Audit of Site-Specific Seismic Input/Demand and the Supporting Analyses (FSAR Section 3.7)

Notes from Dominion NA3 COLA Seismic Update Meeting with NRC April 15, 2015

Action Item Number	Slide Number	NRC or Other Comment Description	Action Assignment	Status
1	General	The staff requested that GEH justify cases with lower passing frequencies (General). This was identified on slide 7 (32 Hz for Full Column LB), and slide 101 (30 Hz for Full Column LB) Action 1 Example: For Slide 7, the NRC asked for justification for the 83 percent captured motion energy for the RB/FB full column LB 32 Hz cases to ensure that, had the LB soil column cases been refined such that their passing frequencies were not lower than 50 Hz, the responses from these refined LB cases are still bounded by the BE and UP cases.	DOM	Open – Passing frequencies have been refined. Reports, RAIs, and July FSAR markups will include changes
2	26	The staff questioned the ISRS results for CB basemat response because ZPA values appear to be less than the PGA.	DOM	Open – Subject is addressed in App. B of CB SSI report
3	FWSC General RB/FB and CB See Slides 27 and 94	The staff requested that DOM demonstrate that soil separation does not impact concrete fill below the FWSC. The staff also requested that DOM check whether the unreinforced concrete fill has sufficient capacity to resist the seismic shear stress, considering the vertical seismic load and buoyance force to reduce the shear capacity.	DOM	Open

Attachment 1

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4	32	Slide 32 states that SDOF oscillators' properties are presented in Technical Report SER-DMN-014, Revision 0 which will be provided for the staff review via eRoom. The staff stated that this is very difficult to review in eRoom and that all reports should be docketed if they support the RAI response.	DOM	Closed – Report submitted 6/3/15 (Letter NA3-15-011)
5	54	The staff cannot distinguish the DCD line from other lines in the graphs. Graphs should be revised to use different line style and/or thickness for the DCD line to facilitate NRC review.	DOM	Open – Addressed in reports and July FSAR markups
6	80	The staff questioned the conclusion that the peaks in the outcrop motion TFs are numerical. Since the SHAKE TFs are smooth as shown on Slide 77, this suggests that the peaks in the TFs may be from SASSI analysis. The staff requested that DOM improve the accuracy of the TFs or justify why those numerical peaks would not impact the responses. The TFs should be provided in the relevant technical report(s) for staff's review.	DOM	Open – Addressed in reports, RAI, and July FSAR markups
7	FWSC General	The staff questioned the details of anchorage of the FWSC to the concrete fill. The details will need to be evaluated.	DOM	Open
8	89	The staff observed that in Slide 89, the top two graphs show the UB curve going below the BE curve.	DOM	Open – Addressed in FWSC report
9	General	NRC suggests that a summary table of cases, base cases, and sensitivity studies (similar to the table in the SCP) be added to the FSAR to facilitate the staff review.	DOM	Open – Included in applicable reports and July FSAR markups
10	122	Since the FWSC-CB SSSI effects are impacting the responses, the staff questioned whether there are any other neighboring buildings that could contribute to the SSSI effects of the CB and FWSC in the x-direction (perpendicular to the two buildings). As such, please	DOM	Open- Addressed in RAI 3.7.2-16 and July COLA markups

		justify why the potential effect of SSSI on other Category I structures (RB/FB) considering the structures aligned in another direction (e.g., RB/FB-TB) will not be important.		
11	General	The staff recommended that an ITAAC may be required if the structural properties of the soil profiles is impacting the SSI/SSSI responses.	DOM	Letter End of July
12	SSE/OBE Damping	The staff discussed the acceptability of applying SSE damping to uncracked concrete stiffness per the RG 1.61.	DOM	Closed 4/29/15. NRC's initial review results: satisfied with use of damping values
13	169	The site specific conditions V&V questions related to whether or not the problems are representative of NA3 site and soil conditions. For example, the S and P wave velocities seem too high for the NA3 site. Look at these problems. Consider what S&L did for EF3 (took an average Shear Wave Velocity and extrapolated it for the V&V problem(s)). There were also questions regarding whether or not the Day solution could be used for a meaningful comparison or if the better approach is to refine the mesh. The staff particularly reviews those V&V problems that are applicable to the NA3 conditions; therefore, increasing the shear wave velocity or decreasing the mass density to increase the passing frequency may invalidate the affected V&V problems and new V&V would be needed.	DOM	Open – Addressed in V&V report and RAI 3.7.2-26
14	3.7.1	The staff requested the figures showing the NEI check was met by comparing PBSRS with the envelope of surface response spectra obtained from final SSI input time-histories at the surface of the LB, BE, and UB soil columns.	DOM	Open – Addressed in July COLA markups

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15	3.7.1	The staff also noted that parameters were not included to show how they compared to the earthquake seed. Are they higher or lower? Why is that acceptable? Provide comparison of the characteristic values (V/A, AD/V^2) for the site-specific input time histories with those of the controlling earthquakes (see SRP 3.7.1) and provide justification of any inconsistencies.	DOM	Open - Addressed in July COLA markups
17	V&V ACS-SASSI	The staff requests assurances that V&V are adequate for ACS-SASSI if using this for NA3 SSI results.	DOM	Open - Report submitted 5/29/15 (Letter NA3-15-009) (Appendix I of RB/FB Seismic Analysis Report)
18		The NRC asked (as part of its summary of its understanding of the presentation preliminary results) about RPV support brackets. NOTE: DOM pointed the NRC to DCD Figure 3G.1-57, "RPV Support Bracket and Vent Wall."	NRC	Open – Will be addressed in structural design report
19		The presentation did not include any results showing the effect of stiffness variation on FWSC seismic demand and ISRS.	DOM	Open – Addressed in FSWC report
20		Because the SSSI results are found important in some cases, the response to RAI 3.7.1-7 should be updated with the SSSI results to address the effects of backfill on the seismic responses of the CB and the FWSC.	DOM	Open- RAI response will be revised
21		The staff has reviewed the Reference Letter NA3-14-044R and has the following comments: (1) In FSAR Section 3.7.1, the applicant referenced Figures 2.0-201 through 2.0-204 for the site-specific design ground motions. However, since the FWSC is also designed for the control motion applied at Elevation 220 ft., it should also be referenced.	DOM	Open – Addressed in July FSAR markup

		(2) SSE design ground motions for plant design along with the OBE for plant shutdown have been defined in the FSAR Section 3.7.1. Section 3.7.4 also establishes the details of the plant shutdown OBE. However, Section 3.7.1.1.6 in the FSAR introduces another terminology "site-dependent at Grade SSE response spectra. Since the SSE ground motions for design purposes and shutdown OBE have already been defined in Section 3.7.1 and 3.7.4, the staff does not understand the purpose of this Section.		
22	Strain compatibile soil profile data (Letter NA3-15-003, 4/27/15)	In the 8 files for strata profiles contained in Enclosure 3 of the Dominion Transmittal Reference NA3-15-003, there are many NaN (Not A Number, for example IEEE defines 0/0=NaN) entries that appear to occur at the same elevations for certain simulated profiles. The staff requests that the applicant explain (1) how the NaN entries in the strata profiles were obtained from the simulated soil profiles that do not have any NaN entries, (2) whether the strata profiles have been used in any downstream analyses, and (3) how these NaN entries were treated if they were used.	DOM	Open (see responses at the end of this document)
23	Strain compatibile soil profile data (Letter NA3-15-003, 4/27/15)	The staff can confirm how the median and LOG SD in the 8 soil profiles were calculated. However, the LF4, HF4, LF5, and HF5 data in the excel file, "RBFB_SC_ProifileData.xlsx" do not match the calculated values in the 8 soil profiles. Please explain how the median and log-SD columns in the excel file were calculated for the four cases (LF4, HF4, LF5, and HF5).	DOM	Open (see explanation at the end of this document)

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24	Excel file (Letter NA3-15-003, 4/27/15)	The excel file "RBFB_SC_ProifileData.xlsx" has only 44 soil layers, but the individual 8 soil profile files have 49 layers	DOM	Open (see explanation at the end of this document)

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Discussion:

- If the technical report is part of the RAI response (provides the supporting detailed information), then it should be docketed. If it is a calculation, then it does not need to be docketed. It appears that this is the case for all of the reports. Thus, the reports will be submitted with a proprietary version and a redacted, public version, unless a particular report contains no proprietary information.

- The NRC asked about compliance with RG 1.61 regarding cracked and uncracked cases and OBE versus SSE damping. The NRC (BNL Consultant) noted that the cases should be consistent (and that SSE is acceptable unless stress is low). GEH noted that OBE damping is used for ISRS for RB/FB, CB, and FWSC. OBE damping is used for RB/FB SSI cases, uncracked. SSE damping is used for CB and FWSC SSI cases, uncracked. The NRC indicated that there does not appear to be an issue according to RG 1.61 as to the structures. GEH indicated that if the FWSC results are bounded by the standard design, then further analyses with FE NASTRAN would not be necessary, and the NRC agreed.

NRC Staff Additional Comments:

Responses to Action Items 22 through 24:

The explanation of the methodology used to define the nonlinear properties and itemized responses to Action Items 22-24 follow.

Note: In the response below, the discussion refers to the stratum mapping of P-SHAKE layers (see the underlined in item (2) of AI22). That file for RB/FB is being submitted with the email that forwarded this update of the Action Item List. This was not requested by NRC previously and was therefore not included as part of our previous response. However, this might help your reviewers understand our process.

As described in FSAR Section 2.5.2.5, the simulated (randomized) profiles are developed including a variation in the thickness of different strata (a stratum is defined as a thickness of rock or soil having the same initial dynamic and static properties). Each stratum is then assigned to a number of P-SHAKE layers (with constant and predefined layer thicknesses) depending on the thickness of that stratum. Since, it is desirable to avoid mixing the strain compatible properties from different subsurface media (i.e. rock and saprolite) which in different profile realizations may be assigned to the same layer number, the strain compatible properties are calculated first within the same stratum in each one of the 60 profile realizations (regardless of the realized stratum depth) and then the log-mean strain compatible properties for each stratum across the 60 realizations are obtained. The stratum V_S is calculated based on the equal wave travel time through P-SHAKE layers for the stratum and the stratum damping ratio is calculated by taking the log-mean damping ratios from all P-SHAKE layers for the stratum. The log-mean strain compatible properties are assigned to the BE thicknesses available for each stratum to obtain the LB, BE, and UB strain compatible soil profiles.

Response to Action Item Number 22:

(1) The 60 strain compatible soil profiles for LF4, HF4, LF5, and HF5 hazard levels were provided to the staff in text files “RB-FB-XX#_Profile_Vs.txt” and “RB-FB-

XX#_Profile_Ds.txt", where XX stands for LF or HF and # refers to 4 or 5. The nonlinear portion of these profiles are averaged (as described above) over each stratum and the results for each one of the 60 strain compatible soil profiles are provided in the text files "RB-FB_XX#_Strata_Profile_Vs.txt" and "RB-FB_XX#_Strata_Profile_Ds.txt" which provide the 60 strain-compatible stratum profiles. In these files, the average stratum properties are only calculated for the nonlinear portion of the profiles, and for the linear portion, the notion "NaN" is used. Note that for the linear portion of the profile the properties are considered strain-independent and directly obtained from the considered BE and Log-SD of low strain properties provided in FSAR Section 2.5.2.5.

(2) As described above, for each stratum, the median and logarithmic standard deviation is obtained from the 60 strain-compatible stratum profiles regardless of the depth at which those properties are calculated. The stratum mapping of the P-SHAKE layers is generated as part of the soil column simulation (randomization) and is used for this purpose. The median and logarithmic standard deviation values are associated with the BE thicknesses for each stratum and reported in the last two columns of files "RB-FB_XX#_Strata_Profile_Vs.txt" and "RB-FB_XX#_Strata_Profile_Ds.txt. These values are used in the downstream calculations to determine the LB, BE, and UB soil profiles.

(3) As described in response to question (1), the NaN entries correspond to strata with strain-independent material. The properties for these strata are directly obtained from the considered BE and Log-SD of low strain properties provided in FSAR Section 2.5.2.5.

Response to Action Item Number 23:

As described in part (2) of AI22, the median and logarithmic standard deviation values of strata strain compatible properties (from the last two columns of files "RB-FB_XX#_Strata_Profile_Vs.txt" and "RB-FB_XX#_Strata_Profile_Ds.txt) are associated with the BE thicknesses and used in the Excel file "RBFB_SC_ProifileData.xlsx".

Response to Action Item Number 24:

As described above, the thickness variation of difference strata is included in the randomized soil profiles. Therefore, some realizations of the site profile used in the site-response analyses are deeper than the BE profile and some are shallower. The half-space (Vs=9200 fps) for the BE profile is at 155 ft. deep which corresponds to the layer #44. The deepest realization corresponds to a half-space depth of 183 ft (layer #49). In the text files, all layers are reported to this maximum depth, with the half-space properties (e.g. Vs=9200 fps) reported for the layers between the bottom of each profile and layer #49.

As discussed in response to AI23, the strain compatible properties are obtained from strata strain compatible properties and are associated with the BE thicknesses for the site which is represented by 44 layers. Therefore, 44 layers are used in the Excel file "RBFB_SC_ProifileData.xlsx".

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July 1, 2015 – Call summary:

SSSI report on CB sent by Dominion needs to be resent due to a change to the SSI analysis (1 of 3 Technical reports sent).

4 new reports are being sent to PM Now – PM received on July 1, 2014, put on G:\drive and provided CDs to staff

Depending on the quality and timeliness of reports at end of July – First Audit on demand calculations SSI and SSSI are tentative for last week of October GE office in Wilmington looking at examples where the exceedances occur only.

Second Audit on capacity would be done in March/April 2016, time frame (stability issues would be covered in either audit TBD).

Additional Audit for Section 2.5 is not expected at this time.

Audit of Site-Specific Seismic Input/Demand and the Supporting Analyses (FSAR Section 3.7)

July 10, 2015, Dominion Clarification Questions on WG3-U71-ERD-S-0001 (RB/FB SSI Analysis)

1. It appears that all the stiffness variation sensitivity analyses for fully embedded (FE) cases were performed using the MSM method of ACS SASSI instead of SASSI2010. Please explain the reason for not using SASSI2010 in these cases.

2. For the MSM model, please identify the locations of the interaction planes and describe whether they are consistent with the identified interaction planes in the benchmarking study. Section 4.3 does not appear to include any description in this regard.

3. Table 4.2.1 indicates the lowest cut off frequency is 32 Hz while the report (Page 17 of 602) identified the cut-off frequency of 33 Hz.

4. Discussion on the last paragraph of Page 17 of 602 is not clear without any reference to specific figures. Please as an example, discuss with reference to specific figures in the report.

5. Page 26 of 602 indicates that differences in maximum responses obtained from PE and FE models are negligible. However, the figures cited (Figures 5.2-5) in the report indicate that the difference could be approximately 20 to 30 percent. Needs further clarification in this regard.

6. In Table 5.6-1 it appears that the partial column UB case yields the maximum eccentricity of 10.7m. However, the report in Page 32 of 602 (last sentence) indicates that the UB full column profile yields the maximum value. In addition, for the full column case while the BE governs, the UB case was identified as governing in Table 5.6-1. Please clarify these inconsistencies.

7. In Section 5.3, the SRSS equations in Step 2 appear to be not consistent with the direction definitions presented in Step 1. The definitions in Step 1 should be revised. Same problem with Section 5.4 in calculating relative floor displacements.

8. According to the guidance in SRP Acceptance Criteria 3.7.2.II.4, uplift for non-symmetric structures may be more affected by the phasing between the three directions of input motions. The RB/FB building is not a symmetric building. The procedure discussed in Section 5.6, “Base Reactions and Contact Pressures,” does not explicitly indicate whether and how the phasing of the input motions is considered in the uplift analysis. Therefore, technical justification should be provided if the effect of different phasing of the input motions is not considered in the calculation of the foundation uplift. If the non-symmetric conditions need to be addressed, then the effect of in-phase and out-of-phase input motions can be considered in the SSI analyses by using plus and minus 1.0 times the magnitude of the input motions. This is especially important as the calculated contact ratio is 84 percent, not much higher than the 80 percent criterion.

9. Table 5.4-1, row at Node 9103 shows NA3 exceeding the standard design for maximum vertical displacement, but is not identified as such in the text and the table. In addition, Section 6.2 states that “The comparisons of the site-specific enveloping displacements

with the corresponding standard design values show that the NA3 high frequency design motion results in displacements that are enveloped by the standard design." This inconsistency needs to be addressed.

10. Table 6.1-2e, "Enveloping Maximum Accelerations for Fuel," there are large differences between the two horizontal directions for NA3 but not so much so for the standard design. Also, Table 6.1-5 shows similar discrepancy to those above for maximum spring forces and displacements. Provide an explanation on these differences.

11. Table 6.2-1 shows that the maximum relative displacements for NA3 are larger than those for the standard design at a few locations but have not been identified as exceedance. This contradicts with the conclusion drawn in Section 6.2, "Enveloping Maximum Displacements."

12. Section 6.3 provides site specific design envelope ISRS which represent the envelope of ISRS results from site specific SSI analysis using LB, BE, and UB soil profile of RB/FB model with upper bound stiffness properties. The site-specific evaluation of the effect of structural stiffness variation is described in Appendix B. According to Appendix B, it appears that for design and qualification of the equipment, ISRS provided in Section 6.3 will be enhanced only if there is a peak exceedance as a result of the sensitivity analysis of greater than 10 percent. The staff needs further justification of the 10 percent criteria. In staff's opinion for equipment and systems seismic qualification, for all identified exceedances due to stiffness variations, the NA3 site specific design ISRS should be enhanced.

13. Appendix D (page 381) states that, "$_{RCCV}$A and $_{RBFB}$W are the maximum acceleration and vertical rigid mode mass of the RCCV LMSM." It should be corrected as "$_{RCCV}$A and $_{RCCV}$W are the maximum acceleration and vertical rigid mode mass of the RCCV LMSM."

14. As shown in Table D.3-3, there is no rigid mass for D/F. Why is that?

15. It seems the second peak in the Appendix I, Figure I-1 is a numerical anomaly in both ACS SASSI and SASSI 2010. Please explain how the results of the analysis would be affected.

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Action Items From Public Meeting with Dominion on September 10, 2015

1. For the stability, soil bearing pressure, and lateral soil wall pressure evaluations of the plant structures, where the enveloping of the sensitivity analysis cases with the results of the site specific design basis was not considered, Dominion should have available the technical basis for not enveloping or not scaling the results accordingly. The sensitivity analysis cases refer to both the cracked vs uncracked cases and SSSI vs SSI cases.

2. NRC will include spent fuel pool rack review in the audit plan for Audit-1.

3. Slide 11 shows that spectral acceleration at 100 Hz at the basemat top is about 0.3g whereas that of the horizontal FIRS is approximately 0.78g. The staff considers that additional justification is needed for this significant reduction of the spectral acceleration at the basemat top for the CB. Since the justification on Slides 9 & 10 is generally also applicable to other buildings, the staff requested similar comparisons for other buildings (such as RB/FB, FWSC FIRS at El 220 ft.) to see whether similar reductions can be observed. The applicant should prepare an explanation for any differences observed for these buildings. The staff will review this issue at Audit–1.

4. Slide 12: The staff will review at Audit-1 the calculation method and results for determining the capacity of the concrete fill below the FWSC. The staff will also review whether the concrete fill below FWSC requires reinforcement.

5. Slide 21: The applicant is performing additional SSI/SSSI analysis to evaluate the effect of soil separation between concrete fill below FWSC and the surrounding soil. The staff will review these calculations during Audit-1 to evaluate the impact of soil separation on site-specific demand for the FWSC (including on the demand on the concrete fill). These analyses cases should be reflected in the FSAR and the pertinent FSAR Tables.

6. Slide 26: Dominion has performed evaluations for the effects of spurious peaks in the transfer functions, and these evaluations were not documented in the submitted reports. The staff will review the documentation during Audit-1.

7. Slide 28: FSAR Tables 3A.15-201 through 3A.15-206 should be updated as appropriate to reflect the additional SSI/SSSI analyses performed.

8. Slides 29 and 127: Dominion will revise the design commitments for considering SSSI effects on Category I structures due to interaction of Category II structures. The staff will review this issue at Audit-1.

9. Slide 31: The staff will review the V&V report to determine that soil properties used for V&V problems are representative of the North Anna 3 site conditions.

10. Slides 32 and 81: FSAR should include the comparison of envelope of the raw ARS with PBSRS for the NEI check and justifications for acceptability of any dips of surface ARS envelop below the PBSRS.

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11. Slide 38: The staff will review in Audit-1 comparison of characteristic values for NA3 time histories and earthquake seed during the Audit-1.

12. Slides 40 and 60: The staff will review V&V of ACS SASSI for application to North Anna 3 sensitivity analysis.

13. Slide 43: Dominion will revise the FWSC seismic analysis report to include results from two additional sensitivity analyses on FWSC. The report should also reflect additional SSI/SSSI analysis being performed for soil separation.

14. Slides 46 and 57: The staff will review in Audit-1 development of strain compatible soil profile.

15. Slide 65: Dominion is revising CB and FWSC seismic analysis reports to clarify the method of determining the potential uplift and contact ratio of the foundation mat. The staff will review this issue during Audit-1.

16. Slide 67: Dominion is performing uplift calculation for RB/FB to address effect of excitation direction and the RB/FB seismic analysis report will be revised. The staff will review this issue during Audit-1.

17. Slide 74: DOM will explain the exceedances of the maximum relative displacements in the FSAR

18. Slide 107: Dominion will include in FSAR the basis of defining CB control motion at CB basemat instead of bottom of concrete fill.

19. Slide 109: The staff will discuss with Dominion on the OBE definition for plant shutdown in September 23, 2015, phone call.

20. Slide 116: NRC will review damping values comparing with those values with DCD model during the audit. The basis should be included in the FSAR.

21. Slide 124: Dominion will include in the FSAR consideration of any exceedances in the CB due to site-specific CB-RB/FB SSSI analysis.

22. Slide 126: The staff requested DOM to provide site-specific ITAAC for the access tunnel

23. Although not specifically requested at the meeting, the staff requests Dominion to provide a list containing the transmittal schedule of the revised seismic demand related technical reports and the corresponding FSAR section update including the issues being addressed by the revisions.