UNISTAR NUCLEAR ENERGY

NRC Public Meeting
Calvert Cliffs Nuclear Power Plant Unit 3

Discussion of COLA Site-Specific Seismic Analyses

November 1st, 2011

COLA Seismic Analysis Discussion Agenda

COLA Seismic Analysis Discussion Agenda

- Background and recent events
- Methodology and inputs used for seismic confirmatory analysis
- Summary of inputs and requests
- Comments and conclusion

- Background
- Meeting purpose
- Seismic closure scope
- Drivers of Seismic update
- Impacts of site specific seismic inputs

Background

- March 31, 2011 - UniStar submits the results of the qualitative approach to Seismic Reconciliation in CCNPP3 COLA Update
- June 23, 2011 - NRC presents the results of their review of COLA update and; basically states that a quantitative approach is needed to reconcile the CCNPP3 site characteristics
- July 12, 2011 - NRC issues Near Term Fukushima Task Force Report
- August 3, 2011 - NRC issues CCNPP3 Seismic RAI's 314 and 315
- August 23, 2011 - UniStar submits a letter agreeing to perform a quantitative reconciliation
- August 23, 2011 - Mineral, VA Earthquake occurs
- September 1, 2011 – NRC issues Draft Generic Seismic Letter
- Forecasted January 2012 – EPRI/NRC/DOE CEUS Seismic Source Model Report will be issued
- Forecasted 2015 – New Industry Earthquake Attenuation Model

Meeting Purpose

- The purpose of this meeting is to describe UniStar's schedule, approach, methodology, and inputs being used to address:
  - the NRC requests related to seismic confirmatory analyses contained in RAI's 314 and 315
  - the impact of the Mineral, VA Earthquake (RAI 322) and,
  - the EPRI/NRC/DOE CEUS Seismic Source Model

  as related to the seismic analysis, reconciliation, and design of CCNPP3 and;
- To obtain NRC's comments/agreement with UniStar's approach

Seismic Closure Scope

- Seismic Category I Structures
  - Confirmatory Analyses
    - Nuclear Island
    - Emergency Power Generation Building
    - Essential Service Water Building
  - Design Basis Analysis
    - Common Basemat Intake Structure
- Seismic Category II Stability Analyses
  - Confirmatory Analysis
    - Nuclear Auxiliary Building
  - Design Basis Analyses
    - Combined Turbine Building/Switchgear Building
    - Access Building

Primary Drivers of Seismic Update

- Site Specific Seismic Input
  - New Madrid Earthquake Impact (RAI 284)
  - Mineral, VA Earthquake Impact (RAI 322)
  - EPRI/NRC/DOE CEUS Seismic Source Model & Attenuation Model
  - Fukushima event resolution/Generic Issue 199, Draft Generic Letter (EPRI/NRC/DOE CEUS Seismic Source Model referenced)
- US EPR Generic Structures Analysis Methods
  - Stick Model versus Finite Element Model
  - Embedded Structures
  - Qualitative versus Quantitative Seismic Reconciliation (RAI's 314 & 315)
- License Application Information Required for Seismic Category II Structures
  - Analysis and Design Methods
  - Stability Analysis Results (RAI 315)

Schedule Impact of Site Specific Seismic Input

- New Madrid Earthquake evaluation factored into overall schedule provided in UniStar's August 23rd letter to the NRC
- Mineral, VA Earthquake could be addressed in the short term
- EPRI/NRC/DOE CEUS Seismic Source Model will result in postponement of the Seismic Reconciliation Process by:
  - the duration required to issue the new EPRI/NRC/DOE Report (valid approach to resolve the seismic portion of Fukushima event)
  - plus the duration required by the NRC to implement the new EPRI/NRC/DOE Report for new plants
  - plus the duration required for UniStar to assess the EPRI/NRC/DOE Report and update the CCNPP3 GMRS (UniStar will verify impact prior to proceeding with the Seismic Analyses)
- New Attenuation Model (Impact Unknown)

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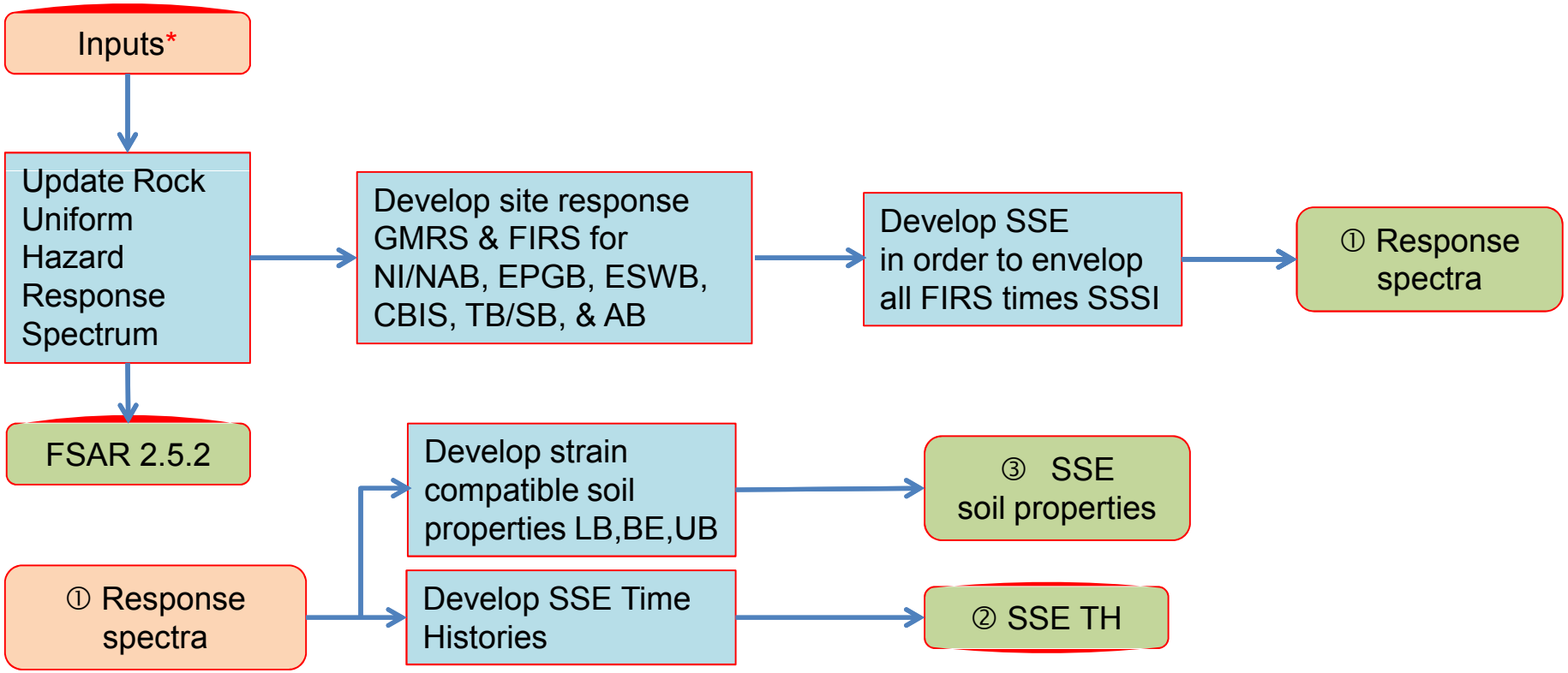
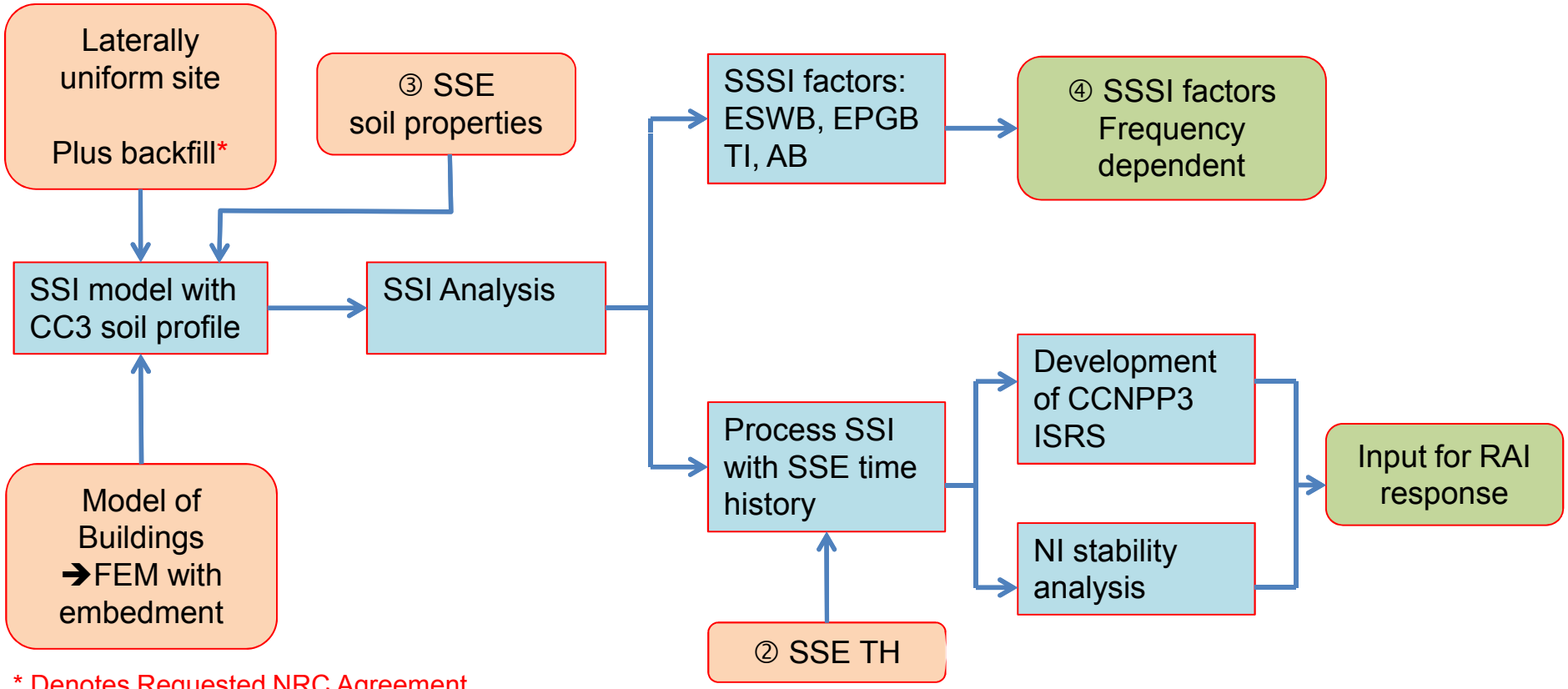
- Seismic update process
- Structure specific analysis inputs
- NRC's Comments / Agreement

Seismic Update Process
Development of Site Specific Seismic Input



* Denotes Requested NRC Agreement

Seismic Update Process
Confirmatory Analysis of Nuclear Island



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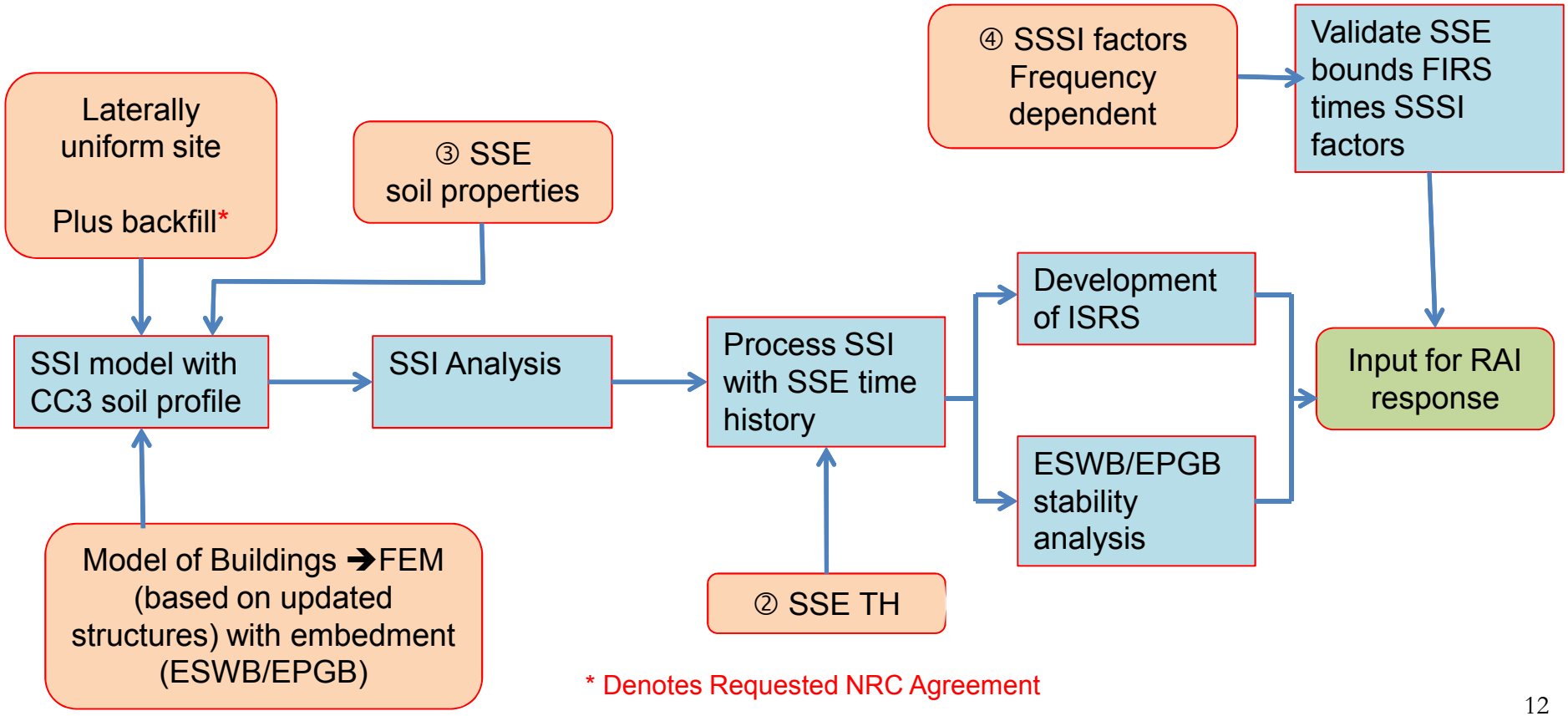
Seismic Update Process
Confirmatory Analysis of ESWB/EPGB



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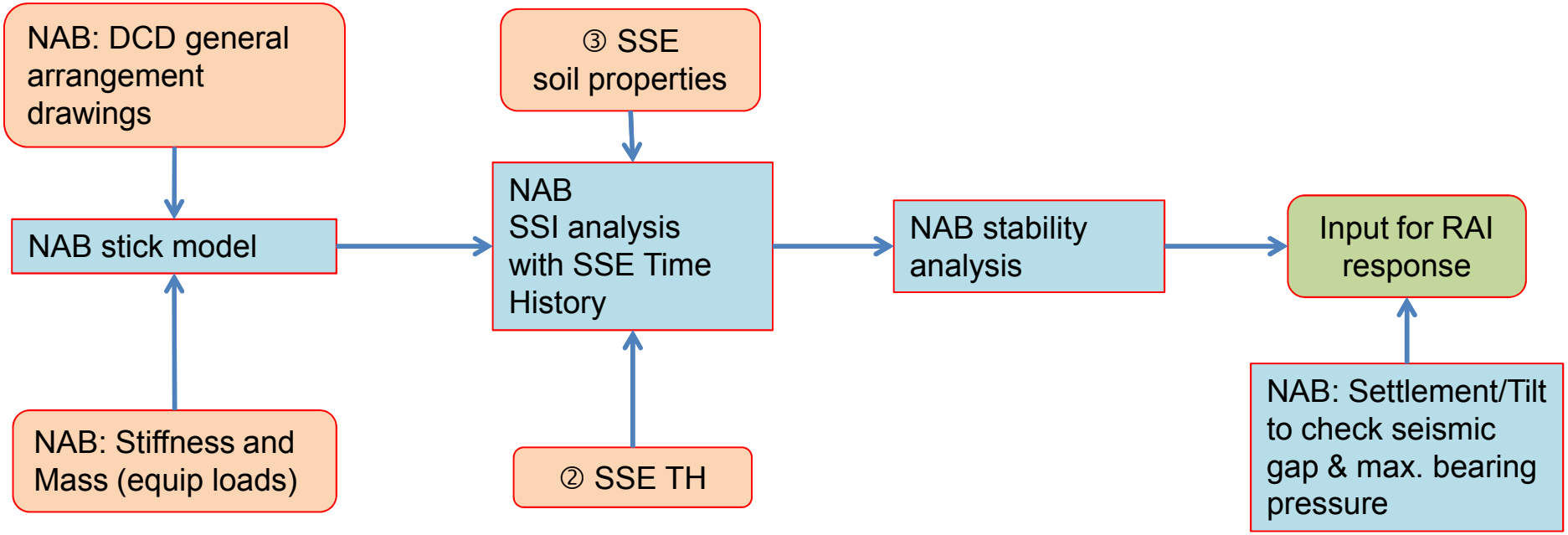
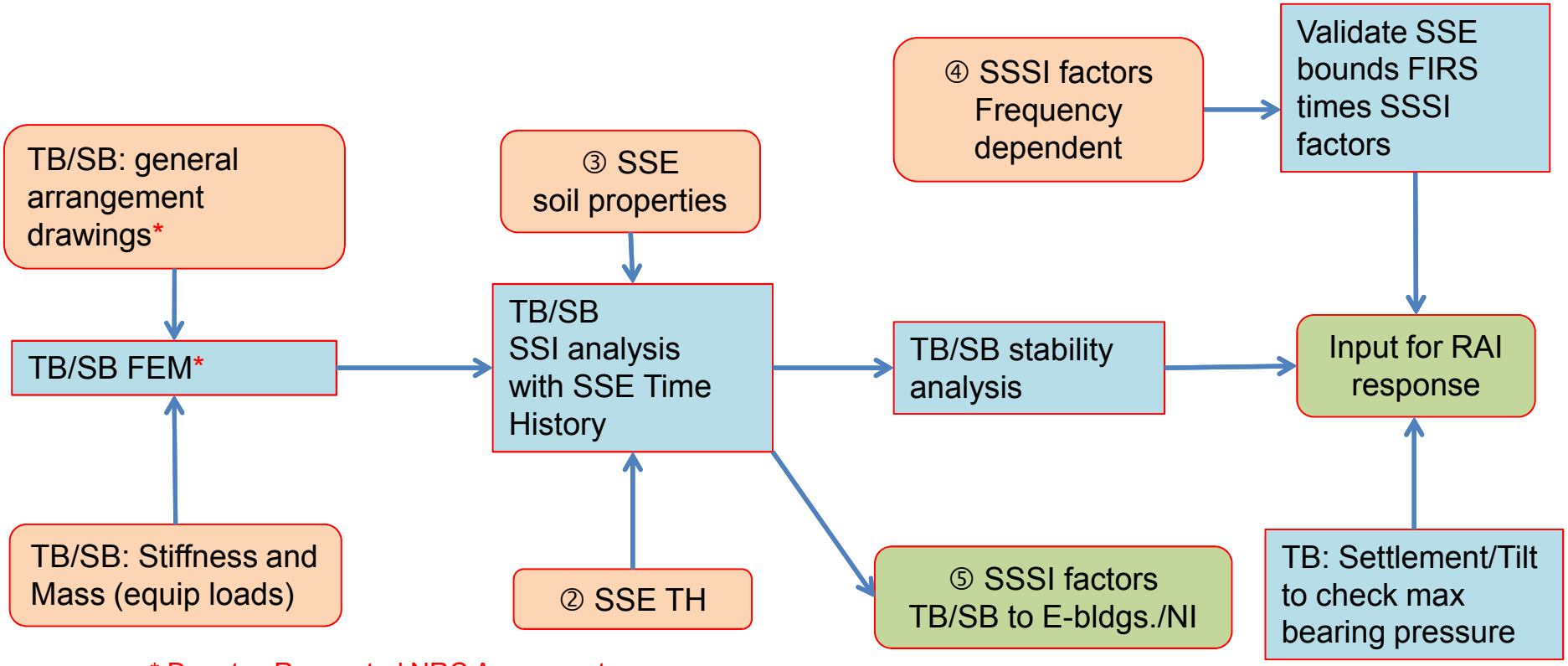
Seismic Update Process
Confirmatory Analysis of Nuclear Aux Bldg.



Seismic Update Process
Design Basis Analysis of Turbine Island



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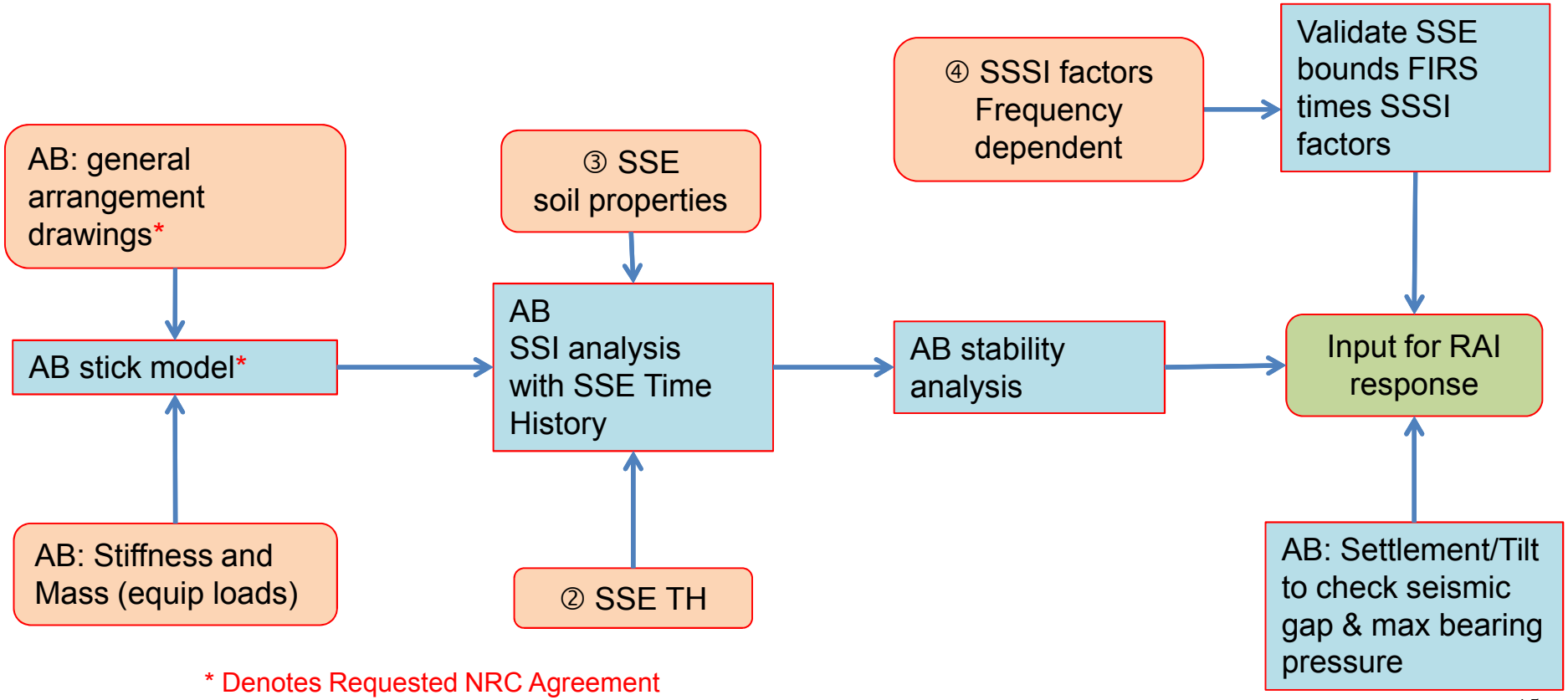
Seismic Update Process
Design Basis Analysis of Access Bldg.



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Structure Specific Analysis Inputs

- Multiple Building Locations (EPGB & ESWB)
- Stick Models versus Finite Element Models
- Choice of Soil Columns (One Native Soil Column per Building Group)
  - Embedment Depth
  - Backfill/Native Soil Column
  - Lateral Uniformity of Site Soil Profile (see RAI 276 Question 02.05.04-29)
  - LB, BE, and UB Shear Wave Velocity Profiles
- OBE Damping versus SSE damping
- Seismic Stability Analyses
- Differences between U.S. EPR FSAR Generic Seismic Analyses and CCNPP3 Analyses

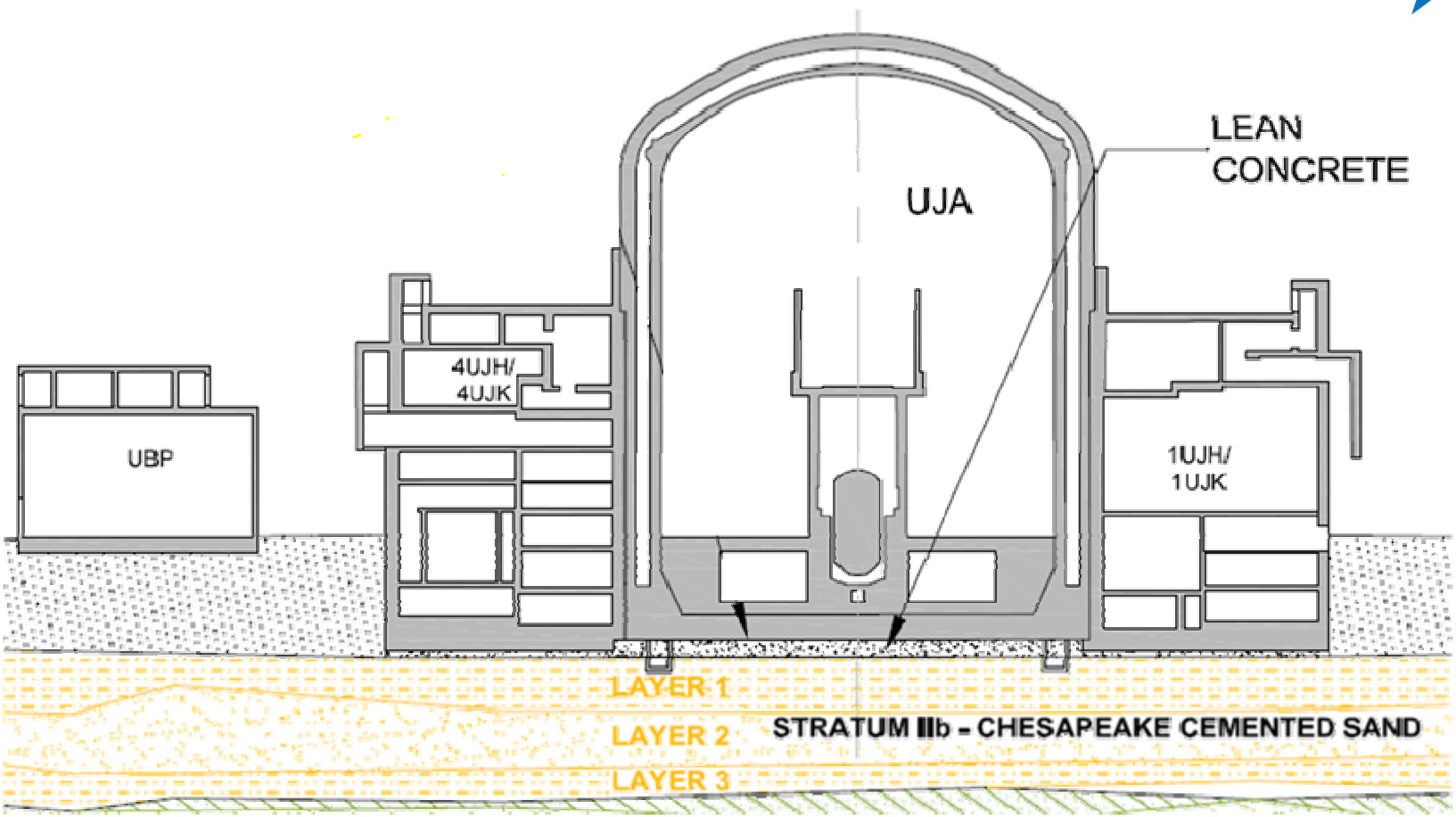
Multiple Building Locations

- Confirmatory Seismic Analyses of EPGB's will be performed using one Soil Structure Interaction Model
- Confirmatory Seismic Analyses of ESWB's will be performed using one Soil Structure Interaction Model
- Basis for this approach is lateral uniformity of site soil profile and relatively consistent backfill depths

Stick versus Finite Element Models

- Confirmatory Analyses will use the same model type as US EPR FSAR
  - Nuclear Island, EPGB, and ESWB are Finite Element Models
  - Nuclear Auxiliary Building is a Stick Model integrated with the FEM of the Nuclear Island in SASSI, and a 3D FEM for stability analysis
- Design Analyses
  - Finite Element Models
    - Category I Common Basemat Intake Structure
    - Category II Turbine Building/Switchgear Building
  - Stick Models
    - Category II Access Building

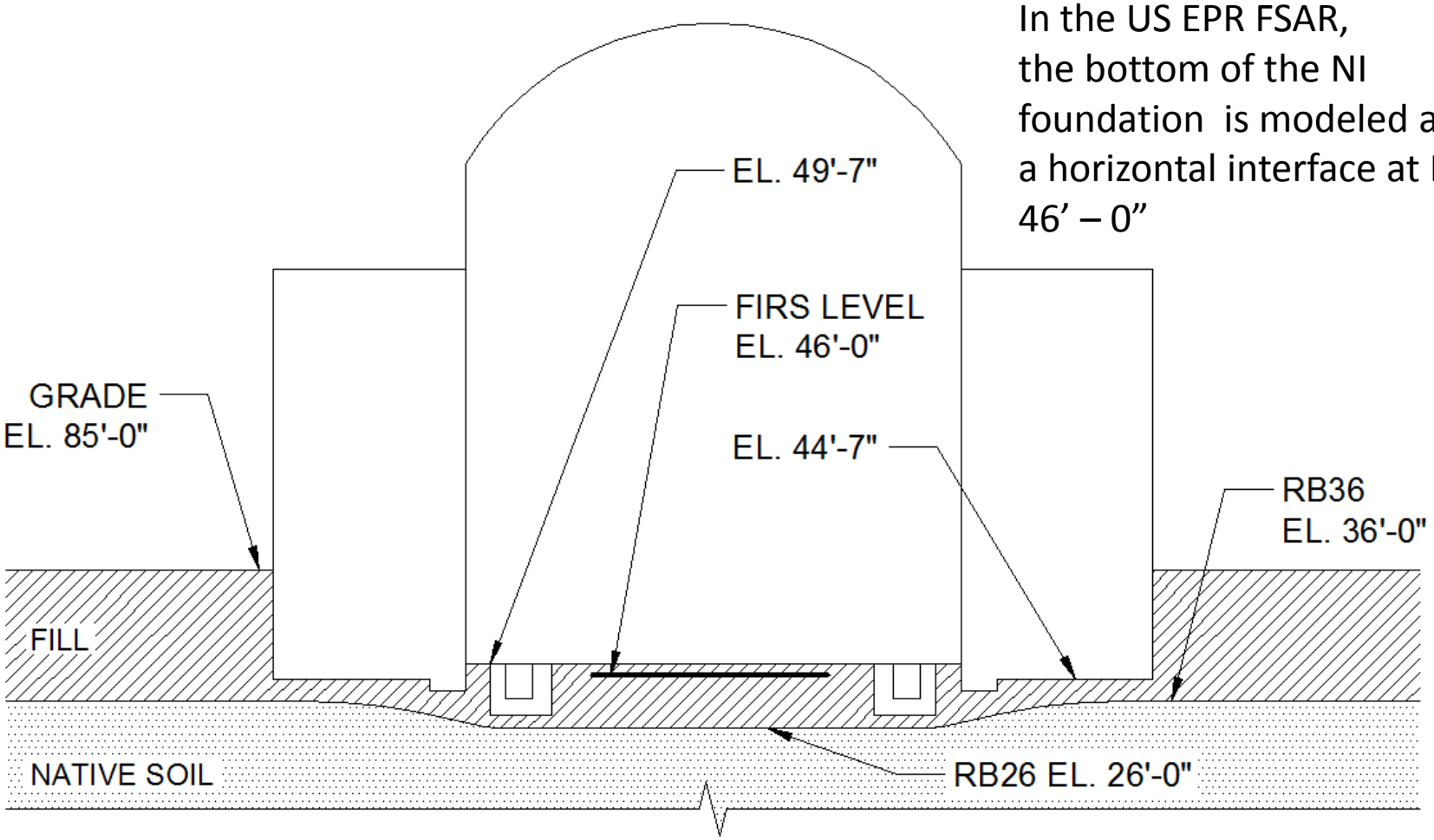
Choice of NI Backfill Soil Column



Influence of Backfill: Previous Configuration

Choice of NI Backfill Soil Column

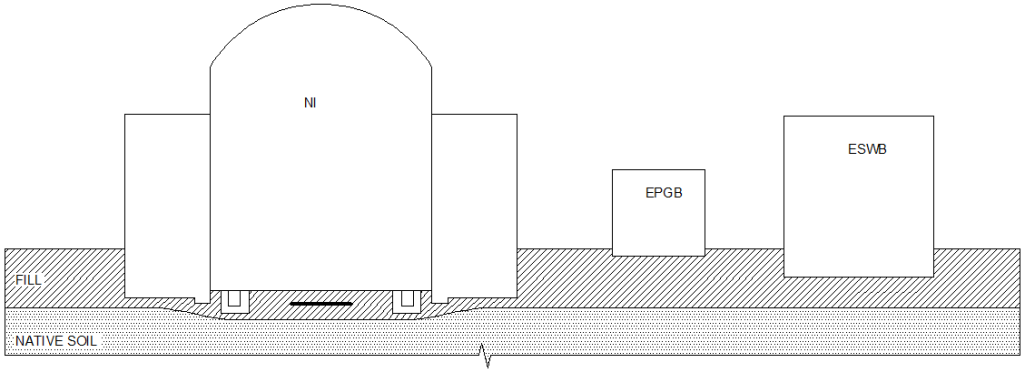
In the US EPR FSAR, the bottom of the NI foundation is modeled as a horizontal interface at EL 46’ – 0”



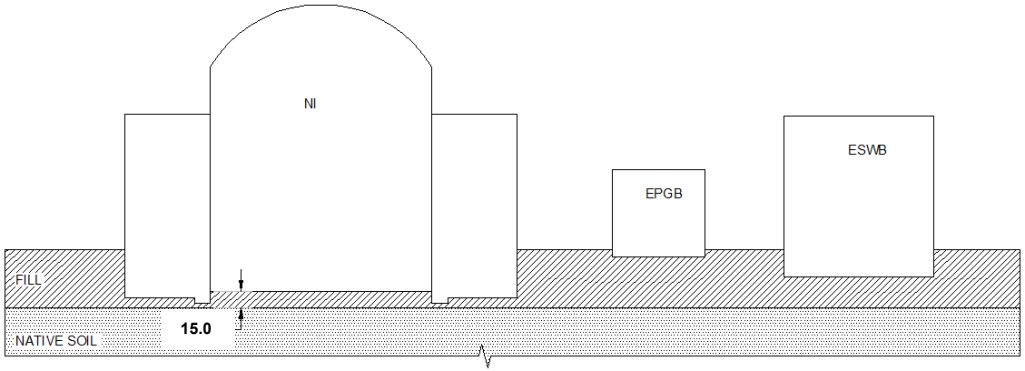
Influence of backfill: New Fill Configuration

Choice of Soil Column: Conclusion

Fill-Native Soil interface elevation is uniform and shear wave velocity profile the same at all locations



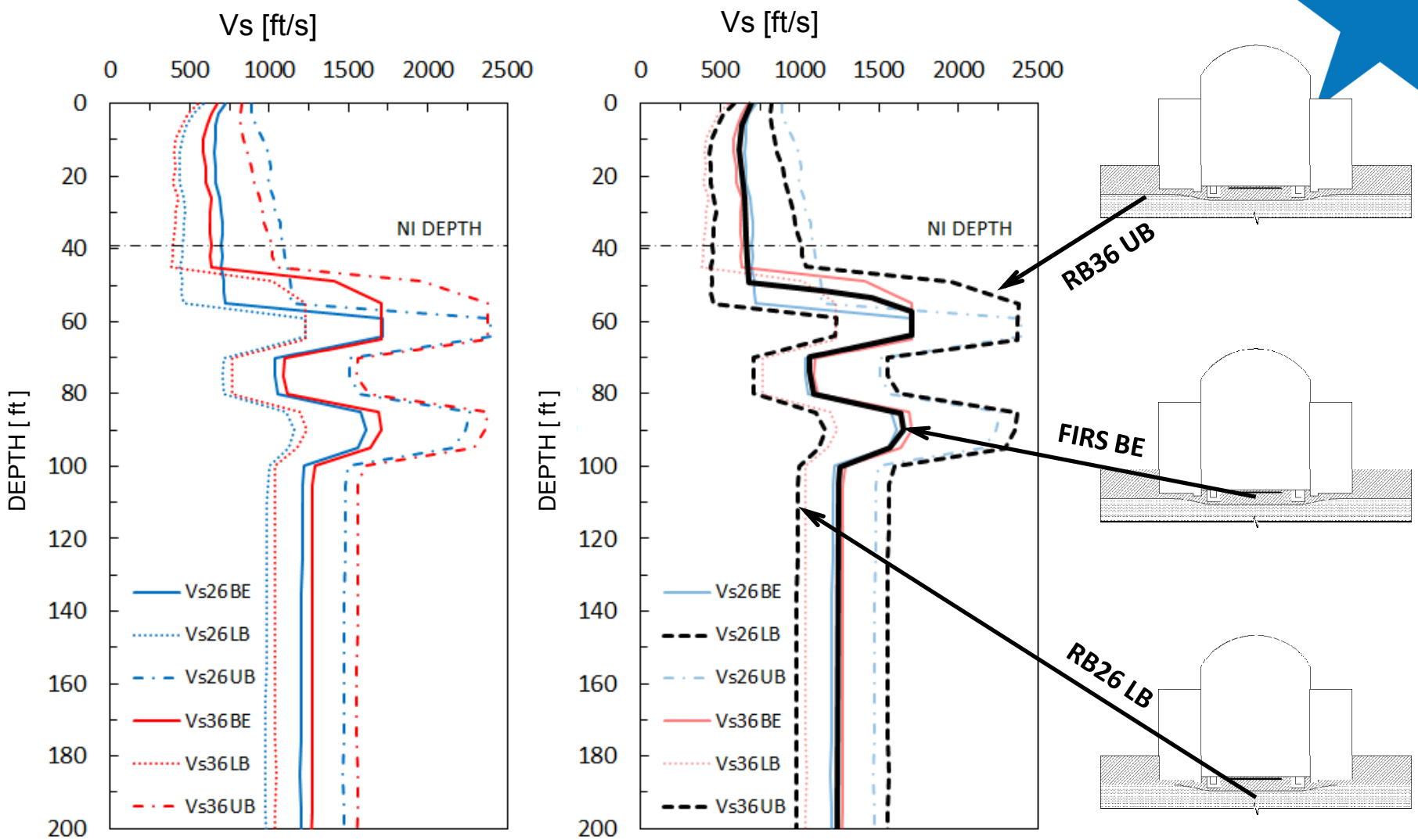
One average backfill soil profile is used for each for each group of buildings



This approach is consistent with:

- The level of accuracy required for a confirmatory analysis
- The technical capabilities of SASSI software

Choice of Soil Column: Conclusion



SSI Soil Profiles

Selection of OBE or SSE Damping

- In developing CCNPP3 In-Structure Response Spectra for comparison with US EPR FSAR spectra, CCNPP3 **confirmatory analyses** will use OBE structural damping
  - Eliminating the question of structural response compatibility with higher damping
- **Design Analyses of Category I** Common Basemat Intake Structure uses SSE damping for design and OBE damping for development of ISRS
- **Stability Analyses of NAB (Cat II structure)** will use OBE damping, as it is generically designed to the US EPR CSDRS
- **Stability Analyses of other Category II** Structures will use SSE damping

Seismic Stability Analyses

- Coefficients of Friction for each of the Seismic Category I and II structures is based on values for each of the backfill, soil, and waterproofing interfaces (Refer to COLA Table 3.8-1)
- Common Basemat Intake Structure analysis was based on two different soil characterizations:
  - Case 1: a 0.6 friction value
  - Case 2: a 0.21 friction value with 1.2 ksf adhesion
  - Case 1 was determined more critical than case 2
- Passive Soil Pressure resistance is conservatively neglected for each of the Seismic Category I and II structures
- Common Basemat Intake Structure takes benefit of side wall friction
- COLA Design Results for Category II Structures limited to Stability Analyses

Differences between U.S. EPR FSAR Generic Seismic Analyses and CCNPP3 Analyses

OBE versus SSE Structural Damping

- Comparison of In-Structure Response Spectra
  - US EPR FSAR uses SSE damping,
  - CCNPP3 uses OBE damping
- Stability analysis of NI, EPGB and ESWB
  - US EPR FSAR uses SSE damping,
  - CCNPP3 uses OBE damping
- Stability analysis of the NAB
  - US EPR FSAR uses SSE damping,
  - CCNPP3 uses OBE damping

Differences between U.S. EPR FSAR Generic Seismic Analyses and CCNPP3 Analyses

Concrete Cracking

- Comparison of In-Structure Response Spectra
  - US EPR FSAR analyzes both cracked and un-cracked concrete
  - CCNPP3 uses un-cracked concrete section properties
- Stability analysis of NI, EPGB and ESWB
  - US EPR FSAR uses cracked and un-cracked concrete properties
  - CCNPP3 uses un-cracked concrete section properties
- Stability analysis of the NAB
  - US EPR FSAR uses cracked concrete properties
  - CCNPP3 uses un-cracked concrete section properties
- The use of un-cracked concrete section properties is:
  - consistent with the site specific SSE level when applied to structures designed to the US EPR CSDRS
  - Any additional response due to cracked concrete would be covered by the margin in the standard plant design

Differences between U.S. EPR FSAR Generic Seismic Analyses and CCNPP3 Analyses

- Coefficient of Friction for Building Stability Analyses
  - US EPR FSAR uses 0.5, CCNPP3 uses lower site-specific values in site specific analysis
  - US EPR FSAR includes benefit of 0.36 for EPGB side walls, CCNPP3 does not take benefit of side wall friction
- Passive Soil Pressures for Stability Analyses
  - US EPR FSAR includes benefit of resisting pressures in stability analyses, CCNPP3 does not
- Passive Soil Pressures for the Design of Embedded Walls
  - US EPR FSAR is designed for passive pressures which are adequate for any CCNPP3 site-specific conditions

COLA Seismic Analysis Discussion Agenda

- Background and recent events
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- Summary of requests
- Summary of inputs

Summary of RAI 314 Requests

RAI No./Question	Structure	Requested Action	UniStar Response
314/03.07.01-16	Nuclear Island (NI)	Provide quantitative comparison of In-Structure Response Spectra (ISRS) based on embedded Finite Element Model (FEM)	Will provide ISRS comparison based on CCNPP3 site specific seismic analysis using the embedded FEM model, including the influence of the backfill beneath the NI
314/03.07.01-16	NI	Provide quantitative comparison of mat design loads	Peak basemat toe pressure from US EPR generic analysis will be compared to that obtained from CCNPP3 site specific finite element analysis
314/03.07.01-16	EPGB & ESWB	Confirm that the seismic input motion is less than the modified CSDRS used for the generic design of these buildings	Will develop EPGB and ESWB input motion from the NI Soil-Structure seismic analysis to take into account the influence of the NI on the EPGB and ESWB

Summary of RAI 314 Requests

RAI No./Question	Structure	Requested Action	UniStar Response
314/03.07.01-17	Common Basemat Intake Structure (CBIS)	Impact of backfill on building frequency response	No backfill beneath CBIS
314/03.07.01-17	Many	Provide ITAAC shear wave velocity criteria for the NI, CBIS, and Seismic Category II structures	Will provide shear wave velocity criteria for NI, CBIS, and Seismic Category II structures developed in the same manner as the existing EPGB and ESWB

Summary of RAI 315 Requests

RAI No. & Question	Structure	Requested Action	UniStar Response
315/03.07.02-62	Nuclear Auxiliary Building (NAB)	Perform a complete stability analysis and provide: • Seismic Input • Model • Coefficients of friction	Respond as requested.
		• Consideration of sidewall pressures • Seismic capacities considered in stability evaluation • Method to determine and compare peak and allowable bearing pressure • Stability factors of safety • Net displacement between NI and NAB	
315/03.07.02-63	Turbine/ Switchgear Building & Access Building	Provide seismic analysis and stability evaluation methods similar to those listed for the NAB above and stability results as discussed for the NAB above. Provide design results ITAAC.	Respond as requested.

Summary of RAI 315 Requests

RAI & Question	Structure	Requested Action	UniStar Response
315/03.07.02-64	EPGB & ESWB	Provide methodology, seismic input, and seismic models for stability evaluations similar to that described above for the NAB plus: • Address adhesion • Lateral soil pressure treatment	Respond as requested.
315/03.07.02-64	NI	Provide stability evaluation information as requested for EPGB and ESWB above, including the impact of the structural backfill	Respond as requested.
315/03.07.02-64	CBIS	Provide stability evaluation information as requested for the EPGB & ESWB above, including how side wall friction was considered	Respond as requested.
315/03.07.02-65	ESWB	Determination of lateral soil pressures during seismic loads	Respond as requested.
315/03.07.02-66	EPGB & ESWB	Seismic analyses should include redesign of US EPR generic structures	Analyses will be based on updated US EPR building arrangements

Summary of Mineral, VA earthquake RAI 322

RAI & Question	Structure	Requested Action	UniStar Response
2.05.02-23	All Seismic Category I and II Structures	1) review the adequacy of the each of the Earth Science Teams source models that incorporate this earthquake (including the Law Engineering Team) in terms of the maximum magnitude probability distribution, source geometry, probability of activity, and seismicity rates; and 2) address the impact of any necessary modifications to CVSZ on the GMRS.	Respond as requested. This effort is a new precursor to the CCNPP3 seismic reconciliation effort

Structure Specific Analysis Inputs Summary: Confirmatory Analysis Category I Structures

Structure	No. of Building Locations/ Model	Modeling Technique	Seismic input	Structural Damping	Concrete Cracking Assumption	Backfill Depth	Embed Depth	No. of Shear Wave Velocity Profiles	Coefficient of Friction & Passive Earth Pressure
Seismic Category I									
Confirmatory Analyses									
Nuclear Island	1/1	SSI FEM same as US EPR	Site specific SSE applied as Shake outcrop at bottom of NI foundation elevation	OBE Damping	uncracked	10-20 ft under the basemat	39 feet El. 46'	1 – LB, BE, UB	COLA Table 3.8-1 Passive Earth
			(Bounding FIRS applied as Shake Out crop at bottom of NI foundation level)						Pressure not used for stability
Emergency Power Generating Building	2/1	SSI FEM same as US EPR	Site specific SSE applied as Shake outcrop at EPGB bottom of shear key elevation (Bounding Modified FIRS[1] applied as Shake Out crop at EPGB bottom of shear key level)	OBE Damping	uncracked	32.5 feet under the shear key	11 feet El. 74'	1 – LB, BE, UB	COLA Table 3.8-1 Passive Earth Pressure not used for stability
Essential Service Water Building	4/1	SSI FEM same as US EPR	Site specific SSE applied as Shake outcrop at bottom of ESWB foundation elevation (Bounding modified FIRS[2] applied as Shake Out crop at ESWB bottom of foundation level)	OBE Damping	uncracked	12.5 feet under the basemat	31 feet El. 54'	1 – LB, BE, UB	COLA Table 3.8-1 Passive Earth Pressure not used for stability

[1]Modified FIRS = Frequency dependent SSSI factors x EPGB FIRS at bottom of shear key
[2]Modified FIRS = Frequency dependent SSSI factors x ESWB FIRS at bottom of foundation
SSSI factors are frequency dependent factors determined from ratio of EPGB/ESWB surface footprint spectra divided by NI surface motion input spectra from NI SASSI analysis (> or = 1.0)

Structure Specific Analysis Inputs Summary: Design Basis Category I Structure

Structure	No. of Building Locations/Model	Modeling Technique	Seismic input	Structural Damping	Concrete Cracking Assumption	Backfill Depth	Embed Depth	No. of Shear Wave Velocity Profiles	Coefficient of Friction & Passive Earth Pressure
Seismic Category I									
Design Basis Analysis									
Common Basemat Intake Structure	1/1	SSI FEM	Site specific SSE applied as Shake outcrop at bottom of the base mat	Design –SSE ISRS - OBE	Partially cracked based on stress level	None	37.5 feet	1-LB, BE, UB	COLA Table 3.8-1 Passive Earth Pressure not used for stability Side friction - stability

Structure Specific Analysis Inputs Summary: Category II Structures

Structure	No. of Building Locations/ Models	Modeling Technique	Seismic input	Structural Damping	Concrete Cracking Assumption	Backfill Depth	Embed Depth	No. of Shear Wave Velocity Profiles	Coefficient of Friction & Passive Earth Pressure
Seismic Category II Stability Analyses									
Confirmatory Analyses									
Nuclear Auxiliary Building	1/1 – combined with NI Model	3D ANSYS FEM model time history analysis with Site Specific SSE	Developed from NI SSI analysis with site specific SSE	OBE Damping	Un-cracked	Same as NI	Same as NI	Same as NI	Same as NI
Design Basis Analyses									
Turbine Island (TB/SB)	1/1	SSI FEM Based on GA Drawings	Site specific SSE applied as Shake outcrop at bottom of TB/SB foundation elevation (Bounding modified FIRS)	SSE Damping	cracked	21 feet under the basemat	28 feet EL. 57'	1-LB, BE, UB	0.52 Mud Mat – Structural Fill
Access Building	1/1	SSI Stick Based on GA Drawings	Site specific SSE applied as Shake outcrop at foundation of AB (Bounding modified FIRS)	SSE Damping	cracked	12 feet under the basemat	37 feet EL. 48'	1-LB, BE, UB	0.52 Mud Mat – Structural Fill

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NRC feedback on:

- Proposed methodology
- Consideration of EPRI/NRC/DOE CEUS Data

Needed by UniStar to provide updated schedule by Nov. 30th