Requests for Additional Information (RAIs)
ESBWR Design Control Document (DCD) Sections 3.7.1 through 3.7.3
(Includes 05/24/06 GE Responses and Staff Assessments following 06/05-08/06 Audit)

RAI Number	Reviewer	Question Summary	Full RAI Text / GE Response / Staff Assessment
3.7-1 (5/19/06)	Cheng T	Add the phrase "and within applicable stress, strain, and deformation limits." (3.7)	In the second paragraph of DCD Section 3.7 (Page 3.7-1), the applicant stated that seismic Category I structures, systems and components (SSCs) are designed to remain functional. The applicant is requested to modify this sentence to read "seismic Category I structures, systems and components (SSCs) are designed to remain functional and within applicable stress, strain, and deformation limits." GE Response: Agreed. A markup of the affected DCD page is attached. **Staff Assessment: GE's response is acceptable. This RAI will be considered resolved after DCD changes are formally submitted.**
3.7-2 (5/19/06)	Cheng T	Provide design information for non-seismic (NS) SSCs. (3.7)	In the fifth paragraph in Page 3.7-1 (DCD Section 3.7), the applicant provided the seismic analysis and design criteria for the non-seismic (NS) SSCs. In order to assist the staff to complete its review, the applicant is requested to: (a) (1) identify the NS structures (which are to be designed to the International Building Code (IBC) seismic criteria) that are included in the scope of the ESBWR DCD; (2) explain why they are not classified as C-I or C-II; and (3) identify where the seismic design basis calculations are described in the DCD. (b) (1) identify what NS equipment is seismically qualified (either by test or analysis) to IBC seismic criteria; and (2) describe the technical rationale for such seismic qualification. (c) clarify what is the scope of the COL applicant's responsibility to implement IBC seismic design criteria for NS SSCs?

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			GE Response: (a) Please refer to DCD Tier 2 Table 3.2-1 for identification of NS structures. They are not classified as C-1 or C-II because their failure will not adversely affect the performance of safety related SSCs. Therefore, seismic design basis calculations are not done at this stage for the DCD. A Markup of the affected page 3.7-1 is attached. (b) NS equipment including its anchorage is designed to IBC seismic criteria which is the standard industry practice for industry grade components. (c) IBC seismic design requirements for NS SSCs will be used and the requirements will be implemented through design, fabrication, and installation specifications and purchase order documents. **Staff Assessment: GE's response is acceptable, provided removal of the following from DCD p. 3.7-1: "Non-seismic (NS) structures and equipment are those that do not fall into Seismic Category I or II definitions. These are shown on Table 3.2-1. NS structures and equipment are designed for seismic requirements in accordance with the International Building Code (IBC) Reference 3.7-1. The building structures are classified as Category IV (Power Generating Stations) with an Occupancy Importance Factor of 1.5. Either of the methods permitted by IBC, simplified analysis or dynamic analysis, is acceptable for determination of seismic loads on NS structures and equipment." This RAI will be considered resolved after DCD changes are formally submitted.**
3.7-3 (5/19/06)	Cheng T	Request for clarification of the OBE. (3.7)	At the top of page 3.7-2 in DCD Section 3.7, the applicant stated "The Operating Basis Earthquake (OBE) is not an ESBWR design requirement." The applicant is requested to revise this statement to indicate that specification of the OBE is a design requirement, but requires no explicit analysis if it is chosen to be $\leq$1/3 of the safe shutdown earthquake (SSE). GE Response: Agreed. A markup of the affected DCD page is attached.

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			<u>Staff Assessment</u>: GE's response is acceptable. This RAI will be considered resolved after DCD changes are formally submitted.
3.7-4 (5/19/06)	Cheng T	Request for large size design structural drawings of RB/FB and CB. (3.7)	In order to facilitate the staff's review of DCD Section 3.7, the applicant is requested to submit clear, large scale, detailed structural drawings (These drawings show the location and description of water tanks, distance between buildings, thickness of floors and walls, elevation and thickness of seismic Category I foundations, etc.) of the ESBWR Seismic Category I structures and foundations, and any other structures and foundations that are within the scope of DCD Section 3.7. <u>GE Response</u>: Enclosure 2 contains the requested drawings. Note that these drawings correspond to the General Arrangement (GA) figures in DCD Chapter 1 and the structural design figures in DCD Section 3G. **<u>Staff Assessment</u>: Large size drawings and CDs were provided. GE's response is acceptable.**
3.7-5 (6/30/06)	Cheng T	Clarify the definition of the SSE used for the design, and justify the use of generic and North Anna ground motion will lead to acceptable design. (3.7.1)	In DCD Section 3.7.1, the applicant stated that seismic design parameters (including seismic ground motion response spectra) considered for the ESBWR seismic design comprise two site conditions, generic and North Anna early site permit (ESP) sites. It is not clear from the descriptions provided in DCD Section 3.7.1 if the intent of the DCD is to show that (a) the design is appropriate for the North Ana site and any other generic site for which the RG 1.60 response spectrum is the appropriate SSE; or (b) if the design is to be considered appropriate for any site whose design response spectrum falls below the envelope of the RG 1.60 and North Anna design spectrum. The applicant also stated on Page 3.7-1, that the SSE is based upon an evaluation of the maximum seismic potential at a site. The DCD indicates that the results from the two separate ground motion sets are considered in the plant evaluations and development of enveloped responses. If the envelope spectrum were to be specified as the SSE, then a single set of time histories appropriate for this envelope spectrum would be used to generate enveloped responses. The staff requests the applicant clarify the definition of the SSE being used for the plant design, and also justify that the enveloped responses from load cases using multiple time histories (generic and North Anna) in fact leads to a conservative result of responses that would be obtained from a single ground motion time history (envelope of generic and North Anna ESP sites).

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			GE Status Update: **To be postponed to 8/18/06.**
3.7-6 (5/19/06)	Cheng T	Provide, in the DCD, a detailed description of analysis procedures, seismic model development, seismic analysis procedure, use of results in the design. (3.7.1)	In DCD Section 3.7.1, the applicant stated that seismic design parameters considered for the ESBWR comprise two site conditions: generic sites and ESP sites. In DCD Section 3.7.1.1 and Appendix 3A, the applicant provided a description of two sets of site conditions that are considered in the ESBWR design. In order to assist the staff in performing its review of seismic analyses and design of the reactor building (RB)/fuel building (FB) and control building (CB), the applicant should include a detailed description of the analysis procedures to show (1) how these two sets of seismic design parameters will be applied to perform seismic analyses; (2) how the structural models are combined as a seismic system model; (3) how the seismic analyses (including the soil-structure interaction (SSI) analyses) are performed; and (4) how the analysis results (seismic member forces, sliding forces, overturning moment and floor response spectra) from these two sets of design parameters are to be combined and used for the design. The applicant is requested to provide the above information in the DCD. GE Response: (1) The two sets of seismic design parameters (generic and North Anna ESP site-specific) are applied separately in performing seismic analyses as described in DCD Sections 3A.3 and 3A.4.1. (2) The structural models are coupled with the foundation media in the form of soil springs and dampers to form the seismic system model as described in DCD Section 3A.5 and shown in Figures 3A.7-4 and 3A.7-5 for RB/FB and CB, respectively. (3) The seismic analyses of the seismic system model described above are performed for soil-structure interaction response, using the time history method of analysis described in DCD Section 3A.5. (4) The analysis results (seismic member forces, sliding forces, overturning moment and floor

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			response spectra) from these two sets of design parameters are enveloped (i.e., worst results among all cases analyzed) and used for the design as described in DCD Section 3A.9. **<u>Staff Assessment</u>: Response is consistent with the discussion during the GE teleconference on 03/31/06. However, the applicant is currently revising the definition of the design basis earthquake as the envelope of the two response spectra. The response to this RAI is acceptable. The application of the revised design basis earthquake will be reviewed under RAI 3.7-5.**
3.7-7 (5/19/06)	Cheng T	Provide a detailed description of North Anna ESP site conditions (e.g., geotechnical properties, etc.) in the DCD. (3.7.1)	In DCD Section 3.7.1, the applicant stated that because the Clinton and Grand Gulf site conditions are bounded by the envelope of the generic site and North Anna site conditions, the North Anna ESP site is selected for further consideration in conjunction with generic sites for site enveloping seismic design of the ESBWR standard plant. In addition to the ground motion response spectra, and time histories provided in the DCD, the applicant is requested to include in the DCD a detailed description of the North Anna site conditions (e.g., geotechnical properties), including response spectra at various depths through the profile consistent with design spectra. <u>GE Status Update</u>: **The response submitting date switched to 6/30/06.**
3.7-8 (6/30/06)	Cheng T	Justify why the PGAs and ground response spectra are the same at two (2) different foundation elevations. (3.7.1)	In DCD Section 3.7.1.1 and DCD Section 3.7.1.1.1, respectively, the applicant stated that for generic site (1) the peak ground acceleration (PGA) of the SSE is 0.3g at the foundation level, and (2) the design response spectra are specified at the foundation level in the free field. It is the staff's understanding that the foundation level of the reactor/fuel building is located at 20m (66.0 ft) below grade and the foundation level of the control building is located at 15.05 m (49 ft) below grade. The applicant is requested to provide its technical basis to justify why the PGAs and ground response spectra are the same at these two (2) different foundation elevations. <u>GE Status Update</u>: Applicant contends their approach is conservative. COL applicant has responsibility to confirm this for the site. Staff questioned this. Applicant to address this in the SASSI analysis it is currently preparing.
3.7-9	Cheng T	Provide the strong	In DCD Section 3.7.1.1.2, the applicant indicated that the total duration of the artificial time histories

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(5/19/06)		motion durations of the time history, and comparison of the fits to the RG 1.60 response spectra. (3.7.1)	used to envelop the RG 1.60 spectra is 22 seconds. In addition, the applicant indicated that the response spectra computed from the synthetic time histories are computed at the additional frequencies of 40, 50 and 100 Hz. This sparse frequency set above 33 Hz is not considered adequate to judge the appropriateness of the time history fit between 33 and 100 Hz. To assist the staff in its review, the applicant is requested to provide the following additional information: (a) the corresponding strong motion durations for the synthetic time history records. (b) a detailed comparison of the fits to the RG 1.60 spectra, up to 100 Hz. <u>GE Response</u>: (a) The corresponding strong motion durations for the synthetic time history records H1, H2, and VT are 13.71, 13.05 and 13.50 seconds, respectively, and they are between 6 and 15 seconds conforming to SRP 3.7.1 requirement. Strong motion duration, Ts, is calculated to be the difference of the times at which 75 percent and 5 percent of the cumulative energy, E(tp), are reached, in accordance with the recommendation in NUREG/CR-5347.The normalized cumulative energy plots are shown in Figure 3.7-9 (1) through (3). (b) A detailed comparison of the fits to the RG 1.60 spectra is shown in Tables 3.7-9 (1) through (15) up to 100 Hz. **<u>Staff Assessment</u>: GE's response is acceptable.**
3.7-10 (5/19/06)	Cheng T	Include, in the DCD, details of implementing the SRP process (Appendix A to SRP 3.7.1) to develop the PSD for the vertical motion. (3.7.1)	In DCD Section 3.7.1.1.2, the applicant indicated that a target power spectra density (PSD) appropriate for the vertical RG 1.60 response spectrum was developed using the same process (Appendix A to SRP Section 3.7.2) as is used to develop the horizontal target. The staff requests the applicant to include the details of its implementation of this process in the DCD, to facilitate staff evaluation. <u>GE Response</u>: The following approach based on Appendix B to NUREG/CR-5347 was used to develop the target power spectra density for RG 1.60 vertical spectrum: (1) Establish initial candidate PSD.

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			(2) Calculate several time histories using the PSD, each with a different phase function. (3) Calculate 2 percent critically damped pseudovelocity response spectrum (PSV) of each time history. (4) Compare the suite of PSVs from (3) to a target PSV. (5) If the average of the suite of PSVs does not fit (this is a visual fit) the target PSV, adjust form of PSD and go to Step (2). (6) Obtain the final PSD DCD Section 3.7.1.1.2 will be revised accordingly. Markups of the affected DCD pages are attached. <u>**Staff Assessment**</u>**: GE's response is acceptable. RAI 3.7-10 will be considered resolved after DCD changes are formally submitted.**
3.7-11 (5/19/06)	Cheng T	Provide justification for the DCD conclusion and a comparison plot of two sets of ground response spectra. (3.7.1)	In the fourth sentence of the first paragraph of DCD Section 3.7.1.1.3 (Page 3.7-4), the applicant stated that, since the low frequency part of North Anna SSE ground response spectra are enveloped by the 0.3g RG 1.60 generic site response spectra with large margins, only the high frequency part needs to be explicitly taken into account. The staff requests the applicant to provide justifications for the conclusion drawn in the DCD and a comparison plot of these two sets of ground response spectra in Tier 2 DCD Section 3.7.1, "Seismic Design Parameters." <u>GE Status Update</u>: **Response submitting date switched to 6/30/06.**
3.7-12 (5/19/06)	Cheng T	Provide descriptions of North Anna ground motions and geotechnical information. (3.7.1)	DCD Section 3.7.1.1.3 provides a description of the North Anna ESP design ground motion (5 percent damping design ground response spectra at different foundation levels, comparisons of response spectra calculated from the modified ground motion time histories with the ESP ground response spectra, etc.). In order for the staff to reach a safety conclusion regarding the design adequacy (based on the ESP ground motion) of the RB/FB and CB, the applicant is requested to provide the following information in the DCD: (a) Which of the ESP ground response spectra (target spectra or spectra/1.10 or spectra*1.30) to be used for the seismic analysis and design?

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			(b) The ESP response spectra for 2 percent, 3 percent, 4 percent, and 7 percent damping ratios. (c) Definition of the “modified” ground motion time histories. (d) Demonstrate that the response spectra calculated from the modified ground motion time histories envelop the design ESP ground response spectra for all damping ratios to be used in the analyses. (e) Demonstrate that the modified ground motion time histories satisfy the PSD requirements (including how the target PSD was calculated). (f) Basis for the statement in the second paragraph of Page 3.7-4, “the cross-correlations between the three individual components are all less than the 0.3 requirement.” (The staff’s position for the cross-correlations between the three individual components is 0.16. This staff’s position had been applied for other design certification review, such as AP600, AP1000, etc.) GE Status Update: **Response submitting date switched to 6/30/06. In discussion, the staff indicated (1) to match response spectrum for 5 percent damping only should be sufficient based on studies, and (2) the SRP 3.7 update will specify 0.16 max. cross-correlation coefficient.**
3.7-13 (5/19/06)	Cheng T	Provide a basis for the damping values specified in DCD Table 3.7-1 and Figure 3.7-36. (3.7.1)	Because friction-bolted steel structures are designed to eliminate slip of the bolted joints by applying a preload, and consequently behave more like welded steel structures, the staff considers 4 percent SSE damping to be appropriate for friction-bolted steel structures. For ≥50 percent fill of cable, and in the absence of physical restraint, the staff considers 10 percent SSE damping to be acceptable for cable trays with all types of supports, including welded steel supports. While higher damping values may be justifiable on a case-by-case basis, DCD Figure 3.7-36 does not distinguish between different types of supports, which is a key parameter in determining the cable tray/support system damping response. In order to complete its review of DCD Section 3.7.1.2, the staff requests that the applicant submit the following additional information related to SSE damping values:

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			(1) Identify whether friction-bolted steel structures are employed in the ESBWR design, and if used, identify and justify the SSE damping value used in the design basis analyses. (2) Provide a detailed technical basis for the applicability of DCD Figure 3.7-36 to all types of cable tray supports, or as an alternative, describe the types of cable tray supports that are applicable to the ESBWR design; define the damping value appropriate for each type of support; and provide the technical basis for the specified damping value. (3) Define and provide technical justification for cable tray damping values when there are physical restraints to free cable motion (e.g., sprayed-on fire retardant material). GE Response: (1) The damping value for friction-bolted steel structures is 4 percent. (2) The damping values for cable tray is reduced to a maximum of 15 percent. (3) If spray-on fire retardants that restrain free cable motion are used, the maximum damping would be limited to 7 percent for cable trays on welded steel supports and 10 percent for cable trays on bolted steel supports. Markups of DCD Table 3.7-1 and Section 3.7.1.2 changes are attached. **Staff Assessment: Response to (1) is Acceptable. Response to (2) and (3) required clarification of GE's basis for 15 percent for bolted supports and 10 percent for bolted supports with spray-on fire retardants. These are more liberal than what is currently being considered for the RG 1.61 revision (10 percent, 7 percent, respectively). GE identified ASCE 4-98 as the basis. Staff has not reviewed/accepted ASCE 4-98 damping. Staff may re-visit cable tray damping for the RG 1.61 revision. GE to identify other applicable references. Resolution needed for cable tray damping.**
3.7-14 (5/19/06)	Cheng T	Revise the DCD to include specific technical information from ASME Code Case - 411-1. (3.7.1)	The applicant is requested to revise the DCD to include the specific technical information from ASME Code Case - 411-1 that it plans to use, and specifically identify the restrictions on its use, consistent with the staff position delineated in prior revisions of Regulatory Guide 1.84. GE Response: Please refer to response to RAI 3.12-19 for this item. It is similar.

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			<u>Staff Assessment</u>: New DCD Figure 3.7-37, Note (6) required a clarification. Applicant indicated that 2 percent damping is used above 33 Hz. Staff inquired about a precedent/technical basis. After discussion with the staff responsible for piping review, GE's response is considered acceptable.
3.7-15 (5/19/06)	Cheng T	Identify building structures to be covered by the scope of DCD Section 3.7.2. (3.7.2)	In DCD Section 3.7.2, the applicant stated that this DCD section applies to "building structures that constitute primary structural systems." The applicant is requested to (1) specifically identify and describe the building structures covered by DCD Section 3.7.2; (2) identify the seismic classification of each building structure; (3) confirm those design basis seismic analyses have been completed for these building structures; and (4) identify where the details and results of the design basis seismic analyses are presented in the DCD. <u>GE Response</u>: (1) The building structures covered by DCD Section 3.7.2 are Reactor Building (RB), Fuel Building (FB), Control Building (CB) and Emergency Breathing Air System (EBAS) Building. First paragraph of Section 3.7.2 will be clarified. A markup of the affected page is attached. (2) Seismic classification of building structures is described in DCD Table 3.2-1 for Structures and Servicing Systems (U). (3) The design basis seismic analyses have been completed for RB, FB and CB. (4) The details and results of the design basis seismic analyses are presented in DCD Section 3A. **<u>Staff Assessment</u>: GE's response is acceptable. This RAI will be considered resolved after DCD changes are formally submitted.**
3.7-16 (8/18/06)	Cheng T	Address the limitation of the formulation of equations of motion described in Section 3.7.2.1.1. (3.7.2)	In DCD Section 3.7.2.1.1, the applicant presents the formulation of the equations of motion in terms of undamped eigenvalues and mode shapes, with solutions obtained by integration in the time domain. The applicant is requested to address the limitations of this formulation, particularly for the case of frequency-dependent SSI stiffness and damping coefficients. <u>GE Status Update</u>: Four (4) cases will be analyzed using SASSI to study layered sites and the effects of frequency-dependent SSI stiffness and damping coefficients.

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3.7-17 (5/19/06)	Cheng T	Provide additional information regarding the analysis method and results of each seismic Category I buildings. (3.7.2)	From the information provided in DCD Section 3.7.2.1.1, the staff cannot determine which of the methods described were actually used for the design basis seismic analyses of the building structures, or how they were implemented. Therefore, the applicant is requested to provide the following information related to DCD Section 3.7.2.1.1: (1) For each building structure covered by DCD Section 3.7.2, identify the specific time history analysis method employed; describe the implementation of the method, including determination of the highest structural frequency of interest and determination/verification of an adequate integration time-step; and discuss how the analysis results were used. (2) If modal superposition time history analysis was employed, identify whether the alternative to the missing mass method documented in Appendix A to SRP Section 3.7.2 was used to account for the contribution of modes with frequencies above f_{ZPA}. If so, explain why it was used instead of the more accurate missing mass method; define the cutoff frequency; and explain how it was determined. The staff notes that the staff's position stated in Draft Regulatory Guide DG-1127 (DG-1127 was released for public comments in February 2005, and is scheduled to be published as Revision 2 of RG 1.92 in Spring 2006) does not accept this alternative procedure. GE Response: (1) The direct integration method of analysis in the time domain as described in DCD Section 3.7.2.1.1 is employed in the seismic analysis for the RB/FB complex and the CB. The highest structural frequency of interest is 33 Hz for generic site and 50 Hz for North Anna site in view of the frequency contents and peak spectra accelerations of the respective ground response spectrum. The integration time step Ät is 0.002 sec for the generic site and 0.001 sec for the North Anna site in order to meet the general criteria described in DCD Section 3.7.2.1 for the maximum integration time step allowed. The adequacy of the selected Ät is confirmed for solution convergence by using one-half Ät to show no more than 10 percent change in response for the representative hard site. For the usage of analysis results, please see the response to RAI 3.7-6. (2) Modal superposition time history analysis was not employed in the building seismic analyses. However, as a general criterion for the treatment of missing mass effect using the modal superposition method, the second to last paragraph in DCD Section 3.7.2.7 will be deleted. Markups of the affected DCD pages are attached.

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			Staff Assessment: At staff's request, GE will develop a roadmap table to identify the analysis method, model utilized, and the computer code used, and the use of the analysis output. GE's response is acceptable. This RAI will be considered resolved after DCD changes are formally submitted. (See related staff assessment under RAI 3.7-36.)

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3.7-18 (5/19/06)	Cheng T	Provide additional information regarding the response spectrum analysis method. (3.7.2)	From the information provided in DCD Section 3.7.2.1.2, the staff cannot determine whether response spectrum methods were actually used for the design basis seismic analyses of the building structures. Therefore, the staff requests that the applicant identify, for each building structure covered by DCD Section 3.7.2, whether the response spectrum analysis method was employed; describe the implementation of the analysis methods, including the method used to account for the contribution of modes with frequencies above f_{ZPA}; and discuss how the analysis results were used. GE Response: Response spectrum methods were not used for the design basis seismic analyses of the building structures documented in DCD Section 3.A. **Staff Assessment: GE will make DCD revision. The staff reviewed the proposed DCD revision, and found acceptable. This RAI will be considered resolved after DCD changes are formally submitted.**
3.7-19 (5/19/06)	Cheng T	Provide additional information regarding the static coefficient analysis method. (3.7.2)	From the information provided in DCD Section 3.7.2.1.3, the staff cannot determine whether the static coefficient method was actually used for the design basis seismic analyses of the building structures. Therefore, the staff requests that the applicant identify, for each building structure covered by DCD Section 3.7.2, whether the static coefficient method was employed; describe the implementation of this method and the technical basis for its use; and discuss how the results were used. GE Response; Static coefficient method was not used for the design basis seismic analyses of the building structures documented in DCD Section 3.A **Staff Assessment: GE will make DCD revision. The staff reviewed the proposed DCD revision, and found acceptable. This RAI will be considered resolved after DCD changes are formally submitted.**
3.7-20 (5/19/06)	Cheng T	Provide a description of how the stick and finite element models	In the first sentence of DCD Section 3.7.2.3, the applicant stated that the mathematical model of the structural system is generally constructed as a stick model or a finite element model. The staff requests the applicant to describe in detail in the DCD the development of the stick models and

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		are developed. (3.7.2)	finite element models for the structural systems covered by DCD Section 3.7.2, including whether the stick model was developed to match the overall dynamic characteristics of a detailed finite element model, the computer code that was used for modeling and analysis, and the information that was required from the analysis. GE Response: The seismic models used for Seismic Category I buildings are stick models. Details of the development of the stick models are provided in DCD Section 3A.7. The first sentence of paragraph 1 in DCD Section 3.7.2.3 will be revised to read “The mathematical model of the structural system is constructed as a stick model for seismic response analysis of primary building structures.” Markups of the affected DCD pages are attached. **Staff Assessment: GE’s response is acceptable. This RAI will be considered resolved after DCD changes are formally submitted.**
3.7-21 (5/19/06)	Cheng T	Provide, in the DCD, the basis for neglecting certain dynamic properties (rotary inertia, etc.) of RB/FB and CB. (3.7.2)	The staff requests that the applicant describe in detail in the DCD how it has implemented the general criteria contained in the third paragraph of DCD Section 3.7.2.3 (i.e., rotary inertia may be neglected since its contribution to the total kinetic energy of the system is small; two- or one-dimensional models may be used if the directional coupling effect is negligible; structures are generally designed to keep eccentricities as small as practical to minimize lateral/torsional coupling and torsional response) in the seismic design/analysis of the primary structural systems covered by DCD Section 3.7.2. GE Response: As described in DCD Section 3A.7, rotary inertia, torsional degrees of freedom and eccentricities are explicitly considered in the three-dimensional stick model of the primary building structures. Rotary inertia of the RPV & internals are neglected because its contributions to both the total plant response and the RPV & internals response is small. The small response contributions follow from the fact that the physical geometry of the RPV & internals is axi-symmetric and is modeled as an axi-symmetric, mathematical, center-line, beam-element model. Furthermore, the RPV direct support (the RPV, Pedestal) is also an axi-symmetric structure and keeps the eccentricities about the vertical, center-line axis as small as practical to minimize lateral/torsional coupling and torsional response. In addition, both the seismic, free-field excitation and the nonseismic suppression pool

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			hydrodynamic loads are characterized by essentially zero rotational components about the model vertical, center-line axis. Consequently, the RPV & internals torsional degrees-of-freedom (DOFs) are not excited by the seismic and the non-seismic suppression pool hydrodynamic loads. Therefore, the RPV & internals torsional rotary inertia can be neglected in the analytical models. The RPV & internals rotary inertia about each of two horizontal, orthogonal axes are also neglected in the analytical models. Sensitivity studies completed during the initial development of GE Boiling Water Reactor (BWR) RPV & internals analytical models illustrated that the model responses were essentially the same whether or not the horizontal rotary inertia components were included. This is due to the fact that the natural frequencies of the pure rotational modes tended to be well above the Zero Period Acceleration (ZPA) frequencies of both the seismic and non-seismic excitations. Consequently, the pure rotational modes contributed essentially zero to the overall response of both the RPV & internals as well as those of the primary structure. **Staff Assessment: Staff reviewed the method for modeling rotary inertia in GE Report 26A6647, Rev. 1, "Seismic Analysis of RB/FB Complex" and discussed with the applicant. Staff also reviewed the RPV methodology employed. On this basis, GE's response is acceptable.**
3.7-22 (5/19/06)	Cheng T	Provide modeling information related to the live and snow loads. (3.7.2)	The second sentence in the second paragraph on page 3.7-10 (DCD Section 3.7.2.3) states that the mass properties in the model include all contributions expected to be present at the time of dynamic excitation, such as dead weight, fluid weight, attached piping and equipment weight, and appropriate part of the live load. For the modeling of live load, the staff requests the applicant to describe, in the DCD, which part and the amount of live and snow loads that are included in the seismic models. (The staff position is that 25 percent of the floor live load or 75 percent of the roof snow load, whichever is applicable, should be included as mass in the global seismic models.) GE Response: Masses in the seismic model included 25 percent of the live load and 100 percent of the roof snow load. DCD Section 3.7.2.3, 4th paragraph and DCD Section 3A.7.1, 5th paragraph will be revised to clarify the amount of live and snow loads included in the seismic models. Markups of the affected DCD pages are attached. **Staff Assessment: Applicant's proposed DCD revisions were inconsistent, one listing**

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			75 percent of snow load and the other 100 percent of snow load. The staff reviewed GE's proposed DCD revision to remove this inconsistency, and found acceptable. This RAI will be considered resolved after DCD changes are formally submitted.
3.7-23 (5/19/06)	Cheng T	Provide modeling information related to the water masses located in the RB/FB complex. (3.7.2)	The third sentence in the second paragraph on page 3.7-10 (DCD Section 3.7.2.3) states that the hydrodynamic effects of any significant fluid mass interacting with the structure are considered in modeling of the mass properties. For the ESBWR, significant amounts of water mass are located at various elevations in the RB (PCC Pool and IC Pool at El. 88.58 ft, GDCS Pool at El. 15.26 ft, and Suppression Pool at El. -3.28 ft). Based on the staff's review experience, the dynamic mass effect and the fluid-structure interaction effect on the overall seismic response of the RB are extremely significant. The staff requests the applicant to provide, in the DCD, a detailed description of pool geometry, total height of water, location of free board, modeling procedure of water mass (sloshing effect and impulsive mass), and how the water was modeled with the main structure. GE Response: Detailed description of pool geometry: - PCC Pool and IC Pool at EL 27000: see Figures 3G.1-4 and 3G.1-46. - GDCS Pool at EL 17500: see Figures 3G.1-3 and 3G.1-59. - Suppression Pool at EL 4650: see Figures 3G.1-2 and 3G.1-48. Total height of water - PCC Pool and IC Pool at EL 27000: see Table 3G.1-4. - GDCS Pool at EL 17500: see Table 3G.1-3. - Suppression Pool at EL 4650: see Table 3G.1-3. Location of free board - PCC Pool and IC Pool at EL 27000; the bottom of EL 34000 slab is at EL 33000. (Figure 3G.1-7). - GDCS Pool at EL 17500; the bottom of EL 27000 slab is at EL 24600. (Figure 3G.1-7). - Suppression Pool at EL 4650; the bottom of beam supporting the diaphragm floor is at EL 15900. (Figure 3G.1-48). As described in Appendix 3A.7.1, the water masses in the pools are included in the stick model, in which the entire water mass is conservatively considered as impulsive mass rigidly attached to

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			the wall/slab nodes for the purpose of predicting overall response of the building structure. **<u>Staff Assessment</u>: Staff reviewed the pool geometries with the applicant and found the approach used for modeling pool water to be appropriate and acceptable. This RAI considered resolved.**
3.7-24 (8/18/06)	Cheng T	Provide a description of how the mass modeling criteria were applied. (3.7.2)	The last two sentences in the second paragraph on page 3.7-10 (DCD Section 3.7.2.3) state that the number of masses or dynamic degrees of freedom is considered adequate when additional degrees of freedom do not result in more than a 10 percent increase in response. Alternatively, the number of dynamic degrees of freedom is no less than twice the number of modes below the cutoff frequency. The staff generally agrees with this criteria, but it is not clear how the criteria has been implemented in the development of the seismic structural models. The applicant is requested to include in the DCD specific information on how these criteria were satisfied for each seismic structural model. <u>GE Status Update</u>: In progress. CB model being refined to meet criterion. Cut-off frequency is 50 Hz. Staff has a concern that the stick models cannot accurately pick up modes to 50 Hz.
3.7-25 (6/30/06)	Cheng T	Provide a description of how the heavy cranes were included in the seismic model of the RB/FB complex. (3.7.2)	For the development of the RB/FB seismic model, the staff requests the applicant to specify in the DCD where the heavy crane (with trolley) is to be parked during plant operation. This information is needed to properly locate the mass and assess the effects of mass eccentricity in the seismic analysis. This information also needs to be identified as an interface item for the COL applicant. <u>GE Status Update</u>: In progress. Sensitivity analysis being performed.
3.7-26 (6/30/06)	Cheng T	Provide information of how the effects of out-of-plane vibration of floors and walls were considered. (3.7.2)	For seismic subsystem analysis, accurate in-structure response spectra are needed at the subsystem support points. The staff requests the applicant to describe in the DCD how it has considered the effects of out-of-plane vibration of floors and walls in the seismic structural models and the development of in-structure response spectra. <u>GE Status Update</u>: In progress. Walls are being evaluated. Simple floor representations included in

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			seismic stick model

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3.7-27 (8/18/06)	Cheng T	Include dimensions in the figures and consider them as Tier 1 information. (3.7.2)	In DCD Tier 1 Figures 2.17.5-1 through 2.17.5-11 and Tier 2 Figure 1.2-1, the applicant did not provide the foundation dimensions for the RB/FB and the CB, nor the distance from the center of the reactor vessel to the edge of the RB/FB foundation. Because this information is important for the structural modeling and the seismic response of seismic Category I structures, the staff requests the applicant to include these dimensions in the above figures and to consider them as DCD Tier 1 information. GE Status Update: In progress.
3.7-28 (5/19/06)	Cheng T	Provide, in the DCD, more detailed information about the modeling of the hydrodynamic coupling effects in the RPV model. (3.7.2)	The applicant described modeling procedures for the reactor pressure vessel (RPV) in the fifth paragraph of DCD Section 3.7.2.3, stating that the RPV and its major internal components are analyzed together with the primary structure using a coupled RPV/supporting structure model. The applicant further stated that for the RPV, (1) the presence of fluid and other structural components introduces a dynamic coupling effect; (2) hydrodynamic coupling effects caused by horizontal excitation are considered by including coupling fluid masses lumped to appropriate structural nodes at the same elevations; (3) the details of the hydrodynamic mass derivation are given in DCD Reference 3.7-6; and (4) the hydrodynamic coupling effects are assumed to be negligible in the vertical excitation and fluid masses are lumped to appropriate structural locations. The staff requests the applicant to include in the DCD the following additional information related to modeling of the RPV and modeling of hydrodynamic coupling effects: a. Describe how the seismic analysis results for the RPV and its major internal components, obtained from the coupled RPV/supporting structure model, were used in design of the RPV. b. Describe how direct fluid loading on the major internal components was considered. Was the fluid load transferred from these internal components to the locations of attachment to/contact with the RPV? c. Describe the methodology in DCD Reference 3.7-6 to derive the hydrodynamic mass, and include the results of implementing the method for the RPV model.

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			d. Provide the technical basis for the assumption that hydrodynamic coupling effects are negligible in the vertical excitation. GE Response: a. Maximum member end forces & moments and accelerations & response spectra at each nodal location from the seismic time history analysis of the primary structure (i.e., coupled RPV/supporting structure) model were used in the design of the RPV and the RPV internal components. b. Fluid loads at internals nodal locations and RPV nodal locations were calculated using hydrodynamic loads calculation method described in response c below and added to RPV contact and attachment locations (i.e., at the appropriate nodal locations). c. To determine the dynamic response of RPV and internals, the inclusion of the hydrodynamic mass is mandatory. The hydrodynamic mass effect comes from the force (due to the change in momentum of the fluid) which an accelerating solid object immersed in a fluid must impart to the fluid in order to cause fluid acceleration. Using the methodology described in DCD Reference 3.7-6, the hydrodynamic mass in the RPV and internals system can be idealized as being that of concentric cylinders. Hydrodynamic mass calculation is based on two or three concentric cylinders. Based on this method diagonal and off-diagonal hydrodynamic masses were calculated for RPV and internal components and used in the RPV and internals model. Leakage effects in the core, guide tubes and steam separators are accounted for in the calculation. d. In the vertical model the predominant effects of the water in the vessel is to load the bottom head. Based on geometry and modeling in the vertical direction, there are no compartmental regions with leakage, which will have coupling effect for the vertical RPV and internals model. Note that the core support plate and top guide are both represented as single nodes in the RPV and internal part of the primary structure model. Based on this and consistent with the all GE BWR vertical model, the hydrodynamic mass coupling between model nodes is assumed negligible. Staff Assessment: **Staff discussed the RPV model with applicant. After discussion with the staff (EEMB) responsible for major component review, the staff determined that the review of the RPV modeling adequacy is outside the DCD Section 3.7 scope, and GE's response is** **considered acceptable for this RAI. EEMB will resume the review of the issue raised in this RAI.**

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3.7-29 (6/30/06)	Cheng T	Clarify the definition of the SSE. (3.7.2)	The first sentence of DCD Appendix 3A, Section 3A.1 states that this appendix presents SSI analysis performed for two site conditions, generic site and North Anna ESP site-specific, adopted to establish seismic design loads for the RB, FB, and CB of the ESBWR standard plant under SSE excitation. The definition of the SSE is not clear to the staff: is it both the 0.3g RG 1.60 ground motion response spectra and the North Anna ESP ground motion response spectra, or is it a combination (envelop) of these two spectra? The staff requests the applicant to clarify the definition of the SSE used for the ESBWR standard plant design in the DCD. <u>GE Status Update</u>: See RAI 3.7-5
3.7-30 (8/18/06)	Cheng T	Include, in the DCD, the limitation of using uniform site impedance function for the ESBWR design. (3.7.2)	The last part of the second paragraph on page 3A-4 of DCD Section 3A.3.1 states that three subsurface conditions (soft, medium, rock and hard rock sites) are considered to be uniform half-space, as provided in Table 3A.3-1 for SSI analyses. According to the staff's review experience, there are a number of sites composed of layered materials that should be considered for siting of nuclear plants. Such sites may have significant variation of shear wave velocity with depth, leading to potentially significant impedance mismatches between layers. Such profiles can have effective impedance functions that are significantly different from those associated with a uniform half-space. (See for example, "Handbook of Impedance Functions" by Sieffert and Cevaer). These sites are typically characterized by impedance functions that are highly frequency-dependent, particularly those associated with radiation damping. The approach of using a frequency-independent assumption for both stiffness and damping in SSI may lead to significantly different computed responses. The behavior (or response) of a massive structure (such as RB/FB or CB) may be significantly influenced by these variations due to site conditions. For the design of a standard plant such as ESBWR, the DCD should address the limitations on site layering that will be required, to ensure the applicability of the ESBWR design, which is based on the assumption of uniformity. The staff requests the applicant to include this information in the DCD, and also identify it as a COL interface item. <u>GE Status Update</u>: See RAI 3.7-16

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3.7-31 (5/19/06)	Cheng T	(1) Justify to vary the shear wave velocity by <u>+</u> square root of 2 for North Anna site, and (2) specify the minimum shear wave velocity of 1000 ft/sec in the DCD. (3.7.2)	The shear wave velocity ranges shown in DCD Appendix 3A, Table 3A.3-1, for the generic site, imply that these wave velocity values are associated with Best Estimate site properties. When the SSI analyses were performed, the applicant would have to consider potential variation in these velocities by ± square root of 2. These requirements would indicate that the site wave velocity ranges used should vary from 707 feet/second to hard rock site with the shear wave velocity to be 8000 ft/sec or higher (fixed-base model). A soil site with the shear wave velocity less than 1000 ft/sec is not acceptable for building a nuclear power plant. (The staff's position that the minimum shear wave velocity of soil foundation is 1000 ft/sec or higher was applied for other design certification review, such as AP600, etc.; and early site permit review, such as Grand Gulf, etc.) Also, the staff noted that the variation shown for the North Anna site in DCD Table 3A.3-2 is <u>+</u> square root of 1.5, which does not meet SRP acceptance criteria. The staff requests the applicant to (1) explain and justify this difference (variation in soil shear wave velocity by <u>+</u> square root of 2 vs <u>+</u> square root of 1.5) in criteria between the generic site and the North Anna site, and (2) revise the DCD to specify that the minimum shear wave velocity. <u>GE Response</u>: (1) SRP 3.7.2 provides for an exception from its recommendation for the variation in soil properties (i.e. G, 2G, and G/2) in the case of well-investigated sites. The North Anna site is considered to be a well-investigated site; therefore the variation of shear wave velocity by + square root of 1.5 is considered more appropriate than + square root of 2. (2) DCD Section 3.7.5.1 item (3) will be revised to read "The equivalent uniform shear wave velocity (Veq) over the entire soil column is no less than 300 m/sec (1000 ft/sec) at seismic strain, which is a lower bound value after taking into account uncertainties. Veq is calculated to achieve the same wave traveling time over the depth equal to the embedment depth plus 2 time the largest foundation plan dimension below the foundation. Markups of the affected DCD pages are attached. **<u>Staff Assessment</u>: GE's response is acceptable. This RAI will be considered resolved after the DCD changes is formally submitted.**

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3.7-32 (8/18/06)	Cheng T	Clarify, in the DCD, how the material damping and SSI radiation damping were considered in the seismic analyses. (3.7.2)	DCD Appendix 3A, Tables 3A.3-1 and 3A.3-2, indicate material (hysteretic) damping values assumed for foundation soils for the various uniform site cases. However, no mention is made in the SSI description of how these damping parameters are combined with the SSI radiation damping values listed in Tables 3A.5-1 and 3A.5-2. The staff requests the applicant clarify in the DCD how these properties (material damping and radiation damping) were considered in the SSI calculations and how significant they are to facilitate responses. GE Status Update: In progress. Only radiation damping currently considered. Soil damping conservatively neglected. New SASSI model will include soil and radiation damping.
3.7-33 (8/18/06)	Cheng T	Justify that the use of the ASCE 4-98 approach to calculate the lateral soil pressure will result in a conservative design. (3.7.2)	DCD Section 3A.5 indicates that the use of lateral pressures computed from the equivalent static pressure analysis listed in ASCE 4-98 is conservative. Based on reviews of a number of facilities, it is known that actual pressures computed from detailed SSI evaluations of embedded foundations are directly influenced by the characteristics of the foundation response spectrum used to define the ground motions as well as the relative stiffness (shear wave velocity) of the soils above the basemat level. The staff requests the applicant clearly indicate in the DCD either (1) the technical basis for the statement that these static pressures are conservative for any site, or (2) any limitations that need to be incorporated into the acceptable site profile characteristics to limit the actual dynamic pressures anticipated. GE Status Update: Lateral soil pressures obtained from the new SASSI analysis will be compared to pressures calculated using the ASCE 4-98 approach.
3.7-34 (6/30/06)	Cheng T	Provide a technical basis to demonstrate that the input design ground motion time histories meet the guidelines specified in the SRP Section 3.7.1. (3.7.2)	In the seismic analysis of the RB/FB and CB for the North Anna site conditions (ground motion and local geotechnical properties), the staff identified the following concerns: a. As indicated in DCD Figures 3.7-24 through 3.7-35, the North Anna ground motions at the base of the RB/FB are different from those at the CB base. The staff's concern is whether these ground motions are treated as design ground motions. If yes, it implies that the design ground motion is not uniquely defined (RG 1.60 ground motion and North Anna ground motions at the foundation base of the RB/FB and CB). The staff requests the applicant (1) clarify the definition of design ground motion in the DCD, and (2) define the design site parameters (Tier 1 information) in Tier 1 Table 5.1-1. b. Do the ground motion time histories generated for the North Anna ground response spectra

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			satisfy the response spectrum enveloping requirements for all damping ratios to be used for the seismic design? If yes, the staff requests that the comparison plots be provided in the DCD. If not, the staff requests the applicant to provide, in the DCD, technical basis for not satisfying these SRP guidelines. c. Do the ground motion time histories generated for the North Anna ground response spectra satisfy the PSD enveloping guidelines? If yes, the staff requests that a detailed description showing how the target PSDs were developed, and showing the comparison, be provided in the DCD. If not, the staff requests the applicant provide, in the DCD, a technical basis for not satisfying these SRP guidelines. GE Status Update: In progress. Similar to RAIs 3.7-8 and 3.7-12.
3.7-35 (8/18/06)	Cheng T	Clarify, in the DCD, (1) what soil damping was used in the SSI analysis, and (2) how the embedded effects were considered in the SSI analysis. (3.7.2)	As stated in DCD Appendix 3A, Section 3A.7, the elastic half-space theory was used for modeling the soil foundation for both the generic site condition and the North Anna site condition. The staff identified the following issues in need of clarification: (1) what soil damping (material damping and energy loss due to wave propagation) was assigned for the SSI analyses, and (2) how the embedment effects (especially at relatively soft soil sites) were considered in the analysis. The applicant is requested to address these clarifications, and also describe how the elastic half-space theory was applied to the North Anna site, in the DCD. GE Status Update: In progress. Embedment effects will be addressed by the new SASSI analysis.
3.7-36 (5/19/06)	Cheng T	Provide a description, in the DCD, of how to consider the missing mass in the seismic response calculation. (3.7.2)	In DCD Appendix 3A, Tables 3A.7-1 through 3A.7-14, the applicant presented the eigenvalue analysis results. Based on the data presented, it appears that the highest modal frequencies considered in the modal time history analyses of the RB/FB are in the range of 10.83 Hz (soft soil) to 11.89 Hz (hard rock). For the CB, it appears that the highest modal frequency considered in the modal time history analyses is 29.10 Hz. The staff requests the applicant include the following information in the DCD: (a) Discuss whether only the modes listed in the cited tables were included in the modal time history analyses. If not, then identify the additional modes included in each time history analysis and provide the basis for their inclusion. If yes, then identify the modes excluded from each time history analysis, up to f_{ZPA} of the spectrum, and provide the basis for their exclusion.

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			(b) Discuss how the missing mass (modal mass corresponding to modes with frequencies higher than the analysis cut-off frequency) was included in the seismic response analyses. The staff notes that the 10 percent criteria stated on page 3.7-10 of the DCD is no longer considered acceptable to the staff (RAI 3.7-17 provides the basis for not accepting the 10 percent criteria). <u>GE Response</u>: (a) As stated in the response to RAI 3.7-17, modal superposition time history analysis was not employed. The direct integration method in the time domain is employed for the seismic analyses. For clarification purposes, a footnote "Modal information shown is not used in the response analysis performed by the direct integration method" will be added to Tables 3A.7-1 through 3A.7-14. Markups of the affected DCD pages are attached. (b) Please see the response to RAI 3.7-17. **<u>Staff Assessment:</u>** **(1) Staff discussed the required input time step needed for dynamic SSI analyses with the applicant, and identified that 0.01sec is acceptable for the case of computations using ground motion inputs associated with the low frequency generic response spectrum. However, analyses performed with inputs enveloping the high frequency spectrum associated with the North Anna site or with the envelope spectrum combining both the generic and North Anna (envelope) spectra will require a time step of 0.005 sec. to properly capture the high frequency responses.** **The staff pointed out a potential problem in GE's planned use of the SASSI -2000 computer code to perform SSI analyses , when using the 0.005 sec time step for the artificial input motions. The version of SASSI-2000 available to GE has a limitation of 4096 input steps. The total input time history duration will then be limited to 20.48 seconds. When performing analyses representing the very broad envelope spectrum, it may be difficult to develop a 20.48 second time history that properly envelopes the spectrum and satisfies the enveloping criteria in NUREG/CR-6728. A total input time history duration of 40.96 seconds (or 8192 points at 0.005 seconds) may be needed to adequately match the broad envelope spectrum. GE will need to address this in its planned SASSI-2000 analyses for the new envelope response spectrum design basis.**

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			(2) The staff requested GE to provide the frequencies and modes shapes up to 50 Hz for the RB/FB stick model. Based on its review of this data, the staff identified a possible problem concerning the lack of coupling in the vertical direction between the RB and the RCCV. The applicant re-calculated the frequencies and mode shapes with and without vertical coupling between the RB and RCCV, using a reduced model in which the 3 sticks representing the RPV were removed. Based on review of these new results, the staff and GE concluded that there is minor, but not totally negligible, vertical coupling. GE indicated that it will include the vertical coupling in its planned SASSI analyses. **GE agreed to revise its response to RAI 3.7-36, to incorporate the information discussed at the audit. This RAI will be considered resolved after the revised RAI response is submitted.**
3.7-37 (8/18/06)	Cheng T	Provide a description, in the DCD, of how to calculate the frequency-dependent and frequency-independent soil stiffness. (3.7.2)	In the third paragraph of DCD Appendix 3A, Section 3A.5, the applicant discussed how to use the frequency-independent soil-spring K_c, and damping coefficient C_c to represent the soil foundation in the SSI analysis of the RB/FB and CB. DCD Tables 3A.5-1 and 3A.2 provide tabulated numerical values of K_c and C_c for the RB/FB and CB. However, the applicant did not describe in the DCD how the frequency-dependent soil-springs (real and imaginary parts of the soil stiffness) were calculated, and how these frequency-dependent soil-springs were converted to frequency-independent soil-springs and damping ratios. The staff requests the applicant provide a detailed description in the DCD. <u>GE Status Update</u>: In progress. Response will be similar to Item 7 of RAI 3.7-49.
3.7-38 (8/18/06)	Cheng T	Provide a description, in the DCD, of theory and method for calculating soil stiffness. (3.7.2)	It is stated in DCD Appendix 3A that the shear wave velocities and material damping ratios are strain compatible. The staff requests the applicant provide the following information in the DCD: (1) the theory (methods or formula) for calculating all soil springs, (2) the method (or formula) for calculating damping ratios, and (3) a clear description how the strain dependency of these values is accounted for in the soil-springs used in the SSI analyses. <u>GE Status Update</u>: In progress. Response to (1) and (2) will be similar to Item 7 of RAI 3.7-49. For (3), spring values are assumed to be at seismic strain level.
3.7-39	Cheng T	Describe how the	For the SSI analyses that were performed, the staff requests the applicant to describe in detail in

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(8/18/06)		structure-to-structure interaction effects were considered in the DCD. (3.7.2)	the DCD how it considered the effect of structure-to-structure interaction through the soil between the RB/FB and CB. The staff considers this a potentially significant effect, especially for the response of the CB. GE Status Update: New SASSI analysis will address structure-to-structure interaction.
3.7-40 (5/19/06)	Cheng T	Provide, in the DCD, a description of how to apply the direct spectra generation method to calculate floor response spectra. (3.7.2)	In DCD Section 3.7.2.5, the applicant stated that direct spectra generation, without resorting to time history, is an acceptable alternative method for developing floor response spectra. The staff notes that application of the direct spectra generation method will require a detailed staff review of the technical basis and sample calculations that demonstrate results equivalent to using time history analysis. Therefore, the staff requests the applicant to (1) identify the specific applications of the direct spectra generation method in the ESBWR design/analysis; (2) describe the methodology used to confirm equivalency to the time history analysis method; and (3) submit numerical results of the comparative analyses. GE Response: The direct spectra generation methodology is not applied to the ESBWR primary structure models to generate in-structure Floor Response Spectra (FRS). However for ESBWR application, the methodology will be applied to generate in-equipment Required Response Spectra (RRS) in subsystems such as piping systems, equipment control panels, local racks, etc. The GE Nuclear Energy developed direct spectra generation methodology is an Independent Support Motion (ISM), response spectrum methodology for generation of in-structure response spectra. It is based on stochastic calculus and statistical theory. The response spectra spectral accelerations are directly calculated based on the subsystem Eigen Data Set (obtained from the subsystem eigenanalysis) and the components of the independent support motion response spectra, which excite the subsystem. Numerical results, including response spectrum plots, of the comparative analyses considered in the verification of the ERSIN computer code are provided in the attachment. (Also see GE response to RAI 3.7-56)

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			<u>Staff Assessment</u>: Computer Code ERSIN performs direct generation of in-structure response spectra using the modal characteristics of the structure and the response spectra at the supports as input. The staff reviewed the validation documentation for ERSIN, and found the results to be conservative when compared to response spectra generated by time-history analysis. GE agreed to identify any previous documented staff acceptance of its use, and also to identify in DCD Section 3.10 (Seismic and Dynamic Qualification of Seismic Category I Mechanical and Electrical Equipment) that its use is for development of equipment RRS. After the discussion with the staff (EEMB) responsible for the DCD Section 3.10 review, the staff determined that the review of DCD section 3.10 is outside the DCD Section 3.7 scope, and GE's response is considered resolved for this RAI. EEMB will resume the review of the issue raised in this RAI.
3.7-41 (5/19/06)	Cheng T	Provide a description of how the 100-40-40 combination method was applied. (3.7.2)	The staff accepts the 100-40-40 method of combination, as described in and subject to the limitations specified in RG 1.92, Revision 2 (in pre-publication stage). Draft regulatory guide DG-1127, issued for public comment in 02/05, states the staff position on this combination method. The staff requests the applicant to confirm adherence to the staff position on use of the 100-40-40 method of combination. <u>GE Response</u>: As stated in DCD Section 3A.5, because the three component ground motion time histories are statistically independent, they are input simultaneously in the response analysis using the time history method of analysis solved by direct integration. Therefore, the 100-40-40 method of combination is not used in the building response analysis. However, the following general criteria, "The use of 100-40-40 method of combination shall be consistent with the requirements of DG-1127" will be added to DCD Section 3.7.2.6, 3rd paragraph. In the structural design of buildings, the 100-40-40 method of combination was used as stated in DCD Sections 3.8.1.3.6, 3.8.4.3.1.2, and 3.8.4.3.1.3. The 100-40-40 method of combination used is consistent with the requirements of DG-1127. **<u>Staff Assessment</u>: GE's response is acceptable. This RAI will be considered resolved after the change to the DCD is formally submitted**.
3.7-42 (5/19/06)	Cheng T	Explain which specific method was used for	In DCD Section 3.7.2.6, the applicant provided a description of the method for combining seismic responses resulting from the three orthogonal components of the input ground motion. The staff

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		combining spatial seismic responses. (3.7.2)	requests the applicant to specifically identify in the DCD which spatial combination method delineated in DCD Section 3.7.2.6 has been used for each of the building structures' seismic analyses. GE Response: Please see the response to RAI 3.7-41. See attached DCD marked-up changes for clarification. **Staff Assessment: GE's response is acceptable. This RAI will be considered resolved after the change to the DCD is formally submitted**.
3.7-43 (5/19/06)	Cheng T	Justify the use of the 10 percent rule for the modal time history analyses. (3.7.2)	In DCD Section 3.7.2.7, the applicant indicated that for modal combination involving high-frequency modes, the missing mass procedure of SRP 3.7.2, Appendix A, applies. This is acceptable to the staff. The applicant also identified an alternative method: modal responses are computed for enough modes to ensure that the inclusion of additional modes does not increase the total response by more than 10 percent. The staff notes that this alternative method is no longer considered acceptable to the staff, because more accurate accountings of the total contribution from high-frequency modes can be achieved by direct calculation of the missing mass contribution. (The staff's position for not accepting this alternative method is stated in RAI 3.7-17.) The staff requests the applicant identify whether the 10 percent alternate method has been used, to describe all applications, and to provide a technical justification for each application. GE Response: Please see the response to RAI 3.7-17. **Staff Assessment: GE's response is acceptable. This RAI will be considered resolved after the change to the DCD is formally submitted**.
3.7-44 (5/19/06)	Cheng T	Identify in the DCD which of the three methods were used to account for the modeling uncertainties when generating the floor response spectra.	In DCD Section 3.7.2.9, the applicant stated that floor response spectra calculated according to the procedures described in Subsection 3.7.2.5 are peak-broadened to account for uncertainties in the structural frequencies resulting from uncertainties in the material properties of the structure and soil and from approximations in the modeling techniques used in the analysis. If no parametric variation studies are performed, the spectral peaks associated with each of the structural frequencies are broadened by ±15 percent. If a detailed parametric variation study is made, the minimum peak broadening ratio is ±10 percent. In lieu of peak broadening, the peak shifting method of Appendix N of ASME Section III, as permitted by Regulatory Guide 1.84, can be used. The staff finds the methods identified to be consistent with SRP acceptance criteria and related staff positions.

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		(3.7.2)	However, to complete its review, the staff requests the applicant to specifically identify in the DCD which methods described in DCD Section 3.7.2.9 were actually used in the development of the design basis in-structure response spectra, to account for parameter variations. Describe the specific applications of each of the three methods. <u>GE Response</u>: As stated in Appendix 3A.9.2, the envelope spectra are peak broadened by ±15 percent. DCD Section 3.7.2.9 will be revised accordingly and markups of the affected DCD pages are attached. **<u>Staff Assessment</u>: The technique used for broadening floor response spectrum peaks is acceptable. The staff noted the applicant's use of the ASCE 4-98 incoherence reduction factor is not acceptable. This issue is identified as new RAI 3.7-58 to be addressed by GE.**
3.7-45 (5/19/06)	Cheng T	Provide a description, in the DCD, of how the torsional effects were considered in the seismic response calculations. (3.7.2)	In DCD Section 3.7.2.11, the applicant stated that one method of treating the torsional effects in the dynamic analysis is to carry out a dynamic analysis that incorporates the torsional degrees of freedom. For structures having negligible coupling of lateral and torsional motions, the torsional effects are accounted for in the following manner: (a) The locations of the center of mass are calculated for each floor. (b) The center of rigidity and torsional stiffness are determined for each story. (c) Torsional effects are introduced in each story by applying a torsional moment about its center of rigidity. (d) The torsional moment is calculated as the sum of the products of the inertial force applied at the center of mass of each floor above and a moment arm equal to the distance from the center of mass of the floor to the center of rigidity of the story, plus 5 percent of the maximum building dimension at the level under consideration. (e) To be conservative, the absolute values of the moments are used in the sum. (f) The torsional moment and story shear are distributed to the resisting structural elements in proportion to each individual stiffness. The staff finds the methods identified to be consistent with SRP acceptance criteria. However, to complete its review, the staff requests the applicant to specifically identify in the DCD which of the

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			methods described in DCD Section 3.7.2.11 were actually used to account for torsional effects in the design basis analyses for the building structures. Describe the specific applications of each method. GE Response: As described in Appendix 3A.7.2, a dynamic analysis that incorporates the torsional degrees of freedom was carried out to treat the torsional effects in the dynamic analysis. DCD Section 3.7.2.11 will be revised accordingly for further clarification and markups of the affected DCD pages are attached. **Staff Assessment**: **GE's response is acceptable**. **This RAI will be considered resolved after the DCD changes are submitted**.
3.7-46 (5/19/06)	Cheng T	Explain how the limitation related to the stiffness-weighted damping was applied in the seismic response calculations. (3.7.2)	From its review of DCD Section 3.7.2.13, the staff identified that the limitation which is imposed on the use of composite modal damping in SRP 3.7.2(II)(13) is not addressed in this DCD section. This limitation, as described in SRP Section 3.7.2(II)(13), states that for models that take SSI into account by the lumped soil spring approach, only stiffness-weighted damping is acceptable. The staff requests the applicant to provide an explanation how this limitation has been considered in the applications of composite modal damping. If not considered, provide a detailed technical basis for the approach used. GE Response: As stated in the response to RAI 3.7-17, the SSI analyses for the RB/FB and CB were performed by the direct integration method in the time domain. The formation of damping matrix for the analysis was explained in the third paragraph of DCD page 3.7-16. The composite modal damping formulations shown in Equations 3.7-14 and 3.7-15 are not used since modal superposition was not employed. However, as a general analysis procedure for damping, the following limitation described in SRP 3.7.2(II) (13) will be added in the first paragraph of DCD page 3.7-16: "For models that take SSI into account by the lumped soil spring approach, the method defined by Equation 3.7-14 is acceptable. For fixed base model, either Equation 3.7-14 or 3.7-15 may be used."

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			Markups of the affected DCD pages are attached. <u>Staff Assessment</u>**: GE's response is acceptable**. **This RAI will be considered resolved after the DCD changes are submitted**.
3.7-47 (5/19/06)	Cheng T	Identify, in the DCD, which method was used to treat damping ratios in the seismic analyses. (3.7.2)	In DCD Section 3.7.2.13, the applicant presented several methods to develop composite modal damping when an SSC consists of structural elements with different damping properties. The applicant stated that for use in modal superposition (modal time history or response spectrum) analyses, the composite modal damping ratio can be obtained based on either stiffness-weighting or mass-weighting. The composite modal damping calculated by either method is limited to 20 percent. Additional approaches applicable to frequency domain analysis and direct integration time history analysis are also presented. The staff requests the applicant to identify which of the methods described in DCD Section 3.7.2.13 were actually used in the design basis seismic analyses of the building structures (RB/FB and CB). Describe the specific applications of each method. <u>GE Response</u>: See the response to RAI 3.7-46. DCD Section 3.7.2.13 will be revised to identify specific applications and markups of the affected DCD pages are attached. <u>Staff Assessment</u>**: The staff reviewed DCD changes (mark-up) proposed by GE and found acceptable. This RAI will be considered resolved after the DCD changes are submitted**.
3.7-48 (5/19/06) (withdraw part b)	Cheng T	Provide additional information to demonstrate the dynamic stability of the RB/FB and CB during an seismic event. (3.7.2)	DCD Section 3.7.2.14 describes the theory and analysis method for calculating the seismic Category I structure overturning moments. As a result of its review, the staff requests the applicant provide the following additional information: (a) In DCD Section 3.7.2.14, the applicant described the use of an energy method to evaluate the stability of structures against seismically induced overturning moments. The applicant is requested to provide a more detailed description of the analysis method, including an explanation of how the energy components for the embedment (W_p) and buoyancy (W_b) are determined, and the technical justification for the two equations given for the velocity terms (V_h and V_v).

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			(b) ~~DCD Section 3.7.2.14 did not provide a description for evaluating seismically induced sliding. Therefore, the applicant is requested to describe the analysis method used to calculate the stability of structures against seismically induced sliding~~. GE Response: The analysis method to evaluate the stability of structures against seismically induced overturning moments is based on the energy method shown in the following reference: BC-TOP-4-A, Rev.3, "Seismic Analyses of Structures and Equipment for Nuclear Power Plants", November 1974, Bechtel Power Corporation. (Additional information provided in response.) **Staff Assessment: The staff had previously accepted Rev. 3 of the Bechtel topical report (BC-TOP-4) in the 1970s (Letter from R.W. Klecker, AEC to J.V. Morowski, Bechtel dated October 31, 1974). GE identified sign differences between its independent derivation of Eqn 4-17 and Eqn 4-17 of BC-TOP-4 for calculating the effects of buoyancy. GE presented numerical results which appear to demonstrate that the BC-TOP-4 contains an error in Eqn 4-17. The staff needs to inform Bechtel if it confirms that an error exists.** **With respect to the velocity terms Vh and Vv, the staff requested the technical basis for using the SRSS method to combine the contribution from peak values of ground velocity and relative velocity. It is not evident that these two values in a time history (say the horizontal direction) are sufficiently uncorrelated, which is needed to use the SRSS method. GE referred to the Bechtel topical report.. The staff needs to evaluate this.** **This RAI remains unresolved.**
3.7-49 (5/19/06)	Cheng T	Provide information for the staff to perform its confirmatory analyses.	The applicant is requested to provide the following information needed for the staff to perform its confirmatory analyses: 1. Detailed finite element (FE) RB/FB model (including figures showing mesh plots, node numbering, etc.) used for the development of the lumped-mass stick model. 2. Detailed fixed-base (fixed at the top of the foundation mat) lumped-mass stick model used in GE's SSI analyses. 3. Large-size structural design drawings of the RB/FB. Specifically, drawings showing the detailed foundation mat and embedded side walls are needed. 4. Soil information used to develop soil springs and soil damping for the SSI analyses of the

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			RB/FB supported by the soft soil condition. 5. Description of the computer code "DAC3N" used by GE for the SSI analyses. 6. Input ground motion time history text files in digitized form. 7. Description of the SSI analytical formulation and digitized response computation results. <u>GE Response</u>: 1. As stated in the response to RAI 3.7-6, a finite element model was not used for the development of the lumped-mass stick model. 2. Detailed fixed-base (fixed at the top of the foundation mat) lumped-mass stick model used in GE's SSI analyses are shown in Table 3.7-49 (1) through (14). 3. Please see the response to RAI 3.7-4. 4. Soil information is shown in DCD Table 3A.3-1. 5. Computer code "DAC3N" is described in DCD Appendix 3C. 6. The digitized data of input ground motion time histories compatible to RG 1.60 are provided in Attachment 3.7-49-A1 and in electronic format (file name: RG1.60_input.pdf) in a CD (Enclosure 3). 7. The SSI analytical formulation is described as follows. The digitized response computation results of RB/FB floor response spectra shown in DCD Figures 3A.8-1 through 3A.8-3 for the fixed-base case are provided in Attachment 3.7-49-A2 and in electronic format (file name: FIX_5pct.pdf) in a CD (Enclosure 3). As stated in the response to RAI 3.7-17, the SSI analyses for the RB/FB and CB were performed by the direct integration method in the time domain. The response of a multi-degree-of-freedom linear system subjected to external forces and/or uniform support excitations is represented by the differential equations of motion in the matrix form in DCD Equation (3.7-1). The viscous damping matrix consists of structure damping and soil radiation damping. As stated in the response to RAI 3.7-46, the structure damping matrix is generated using the DCD Equations (3.7-14) and (3.7-17). As stated in DCD Section 3A.5, the soil is modeled with sway-rocking springs. The base spring is evaluated from vibration admittance theory, based on three dimensional wave propagation theory for uniform half space soil. The assumptions used for the evaluation are as follows.

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			- Uniform half space soil - Rectangular shape foundation - Uniform stress distribution for horizontal and vertical spring - Triangle stress distribution for rocking and torsional spring - Evaluation by load-weighted average displacement (Additional information provided in response.) Staff Assessment: **All modeling data received for RB/FB model. GE will provide CB model details when finalized.**
3.7-50 (8/18/06)	Cheng T	Provide a detailed description of the method applied to determine the cracked concrete stiffness. (3.7.2)	DCD Section 3.7.2.3, "Procedures Used for Analytical Modeling," does not address the method used to develop stiffness values (uncracked concrete sections versus cracked concrete sections) for concrete structural elements for the seismic analysis models. The staff requests the applicant include in the DCD a detailed description of the method applied to determine the stiffness values for both cracked concrete sections and uncracked concrete sections in the seismic analysis models. GE Status Update: To be addressed as part of the new SASSI analyses. 50 percent reduction in concrete stiffness will be analysed.
3.7-51 (5/19/06)	Cheng T	Provide a description of how the cut-off frequency is determined for calculating seismic response of subsystems. (3.7.3)	DCD Section 3.7.3.3.2 provides the approach and method for modeling the subsystems. The staff identified the need for the following additional information: (a) The alternate criterion in DCD Section 3.7.3.3.2 for ensuring a sufficient number of mass degrees of freedom relies on determination of the "cutoff frequency" for the analysis; DCD Section 3.7.2.1.1 is referenced. The staff's review of DCD Section 3.7.2.1.1 noted that only the missing mass method is considered acceptable for capturing the high frequency response contribution (above f_{zpa}). (The staff's position for the consideration of missing mass in the seismic analysis is stated in RAI 3.7-17.) Consequently, there is no acceptable basis in DCD Section 3.7.2.1.1 for determining the "cutoff frequency." The staff requests the applicant to define "cutoff frequency", as it relates to ensuring a sufficient number of mass degrees of freedom, and explain in detail how it is determined for structures, systems, and components. (b) The staff also requests the applicant to clarify its criterion in DCD Section 3.7.3.3.2 related to location of lumped masses, in order to ensure conservative dynamic loads. It appears that the goal would be to drive the natural frequency of the equipment mathematical model toward the

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			peak of the response spectrum. However, the criterion appears to be aimed at lowering the natural frequency. <u>GE Response</u>: (a) The cutoff frequency for the modal superposition analysis of subsystems for seismic and non-seismic building dynamic loads is 100 Hz or the rigid frequency defined as f2 in DG-1127 (see response to RA 3.12-20). All modes with frequencies up to the cutoff frequency are included in the modal superposition and the residual rigid response due to the missing mass associated with the truncated higher frequency modes is accounted for in accordance with the methods described in DCD Subsection 3.7.2.7. For further clarity, DCD Subsection 3.7.2.1.1, 5th paragraph, last sentence "Alternatively, the cutoff frequency may be selected to ensure that the number of modes included is sufficient such that inclusion of all truncated modes does not result in more that a 10 percent increase in total response" will be deleted. (b) The fourth bullet in DCD Section 3.7.3.3.2 will be revised to read as follows: • When an equipment mass is concentrated between two supports, the concentrated mass is located at a point between the two supports where the maximum displacement of the concentrated mass will occur. This will tend to lower the natural frequencies of the equipment system model. Because the equipment fundamental frequency is typically in the higher frequency, lower amplification range of the support input motion response spectra, lowering the natural frequencies of the equipment will move them into the higher amplification region of the excitation and thereby conservatively increase the equipment response level. Similarly, in the case of live loads (mobile) and variable support stiffness, the location of the load and the magnitude of the support stiffness are chosen to lower the system natural frequencies. Similar to above discussion, this ensures conservative dynamic responses because the lowered equipment frequencies tend to be shifted to the higher amplification range of the input motion spectra. If not, the model is adjusted to give more conservative responses. **<u>Staff Assessment</u>: As a result of audit discussion, GE agreed to revise its proposed DCD revision, to more clearly describe its approach for ensuring that a conservative response is obtained for equipment. GE's response is acceptable. This RAI will be considered resolved after DCD changes are formally submitted.**

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3.7-52 (6/30/06)	Cheng T	Provide a description of the analysis method and acceptance criteria for the design of “auxiliary systems.” (3.7.3)	DCD Section 3.7.3.13 does not provide any detail about the methods of analysis employed or the acceptance criteria used to determine structural design adequacy of buried conduits, tunnels, and auxiliary systems. In addition, the applicant did not provide the definition for the term “auxiliary systems.” The staff requests the following additional information to complete its review: (a) a description of the types of SSCs that are included under the category “auxiliary systems;” (b) a description of the analysis method and acceptance criteria for buried conduits; (c) a description of the analysis method and acceptance criteria for tunnels; (d) a description of the analysis method and acceptance criteria for auxiliary systems. <u>GE Status Update</u>: In progress.
3.7-53 (5/19/06)	Cheng T	Provide, in the DCD, a description related to the SSI analysis of the above-ground tanks. (3.7.3)	In DCD Section 3.7.3.15, the applicant described the important elements to consider in the seismic analysis of above-ground tanks. However, several items in the analysis method for the above-ground tanks need to be clarified: (a) DCD Section 3.7.3.15 indicates that the beneficial effects of soil-structure interaction (SSI) may be considered in this evaluation. The applicant is requested to confirm that if SSI effects are important (i.e., may lead to higher responses) then they will (not may) be considered as well. This should be included in the DCD description. In addition, provide a description or reference to an appropriate SSI method of analysis (comparable to those identified in SRP 3.7.3(II)(14)) that is used for the tank analysis. (b) Describe how the damping values for the impulsive mode are determined and whether the values are in accordance with those specified in NUREG/CR-1161. If not, provide the justification for any alternative method. <u>GE Response:</u> (a) DCD Section 3.7.3.15, 6th bullet, 3rd sentence will be revised to read “If the effects of soil-structure interaction results in higher response then an appropriate SSI method of analysis comparable to Reference 3.7-16 is used.” In DCD Section 3.7.6, the following will be added: Reference 3.7-16 Brookhaven National Laboratory, BNL 52361, “Seismic Design and Evaluation Guidelines for the Department of Energy High-Level Waste Storage Tanks and

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			Appurtenances." October 1995. (b) The damping value for the impulsive mode is the same as the tank shell material in accordance with NUREG/CR-1161. DCD Section 3.7.3.15, 2nd bullet, 3rd sentence will be clarified. A Markup of the affected DCD pages is attached. **Staff Assessment: GE's response to Part (a) is acceptable. On part (b), the staff requested GE to clarify how damping is determined and utilized in the analysis if SSI is included in the tank analysis. GE agreed to revise the DCD to address damping when SSI effects are included. GE's response is acceptable. This RAI will be considered resolved after DCD changes are formally submitted.**
3.7-54 (8/18/06)	Cheng T	Specify the lower bound of the soil shear wave velocity to be 1000 ft/sec in the DCD. (3.7.5)	In DCD Section 3.7.5, the applicant indicated that the COL applicant needs to confirm that the site-specific shear wave velocity is no less than 1,000 fps in order to confirm the design adequacy of the plant. However, in following the guidance of the SRP for an individual site evaluation, the COL applicant needs to perform site-specific response calculations, reducing the low-strain shear-wave velocity profile from the Best Estimate (BE) to a Lower Bound (LB) value, defined as the BE divided by the square root of 2. DCD Section 3.7.5 needs to indicate that 1,000 fps is a LB velocity and not a BE velocity, or, as an alternative, the minimum acceptable BE velocity can be specified. In addition, since all design analyses were performed for assumed uniform velocity profiles, the site acceptance criteria needs to include information on what degree of variation from the uniform velocity profile is acceptable for the design. GE Status Update: See RAI 3.7-31.
3.7-55 (6/30/06)	Cheng T	Provide the computer code validation packages, in English, for review. (3.7.2)	To facilitate the staff's evaluation of the adequacy of computer codes used for design and analysis of the ESBWR Seismic Category I structures, the staff requests the applicant submit validation packages, translated into English, for the following computer codes listed in DCD Appendix 3C: SSDP-2D TEMCOM2 DAC3N GE Status Update: In progress. Validation Packages are being translated. User Manuals are not being translated.

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3.7-56 (5/19/06)	Cheng T	Provide the validation package for the computer code “ERSIN” for review. (3.7.3)	DCD Appendix 3D (3D.4.6.1) identifies the ERSIN Computer Program, which provides direct generation of local or global acceleration response spectra. Its stated use is to generate response spectra for pipe-mounted and floor-mounted equipment. To facilitate the staff’s evaluation of this computer code, the applicant is requested to submit a validation package for the specific types of ESBWR applications, including comparisons to response spectra generated by time history analysis. <u>GE Response</u>: For ESBWR application, the ERSIN direct spectra generation methodology will be applied to generate in-equipment Required Response Spectra (RRS) in subsystems such as piping systems, equipment control panels, local racks, etc. The GE ERSIN direct spectra generation methodology is an Independent Support Motion (ISM), response spectrum methodology for generation of in-structure response spectra. It is based on stochastic calculus and statistical theory. The response spectrum spectral accelerations are calculated based on the subsystem Eigen Data Sets (obtained from the subsystem eigen analyses) and the components of the subsystem independent support motion input response spectra. The ERSIN methodology and corresponding verification package was developed in the early 1980s, prior to the conception of the ESBWR project. Consequently the existing verification package does not include any ERSIN vs. Time History generated response spectra comparison plots for ESBWR specific application. However, the ERSIN Design Record File (DRF No. A22-00069) verification contains ERSIN vs. Time History generated response spectra comparison plots for a variety of GE BWR NSSS equipment; e.g., piping systems, equipment control panels, local racks, etc. Numerical results, including response spectrum plots, of the comparative analyses considered in the verification of the ERSIN computer code are provided in the attachment. The GE ERSIN DRF verification package can be reviewed in San Jose at the discretion of an NRC audit team. **<u>Staff Assessment</u>: See assessment under RAI 3.7-40, same subject.**

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3.7-57 (8/18/06)	Cheng T	Demonstrate the seismic model can transmit frequencies up to 50 Hz, and can capture responses due the high frequency components of North Anna ground motion. (3.7.2)	Section 3.7.2.3 of the DCD indicates that the mathematical model of the structural system is constructed either as a stick model or a finite element model. These models are used in the soil-structure interaction (SSI) response analyses to determine seismic response of the soil-structure system as indicated in DCD Section 3.7.2.4 and described in Appendix 3A to DCD Section 3.7. The free-field ground motions used as input to the plant analysis and design are described in DCD Section 3.7.1 and are ground motions that envelope either the RG 1.60 low frequency response spectrum or the high frequency ground motion developed for the North Anna ESP site. DCD Figure 3.7-30 presents a plot of the North Ana design ground response spectrum and indicates a response spectrum that possesses its primary spectral accelerations in the frequency range from about 10 Hz to 50 Hz with a peak spectral acceleration at a frequency of about 20 Hz for the horizontal response spectrum and about 30 to 50 Hz for the vertical response spectrum. Appendix 3A to DCD Section 3.7 presents descriptions of the stick models developed for use in SSI analyses for the primary structures and internals of the plant. DCD Tables 3A.7-5 through 3A.7-14 present the results of eigenvalue analyses that are carried to frequencies as high as 27 Hz. These indicate participation factors of 0.28 at frequencies as high as about 25 Hz. IN **RAI 3.7-XX**, the staff requests the applicant to demonstrate that the stick structural models developed based on the process described in the current DCD can transmit frequencies up to 50 Hz and be able to capture the responses resulted from the high frequency components of North Anna input ground motions. <u>GE Status Update</u>: In progress. CB stick model is being refined by adding additional mass points.
3.7-58	T. Cheng	Use of FRS reduction factors.	**During the discussion of GE's response to RAI 3.7-44 at the on-site audit (06/05-08/06), GE indicated that before broadening the in-structure response spectra by ±15 percent, incoherence reduction factors, taken from ASCE 4-98, were applied to the raw spectrum results obtained from the time history analysis. The staff does not accept the incoherence reduction factors from ASCE 4-98. Therefore, the staff requests GE to submit an ESBWR-specific technical basis for using the incoherence reduction factors.**