U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NRC-011

Combined License Application Review North Anna 3 (NA3)

Safety Panel

March 23, 2017

Panelists

- James Shea – Senior Project Manager
- Vladimir Graizer – PhD Geophysicist
- Manas Chakravorty – Senior Structural Engineer
- Matt Thomas – Reactor Systems Engineer

Safety Panel Topics

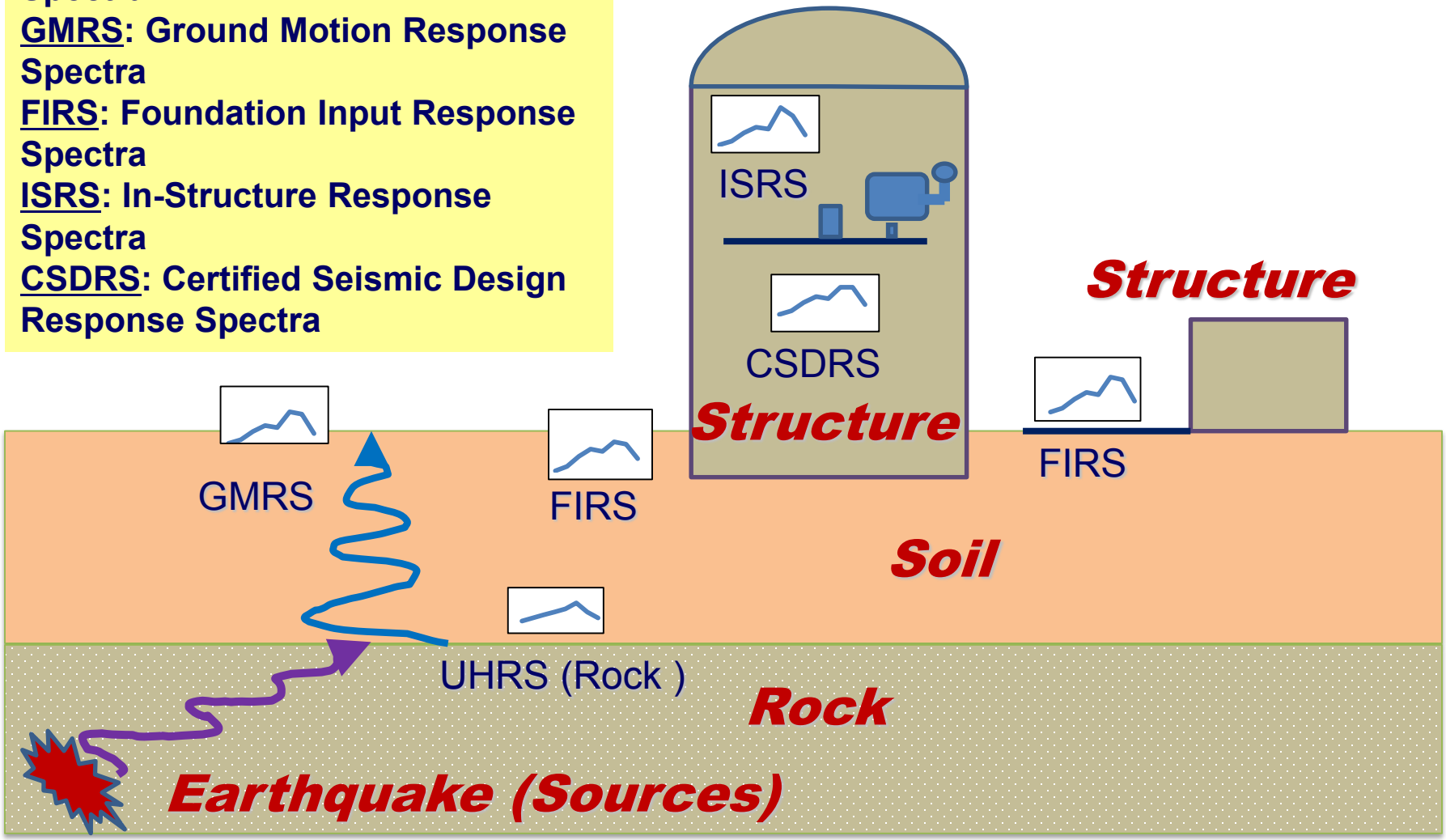
- **Mineral, Virginia Earthquake**
- **Certified Seismic Design Response Spectra (CSDRS) exceedances effect on Structure, Systems, and Components (SSCs) including reactor fuel**

NA3 Seismic Closure Plan 2014

- March 11, 2011, Fukushima event
- August 23, 2011, Mineral, Virginia earthquake
- Central Eastern United States-Seismic Source Characterization Model (CEUS-SSC) (2012)
- The EPRI Ground Motion Model (GMM) updated (2013)

Seismic Parameters

UHRS: Uniform Hazard Response Spectra
GMRS: Ground Motion Response Spectra
FIRS: Foundation Input Response Spectra
ISRS: In-Structure Response Spectra
CSDRS: Certified Seismic Design Response Spectra



Safety Panel Topic 1

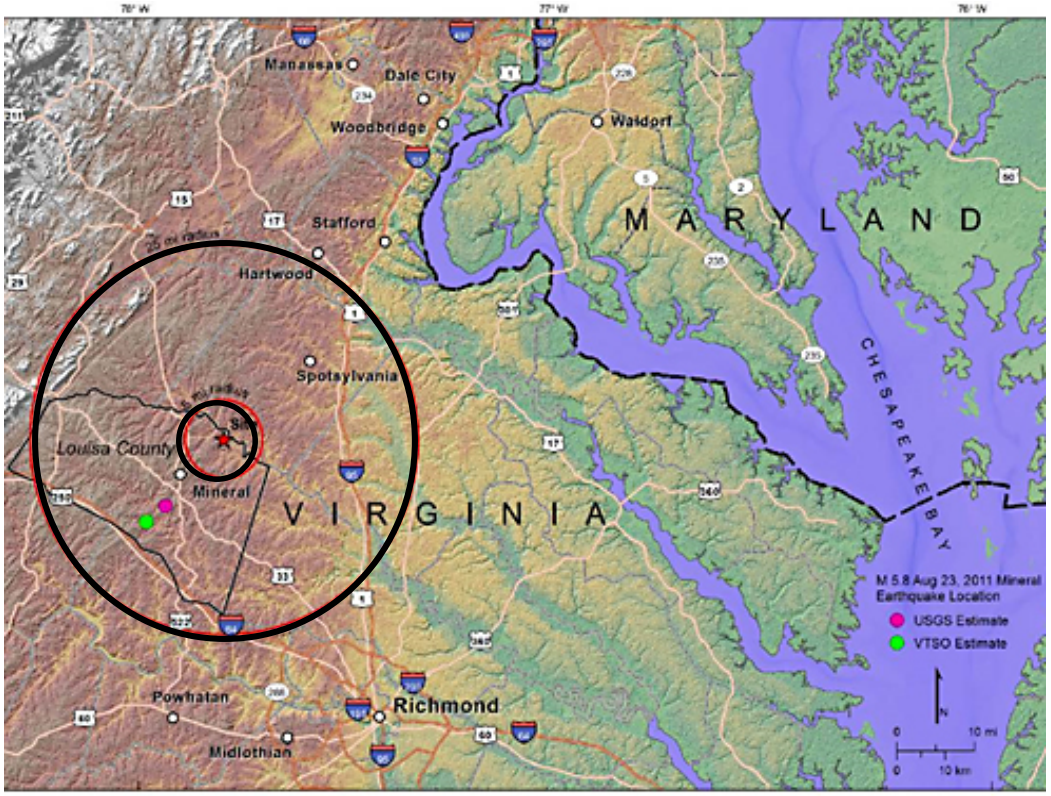
- Mineral Virginia Earthquake
- ESBWR CSDRS Exceedance

Vladimir Graizer – PhD Geophysicist
Office of New Reactors

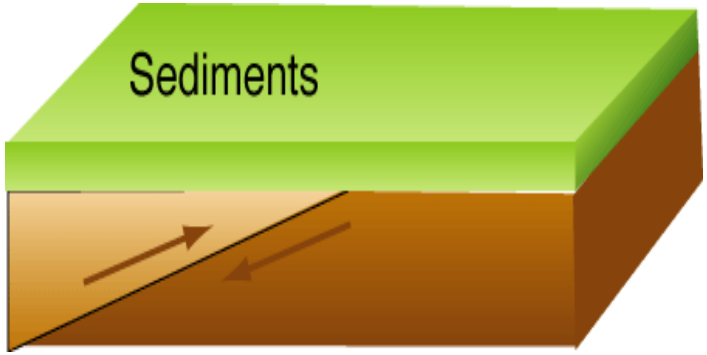
Mineral, Virginia Earthquake August 23, 2011

- M5.8 11 miles from NA3 Site
- Central Virginia Seismic Zone
- Exceeded Design Basis Earthquake for NA1&2
- Staff requested reassessment of the NA3 Probabilistic Seismic Hazard Analysis (PSHA)

North Anna Site and Mineral, Virginia Earthquake



From NA3 FSAR Figure 2.5.2-228



Mechanism of the earthquake was blind reverse fault with hypocenter located at the depth of 5 miles.

Variance from ESP

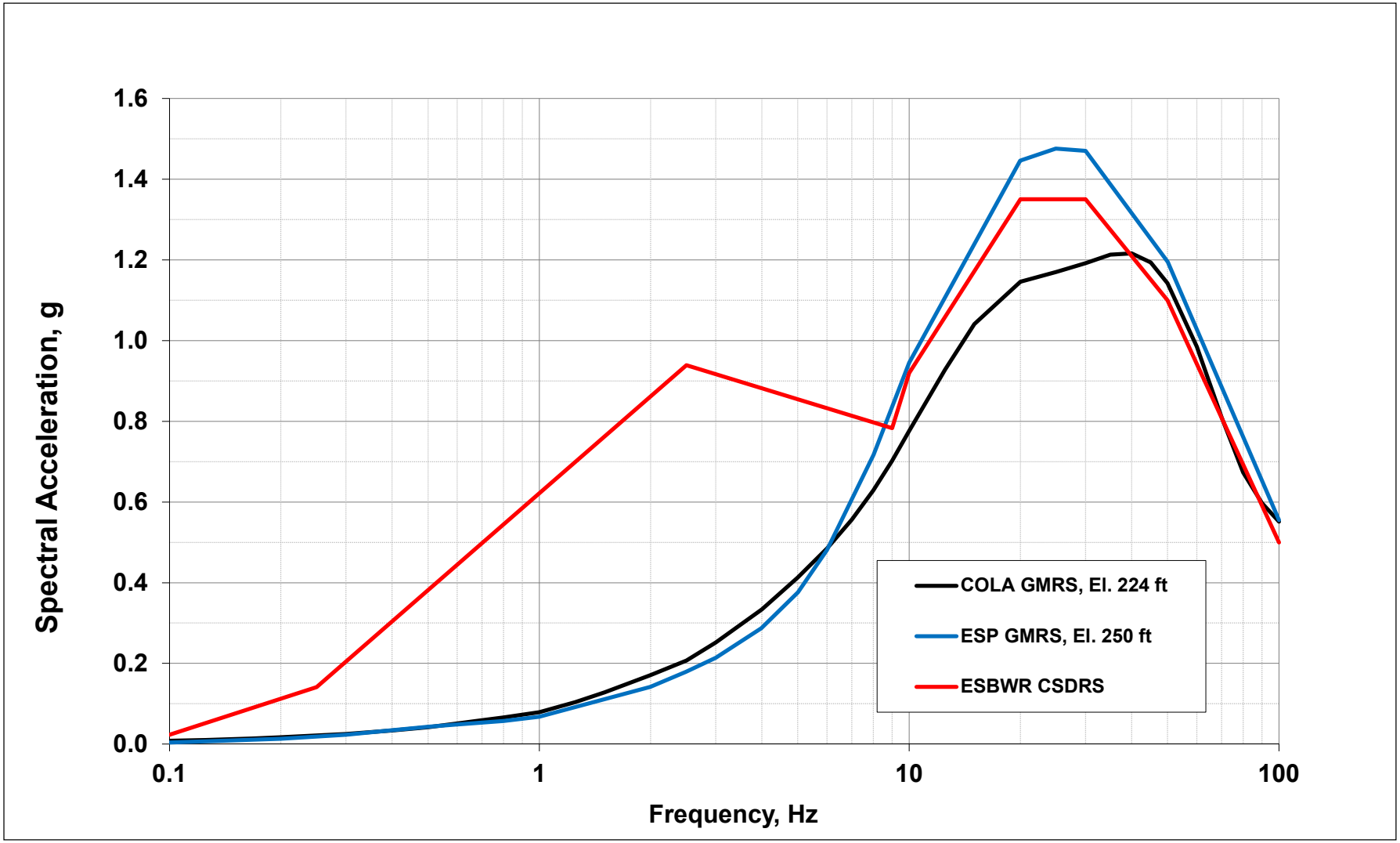
Variance NA3 (2013) ESP VAR 2.0-4: The applicant took a variance from values in the ESP because of:

- **Different building elevations than assumed in ESP**
- **New CEUS-SSC model (NUREG-2115 2012) and new Ground Motion Model (EPRI, 2013)**
- **Mineral, Virginia earthquake**

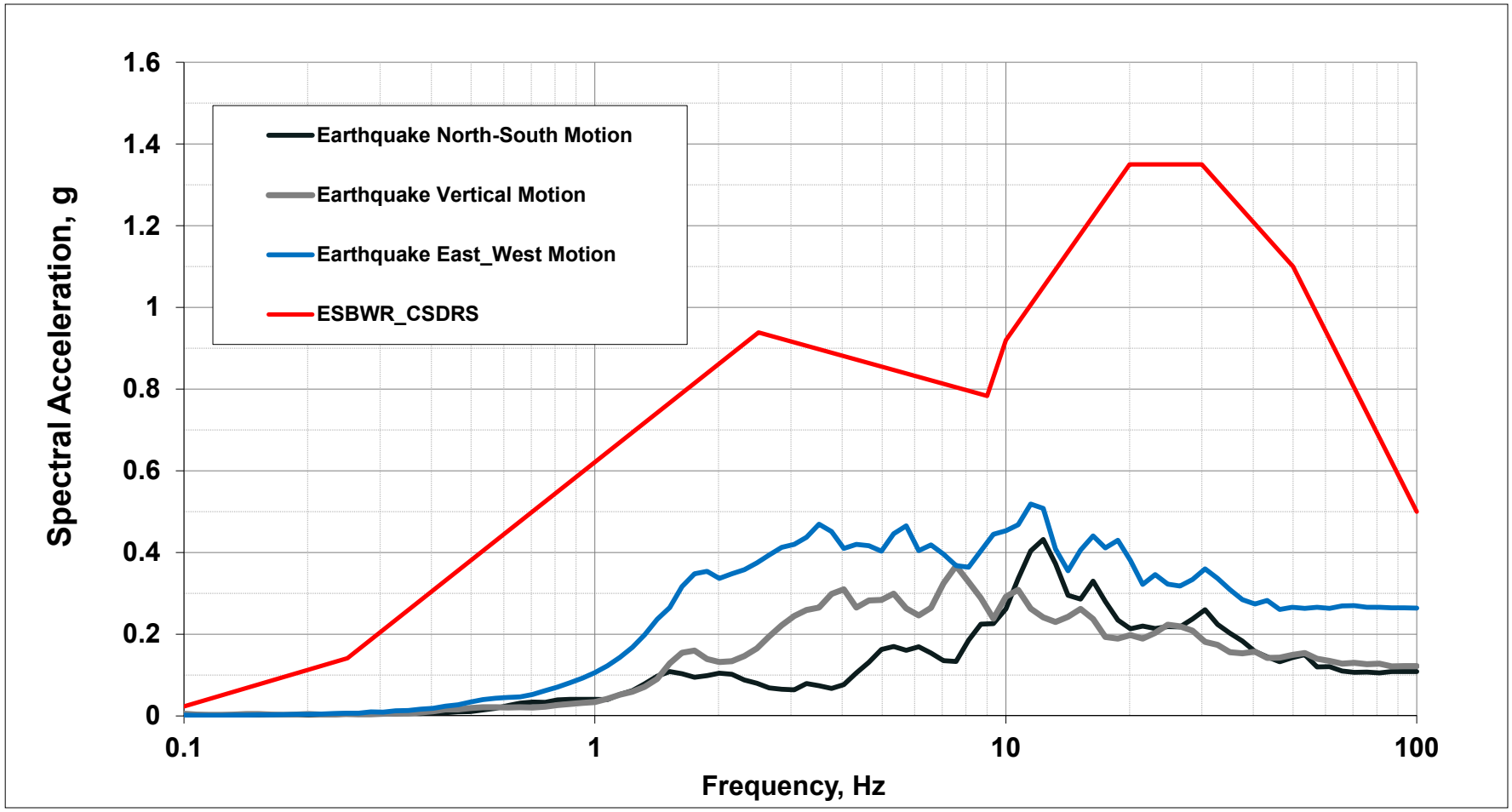
Vibratory Ground Motion

- Staff performed independent PSHA based on updated models
- Staff confirmed that the site-specific COLA ground motion response spectra (GMRS) envelope the North Anna 3 site variations (FSER Chapter 2 Section 2.5.2)

NA3 GMRS and ESBWR CSDRS



Mineral Earthquake Compared to ESBWR CSDRS



Conclusion

- **The site-specific GMRS adequately represents the seismic hazard at the NA3 site and meets the relevant regulatory requirements provided in 10 CFR Part 52 and 10 CFR Part 100**

Safety Panel Topic 2

CSDRS exceedances and its effect on NA3 site specific SSCs

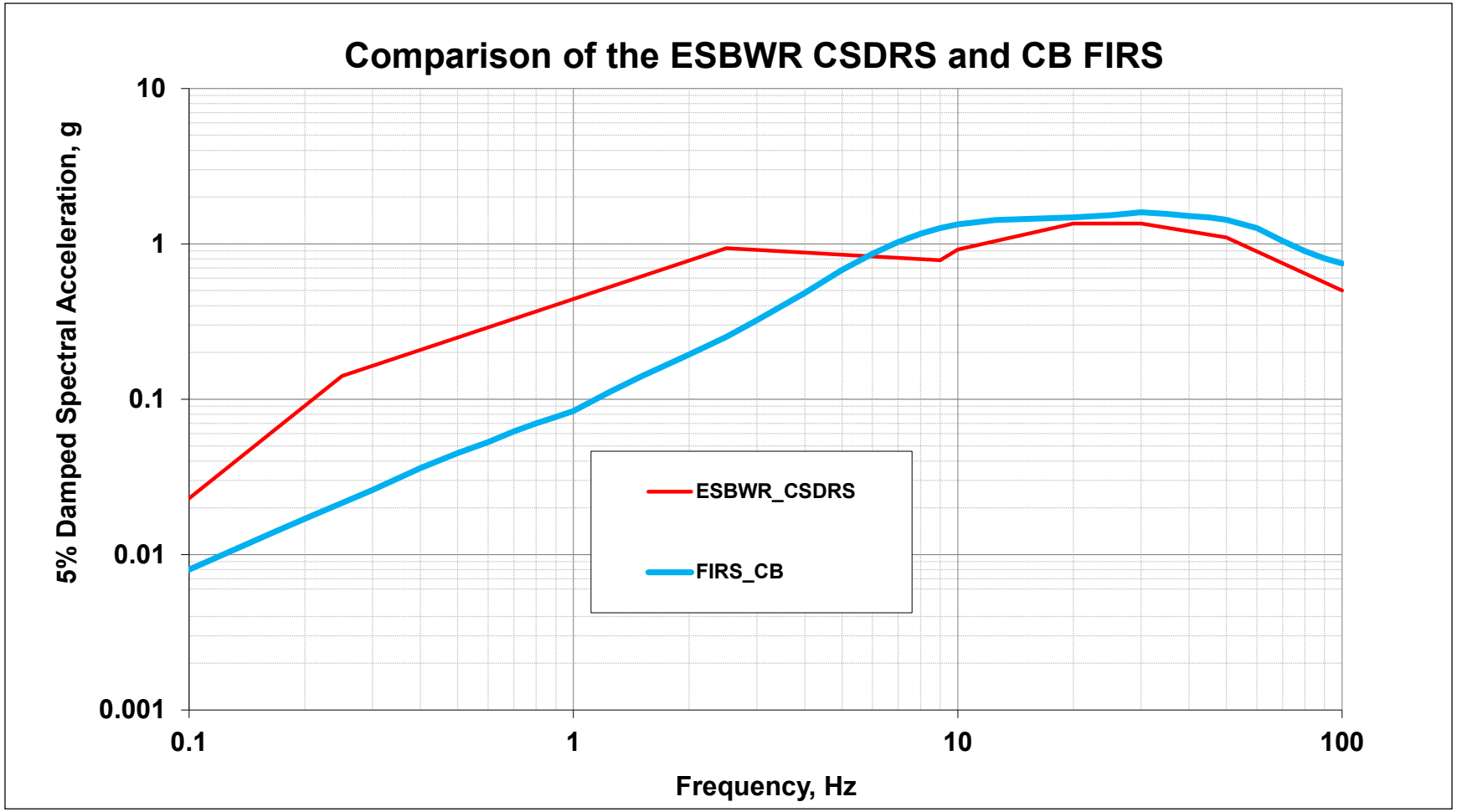
Manas Chakravorty – Senior Structural Engineer

Office of New Reactors

CSDRS exceedances affect NA3 site specific SSCs

- Staff evaluation of the NA3 site specific SSCs analysis evaluated in FSER Chapter 3 Section 3.7 and Section 3.8
- NA3 Departure 3.7-1
- NA3 Exemption 3

NA3 Site Foundation Input Response Spectra (FIRS)



Site-Specific Analyses

Because of this exceedance, the applicant performed:

- **Site-specific analysis to establish seismic demand using FIRS**
- **Site-specific evaluations of Category 1 structures, systems, and components**

Site-Specific Evaluation

- Soil-structure interaction (SSI) analysis was performed to establish the site-specific seismic demand
- Site-specific seismic demand including the In-Structure Response Spectra (ISRS) exceed DCD seismic demand

Site-Specific Evaluation

- Staff reviewed the standard design using the site specific seismic and standard design non-seismic loads which identified some site-specific design changes
- Site-specific required changes include arrangement of rebar, the size of shear ties, welds, anchor bolts and a steel girder

Site-Specific Evaluation

- Staff verified by audit and confirmatory analysis that site-specific seismic demands using the standard methodology required some minor changes to the standard ESBWR
- With these structural design changes, the design met ESBWR acceptance limits

Site-Specific Evaluation

- **Site-specific ISRS that exceed standard design ISRS are used for qualification of equipment and components**
- **ITAAC ensure that the Seismic Category I SSCs are qualified to the seismic design basis loads**

Conclusion

- **Staff confirmed that site-specific seismic loads and non-seismic standard loads with the identified design changes do not exceed structural acceptance limit of the ESBWR standard design**
- **Therefore, with the identified changes, the ESBWR design is acceptable at the NA3 site**

Safety Panel Topic 3

Fuel Assembly and Control Rod Structural Response

Matt Thomas –
Reactor Systems Engineer
Office of New Reactors

Increased Seismic Loads

- **NA3 site-specific seismic exceedances (NA3 DEP 3.7-1) cause increased accelerations at the fuel assembly and control rods**
- **Staff requested the applicant to perform an analysis to demonstrate that fuel assembly and control rod capacity limits are not exceeded under site-specific conditions**

Fuel and Control Rod Review

- The staff reviewed the applicant's site-specific analysis of the fuel assembly and control rod structural response using SRP 4.2 Appendix A
- The staff conducted an audit of the site-specific calculations to confirm that the applicant followed the DCD methodology

Conclusion

- **The staff found that the increase in the combined loading of the fuel assembly and control rod remains bounded by the approved capacity limits; therefore, the fuel assemblies and control rods meet GDC-2**

Acronyms

- CB – Control Building
- CEUS-SSC – Central and Eastern U.S. Seismic Source Characterization
- COL – Combined Operating License
- COLA – Combined Operating License Application
- CSDRS – Certified Seismic Design Response Spectra

Acronyms

- DCD – Design Control Document
- DEP – Departure from Standard Design
- EPRI – Electric Power Research Institute
- EPRI-SOG – Electric Power Research Institute – Seismic Owners Group
- ESBWR – Economic Simplified Boiling Water Reactor

Acronyms

- ESP – Early Site Permit
- FIRS – Foundation Input Response Spectra
- GDC – General Design Criteria
- GDC-2 – Appendix A to 10 CFR Part 50 - Criterion 2—Design bases for protection against natural phenomena
- GMRS – Ground Motion Response Spectra

Acronyms

- ISRS – In-Structure Response Spectra
- ITAAC – Inspections, Tests, Analyses, and Acceptance Criteria
- NA3 – North Anna 3
- NA1&2 – North Anna Units 1&2
  PSHA – Probabilistic Seismic Hazard Analysis
- SRP – Standard Review Plan

Acronyms

- SSCs – Structures, Systems, and Components
- SSE – Safe Shutdown Earthquake
- SSI – Soil-structure interaction
- UHRS – Uniform Hazard Response Spectra
- VAR – Variance to NA3 ESP