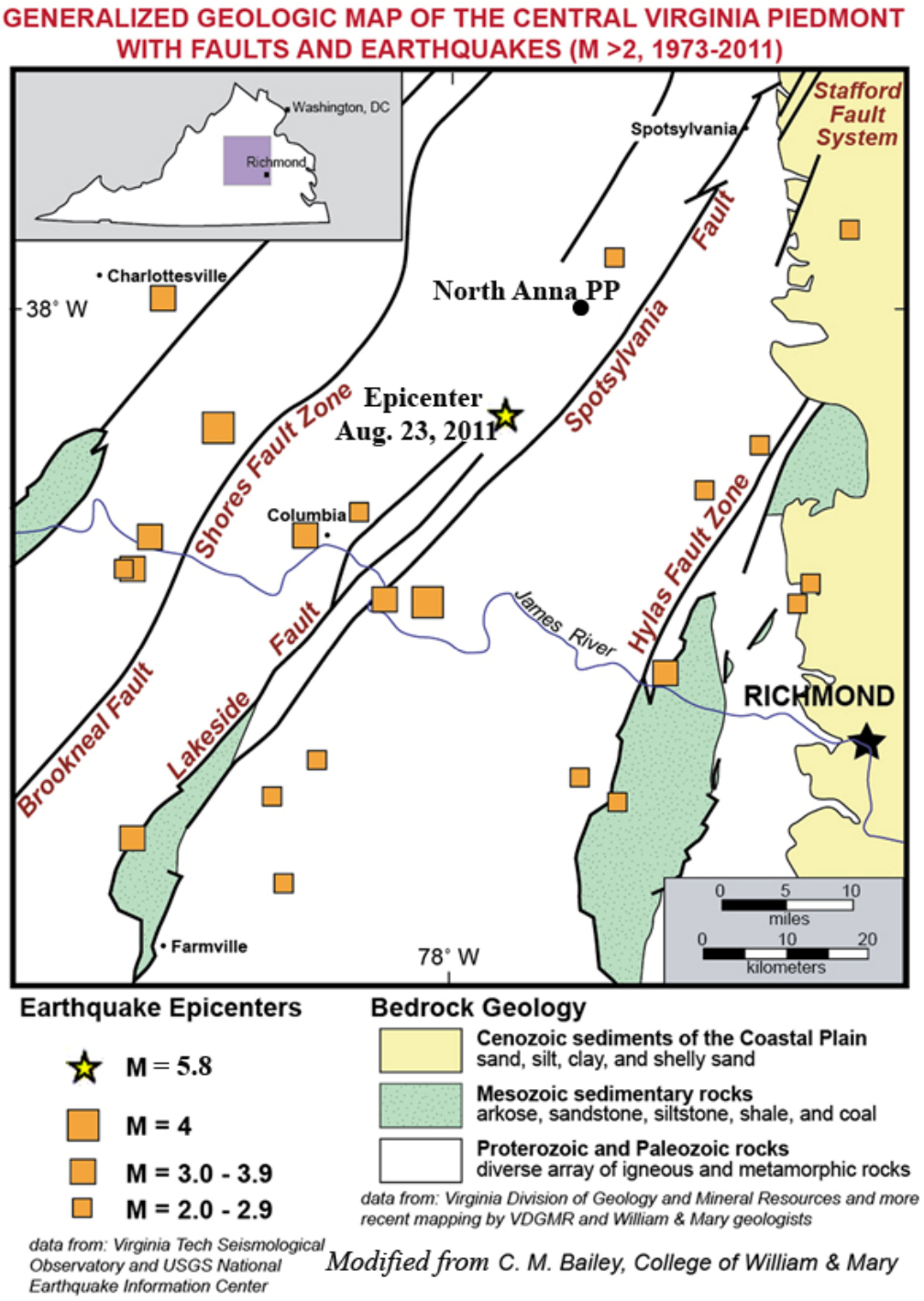
# Event Location



# Impact on Louisa County . . . .

- More than 900 homes damaged
- Every pre-Civil War house in the county was damaged (foundations, chimneys)
- 2 of 6 public schools in the county suffered structural damage
- Estimated costs for repairs in Louisa County exceed $18 million, including damage to public buildings and roadways

# What Happened at NAPS?

- 13:51:00 – Earthquake occurs with both units at 100% power
- 13:51:11 - Reactor Trip Breakers open for both reactors on negative flux rate trip (+/- 5% in 2.5 sec on 2 channels)
- 13:51:12 – Loss of offsite power due to sudden pressure trips on offsite power transformers
- 13:51:20 – All four diesel generators start to power the station
- E-Plan was entered and an Alert declared due to shift manager judgment because seismic panel lost power

# What Happened at NAPS?

- The licensee activated its Technical Support Center, Operations Support Center and Local Emergency Operations Facility
- 14:40 – 2H EDG manually tripped due to coolant leak, 2H bus de-energized
- 15:18 – 2H bus re-energized by the station blackout (SBO) diesel
- 22:58 – Offsite power available
- 8/24/11, 08:51 – Commenced Unit 1 cooldown
- 8/25/11, 11:37 – Commenced Unit 2 cooldown

# NRC Actions

- The NRC activated its Operations Center and Regional Incident Response Centers.
- NRC Resident Inspector for North Anna was in the control room during earthquake response – additional inspectors sent soon after.
- Augmented Inspection Team (Aug. 30 – Oct. 3):
  - Operators responded in accordance with established procedures
  - Ground motion exceeded licensing basis
  - No significant damage to plant
  - Safety system functions were maintained
  - Some equipment issues were experienced

# Safe Shutdown Earthquake (SSE)

- The North Anna Power Station (NAPS) has two SSE ground motions, one for structures, systems, and components (SSCs) located on top of rock, which is anchored at a peak ground acceleration (PGA) of 0.12 g, and the other is for SSCs located on top of soil, which is anchored at a PGA of 0.18 g.

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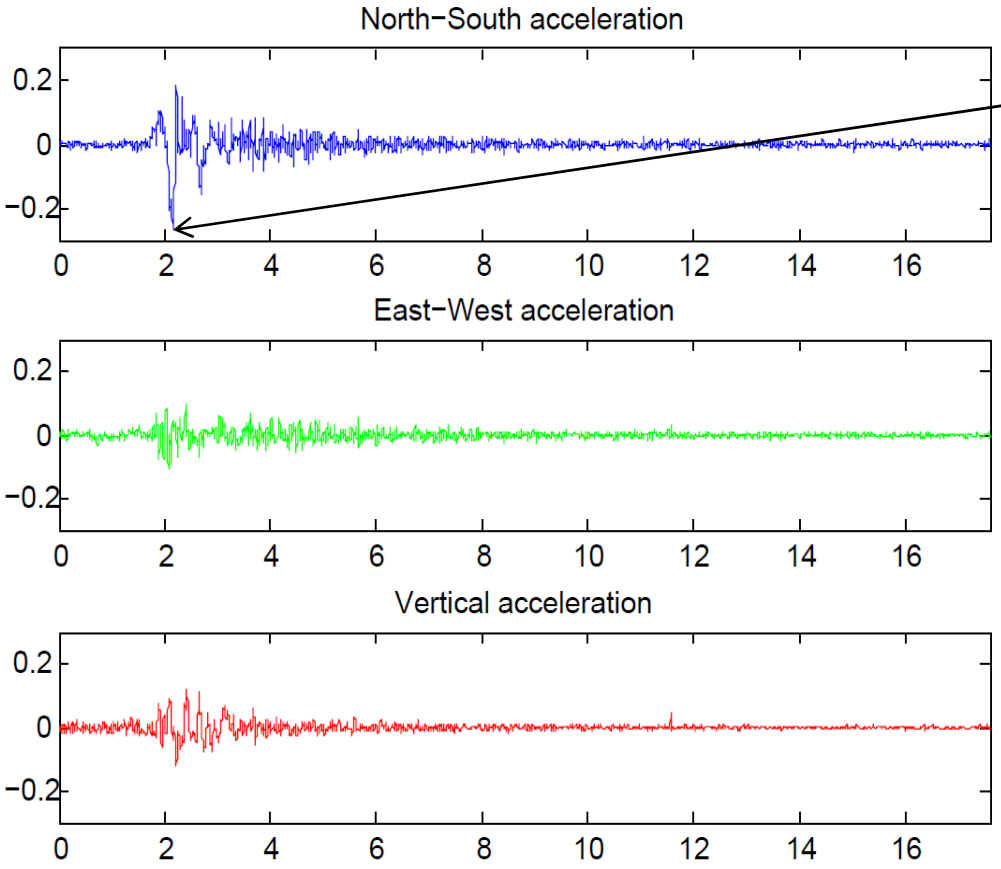
# Recorded Motion at North Anna Plant from Mineral, Virginia M5.8 Earthquake




PGA = 0.26 g

- Plant Foundation Level Kinemetrics SMA-3 records

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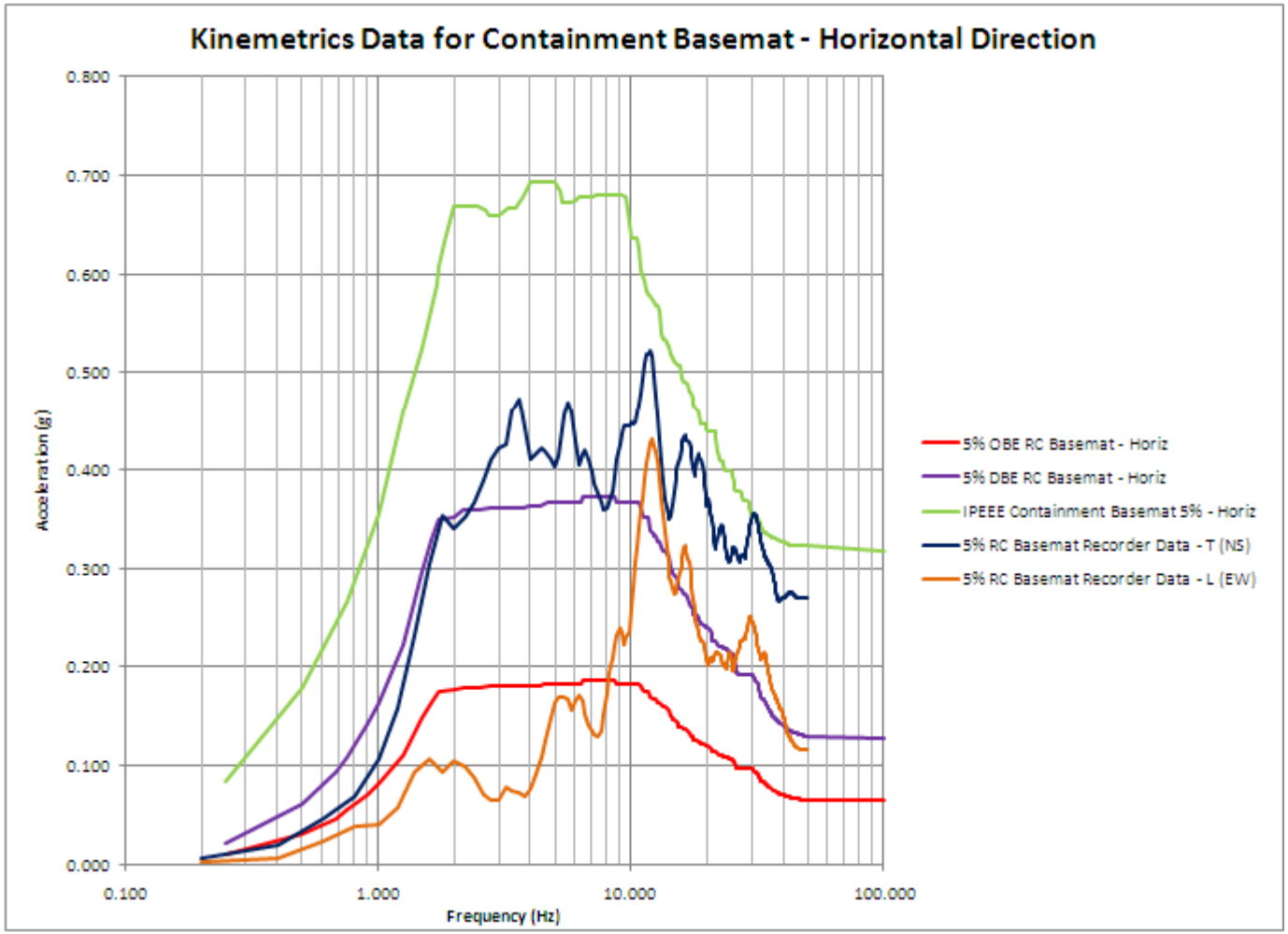
# Response Spectra Comparisons



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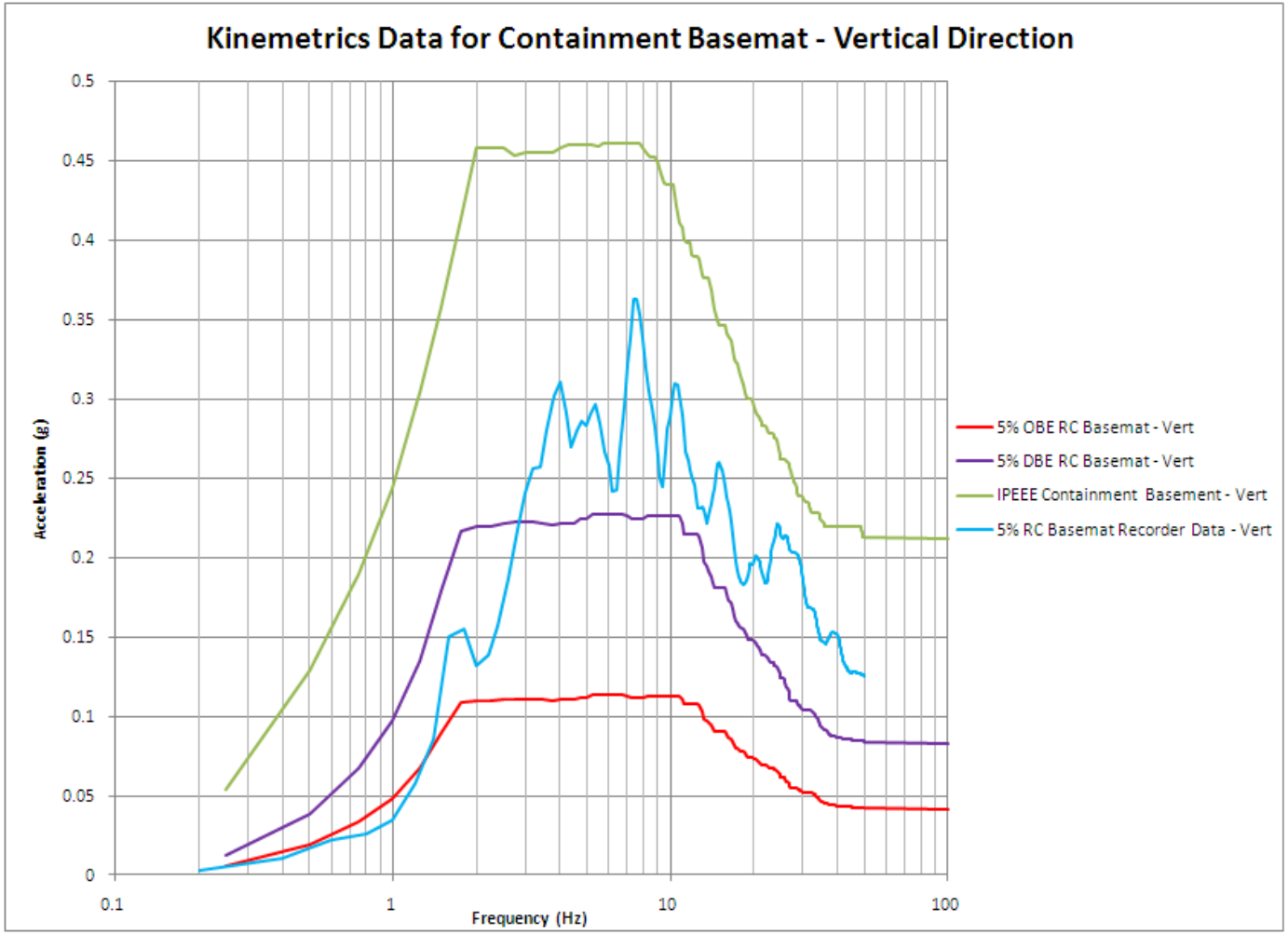
# Response Spectra Comparisons



# Impact to North Anna

25 of 27 TransNuclear vertical casks moved between 1 and 4 ½ inches

NUHOMS horizontal modules had small gaps and corners cracked

**Dry Cask Storage**

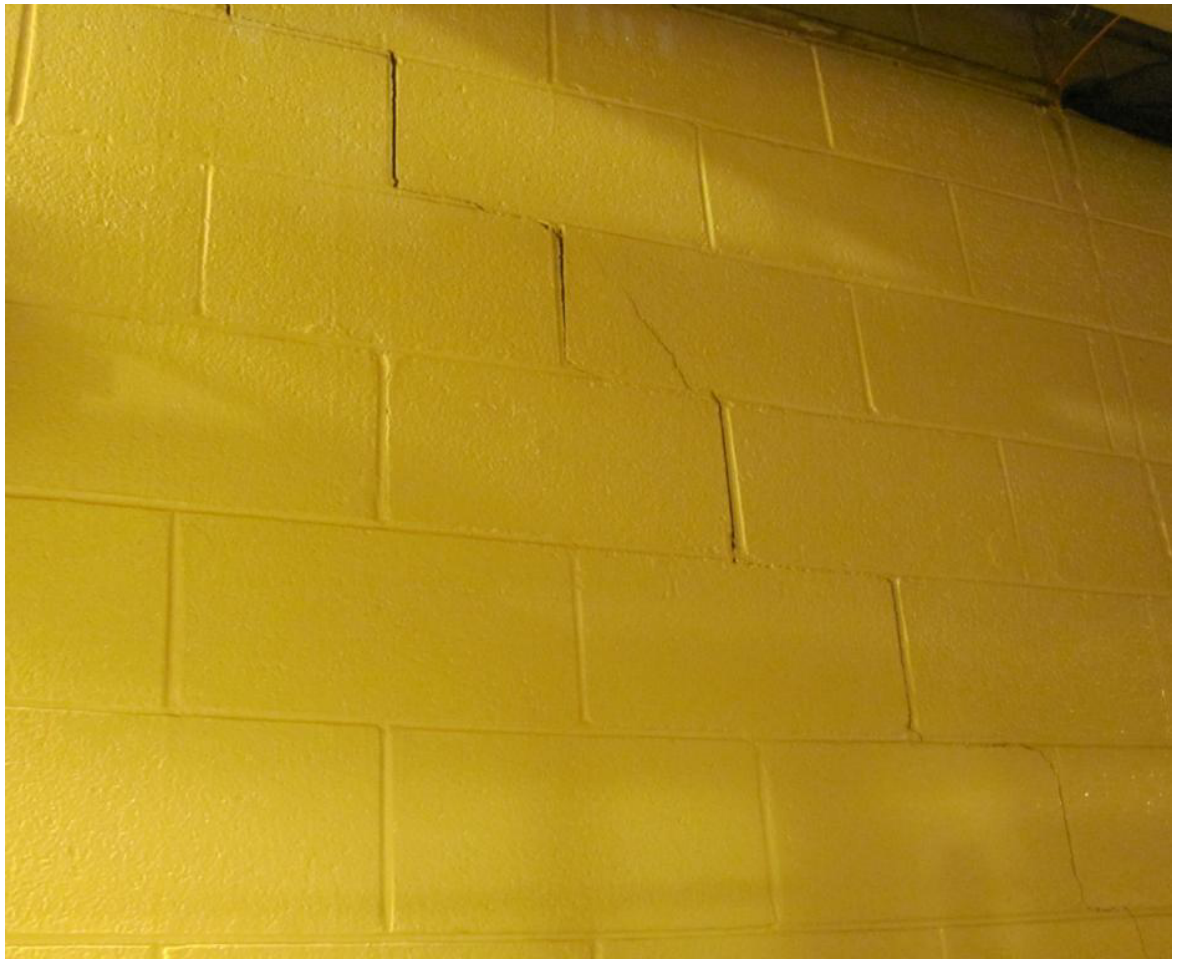
All radiology and temperatures normal

# U2 Turbine Building

Powdex Demineralizer Tanks Base Pedestal (non-safety related)

# Turbine Building Hallway

Crack In Unreinforced Non–Safety Related Block Wall



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# Unit 1 Containment


Surface Crack In Interior Containment Wall

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# U.S. Code of Federal Regulations

- 10 CFR 100, Appendix A, Section V(a)(2)
  - Plant shutdown required if Operating Basis Earthquake (OBE) exceeded
  - Licensee must demonstrate no functional damage to Structures, Systems & Components (SSCs) necessary for operation without undue risk to the health and safety of the public

# Regulatory Guidance

- RG 1.166, Pre-earthquake Planning and Immediate Nuclear Power Plant Operator Post-earthquake Actions, dated March 1997
- RG 1.167, Restart of a Nuclear Power Plant Shutdown by a Seismic event, dated March 1997
  - Refers to EPRI NP-6695 “Guidelines for Nuclear Plant Response to an Earthquake” 1989
  - Guidance implemented by licensee prior to restart
  - Action plan based on damage level
  - Long Term Evaluation if SSE Exceeded
    - Re-evaluate SSCs based on actual seismic loading conditions

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# Short-Term Actions


- ✓ Installed Temporary Free Field Seismic Monitor
- ✓ Installed Qualified UPS to Seismic Monitoring Panel in Main Control Room
- ✓ Revised Abnormal Procedure
- ✓ Complete Start-Up Surveillances

- NRC performed readiness restart inspections from Oct 5 – Nov 7.
- NRC determined licensee performed adequate inspections, walkdowns and testing to ensure that SSCs were not adversely affected by the earthquake
- NRC approved restart on Nov 11.

# North Anna Power Station Long Term Actions

- Install permanent free-field seismic monitoring instrumentation
- Permanently re-power seismic monitoring panel in the main control room
- Re-evaluate safe shutdown equipment (components with identified lower margins)
- Perform seismic analysis of recorded event consistent with EPRI guidance
- Maintain seismic margins in future modifications
- Revise the North Anna Safety Analysis Report
- Coordinate update of seismic design and licensing basis with resolution of existing generic issue on central & eastern U.S. seismic hazard

# Summary

- Significant beyond DBE occurred
- RG 1.167 and EPRI NP-6695 were used by licensee and staff
- No significant damage to SSCs necessary for operation
- NRC staff are reviewing lessons learned
- *More information at: http://www.nrc.gov/about-nrc/emerg-preparedness/virginia-quake-info.html*

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# Experience with Fort Calhoun Nuclear Station after 2011 Flooding

- Missouri River Dams and Flooding
- Events at the Fort Calhoun Site
- Actions
- Summary

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# Upper Missouri River Dams

## (Fort Calhoun and Cooper NPPs also shown)

# Snow and Rain

- By the end of 2010, all dams had storage capacity available for Spring runoff

- Between March and April, the Mountain snowpack accumulated to an all-time high

- The last 2 weeks of April, high rainfalls increased the inflows to the river to near record levels

- A year's worth of rainfall received in 2-1/2 weeks

- Throughout May and June, the Corp of Engineers announced increasing releases to historic levels

# Summary of 2011 Flooding

- April 9, 2011: Fort Calhoun Station shutdown to commence a scheduled refueling outage.
- May 23, 2011: in response to rising water levels along the Missouri River, Fort Calhoun Station operators began implementing flood protection measures.
- June 6, 2011: Fort Calhoun declared a Notice Of Unusual Event (NOUE) in anticipation that the Missouri River level at the plant would reach 1004 ft MSL. The NRC augmented the resident inspector staff to provide around the clock coverage.
- Flooding Action Levels
  - 1014 ft Mean Sea Level (MSL)– Licensing Basis Flood Level
  - 1009 ft –Technical Specification Shutdown Level (Entry Condition for Alert)
  - 1004 ft – Abnormal Operations Procedure Shutdown Level (Entry Condition for NOUE)

# Conditions On Fort Calhoun Site

• Omaha Public Power District (OPPD) initially built sandbag berms around the switchyard control houses

• Earthen berm was built completely surrounding the switchyard

•Water filled Aquadam installed around power block to provide better access and protect the turbine building

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# Backup Plans

- The licensee brought in a spare diesel generator and transformer

- Techniques were developed to use Firewater as backup source for component cooling water and/or raw water

- The licensee staged their fire truck, supplies of diesel fuel, portable pumps and gasoline

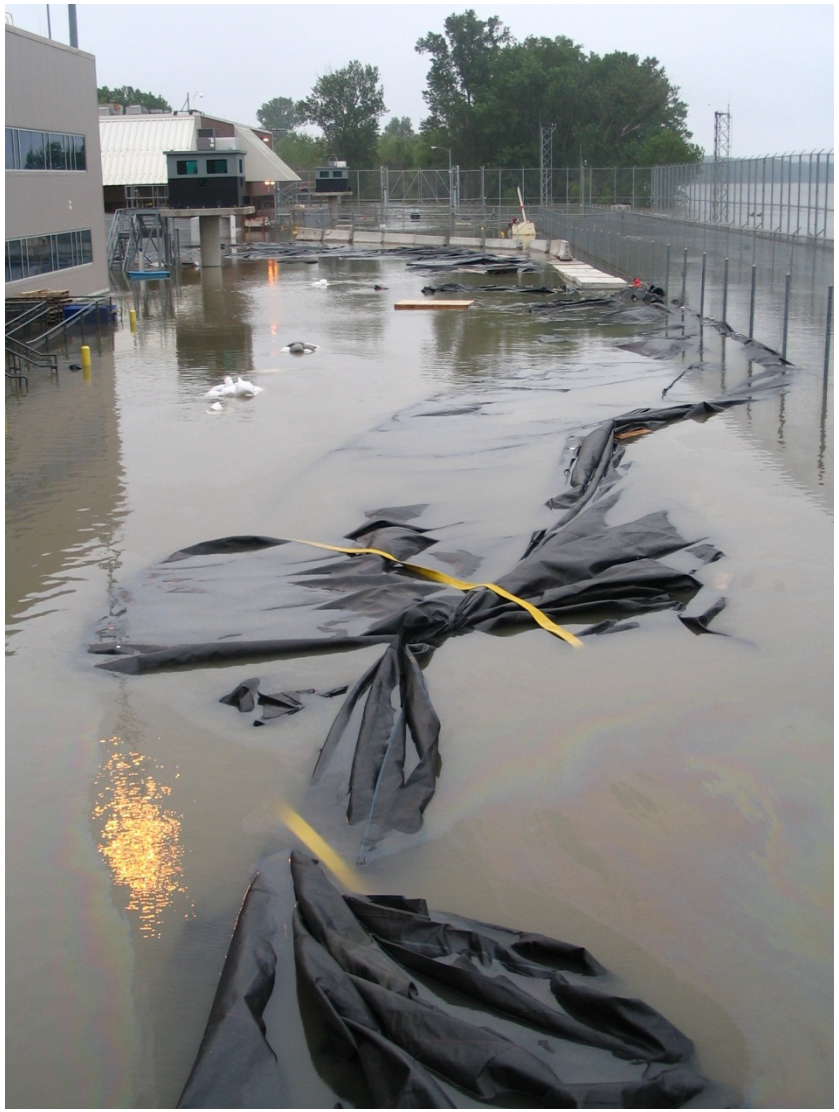

# Failure of Aquadam

- On June 25, 2011, the river level at Fort Calhoun peaked at 1006 feet and 10 inches.

- On June 26, 2011, a small front-end loader ran into the Aquadam puncturing it

- Failure threatened the normal transformers and caused plant operators to disconnect from offsite power

- The NRC entered monitoring mode of emergency response



# Failure of Aquadam

June 26, 2011

- The licensee's pumper truck for backup cooling water was partially submerged

- Actions by plant workers kept water out of the normal transformers

- Water entering a manhole quickly made it's way to the intake structure and threatened the raw water pumps

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# Actions

- On August 29, 2011, Fort Calhoun exited the NOUE.
- On August 30, 2011 Omaha Public Power District (OPPD) issued the Fort Calhoun Station Post-Flooding Recovery Action Plan
- OPPD committed to complete assessments in six Focus Areas.:
  - Site Restoration,
  - Plant Systems and Equipment
  - Equipment Reliability
  - Design and Licensing Basis
  - Emergency Planning
  - Security
- On September 2, 2011, the NRC issued an Confirmatory Action Letter :
  - confirms the actions the licensee plans to take as described in the Post-Flooding Recovery Action Pan and
  - identifies those actions that the NRC has determined need to be completed prior to restart of the plant.

# Summary

- Unprecedented snowfall combined with well above average rainfall

- Water levels onsite were below licensing basis flood levels

- Fort Calhoun remains shutdown

- Licensee taking actions in response to Confirmatory Action Letter

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# NRC Actions in Response to Fukushima Lessons Learned

- Background on Recommendations
- Near-Term Steps
- Summary

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# Background

- Near-Term Taskforce Recommendations
  - Tier 1:  Orders or Demands for Information
    - 2.1 and 2.3 Reevaluations and Walkdowns
    - 4.2 Station Blackout/Loss of Large Areas equipment
    - 9.3 Emergency Planning
    - 7.1 Spent Fuel Pool Instrumentation
    - 5.1 Hardened Vents
  - Tier 2 and Tier 3
    - Recommendation 2.2 Periodic (10-year) updates:  rulemaking

# Recommendation 2.1

- Reevaluate hazards at operating reactor sites
  - Develop hazard information and submit intermediate report
  - New hazard model for Central and Eastern U.S. available: http://www.nrc.gov/reading-rm/doc-collections/news/2012/12-010.pdf
- Determine if there is a need for additional regulatory actions
- Develop integrated risk assessment approaches and acceptance criteria
- Final assessment report with identified vulnerabilities and actions taken or planned
- In implementing Rec. 2.1, staff is considering the scope as:
  - Plant
    - » Full power operations for seismic
    - » All modes of operation for flood
  - Spent fuel pool
    - » all modes/configurations for seismic and flood

# Recommendation 2.3

- Develop a methodology and acceptance criteria for walkdowns
- Perform walkdowns using the methodology
- Identify and address plant-specific vulnerabilities
- Verify the adequacy of monitoring and maintenance procedures
- In developing guidance, staff is considering:
  - Insights from recent walkdowns and events
  - NUREG-1742 – IPEEE Perspectives
  - Combined effects, such as adverse weather

# Near-Term Steps

- To implement will recommend to Commission that NRC issue Orders and Demands for Information
- Issue Orders and Demands for Information, with Commission approval
- Continue interactions with the external stakeholders

# Follow-on Steps

- Licensees submit hazard information, including near-term steps if re-evaluated hazard is higher than licensing basis hazard
- Licensees submit Integrated Risk Assessments, if re-evaluated hazard is higher than licensing basis hazard
- Based on information received, NRC will decide on future regulatory actions

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# Summary

- Recommendations 2.1 and 2.3 part of larger Near-Term Taskforce Tier 1 work
- Hazard Reevaluations
- Risk/Integrated Assessments