Charles R. Pierce
Regulatory Affairs Director

Southern Nuclear
Operating Company, Inc.
40 Inverness Center Parkway
Post Office Box 1295
Birmingham, AL 35201

SOUTHERN COMPANY

March 31, 2014

Docket Nos.: 50-424
50-425

NL-14-0344

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555-0001

Vogtle Electric Generating Plant – Units 1 and 2
Seismic Hazard and Screening Report for CEUS Sites

References:

1. NRC Letter, "Request for Information Pursuant to Title 10 of the Code of Federal Regulations 10 CFR 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated March 12, 2012.
2. NEI Letter to NRC, "Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations," dated April 9, 2013. ML13101A379.
3. NRC Letter, EPRI Final Draft Report XXXXXX, Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic," as an Acceptable Alternative to the March 12, 2012, Information Request for Seismic Reevaluations, dated May 7, 2013. ML13106A331.
4. EPRI Report 1025287, "Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic. ML12333A170.
5. NRC Letter, Endorsement of EPRI Final Draft Report 1025287, Seismic Evaluation Guidance, dated February 15, 2013. ML12319A074.

Ladies and Gentlemen:

On March 12, 2012, the Nuclear Regulatory Commission (NRC) issued Reference 1 to all power reactor licensees and holders of construction permits in active or deferred status. Enclosure 1 of Reference 1 requested each addressee in the Central and Eastern United States (CEUS) to submit a Seismic Hazard Evaluation and Screening Report within 1.5 years from the date of Reference 1.

In Reference 2, the Nuclear Energy Institute (NEI) requested NRC agreement to delay submittal of the final CEUS Seismic Hazard Evaluation and Screening Reports so that an update to the Electric Power Research Institute (EPRI) ground motion attenuation model could be completed and used to develop that information. NEI proposed that descriptions of subsurface materials and properties and base case velocity profiles be submitted to the NRC by

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September 12, 2013, with the remaining seismic hazard and screening information submitted by March 31, 2014. NRC agreed with that proposed path forward in Reference 3.

Reference 4 contains industry guidance and detailed information to be included in the Seismic Hazard Evaluation and Screening Report submittals. NRC endorsed this industry guidance in Reference 5.

The attached Seismic Hazard Evaluation and Screening Report for the Vogtle Electric Generating Plant (VEGP) site provides the information described in Section 4 of Reference 4 in accordance with the schedule identified in Reference 2.

This letter contains no NRC regulatory commitments. If you have any questions, please contact John Giddens at 205.992.7924.

Mr. C.R. Pierce states he is Director of Regulatory Affairs of Southern Nuclear Operating Company, is authorized to execute this oath on behalf of Southern Nuclear Operating Company and, to the best of his knowledge and belief, the facts set forth in this letter are true.

Respectfully submitted,

C. R. Pierce

C.R. Pierce
Regulatory Affairs Director

CRP/JMG/RCW

Sworn to and subscribed before me this 31 *day of* March, *2014.*

Laura L. Crofts
Notary Public

My commission expires: 10/8/2017

Enclosure 1: Vogtle Electric Generating Plant - Units 1 and 2
Seismic Hazard Reevaluation and Screening for Risk Evaluation

cc: Southern Nuclear Operating Company
Mr. S. E. Kuczynski, Chairman, President & CEO
Mr. D. G. Bost, Executive Vice President & Chief Nuclear Officer
Mr. T. E. Tynan, Vice President – Vogtle
Mr. B. L. Ivey, Vice President – Regulatory Affairs
Mr. B. J. Adams, Vice President – Engineering
Mr. D. R. Madison, Vice President – Fleet Operations
RTYPE: CVC7000

U. S. Nuclear Regulatory Commission
Mr. V. M. McCree, Regional Administrator
Mr. R. E. Martin, NRR Senior Project Manager – Vogtle
Mr. L. M. Cain, Senior Resident Inspector – Vogtle

State of Georgia
Mr. J. H. Turner, Environmental Director Protection Division

SOUTHERN
COMPANY

Enclosure 1 to SNC Letter
NL-14-0344

Vogtle Electric Generating Plant
Units 1 and 2

Response to Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Fukushima Near-Term Task Force Recommendation 2.1: Seismic for Seismic Hazard Reevaluation and Screening for Risk Evaluation

This report provides information in response to NRC's March 12, 2012, 10CFR50.54(f) letter requesting nuclear power plant licensees to perform seismic hazard reevaluation and screening for risk evaluation pursuant to the recommendations in NRC's Near-Term Task Force review of the accident at the Fukushima Dai-ichi nuclear facility.

1.0 Introduction

Following the accident at the Fukushima Daiichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the NRC Commission established a Near Term Task Force (NTTF) to conduct a systematic review of NRC processes and regulations and to determine if the agency should make additional improvements to its regulatory system. The NTTF developed a set of recommendations intended to clarify and strengthen the regulatory framework for protection against natural phenomena. Subsequently, the NRC issued a 50.54(f) letter that requests information to assure that these recommendations are addressed by all U.S. nuclear power plants. The 50.54(f) letter requests that licensees and holders of construction permits under 10 CFR Part 50 reevaluate the seismic hazards at their sites against present-day NRC requirements. Depending on the comparison between the reevaluated seismic hazard and the current design basis, the result is either no further risk evaluation or the performance of a seismic risk assessment. Risk assessment approaches acceptable to the staff include a seismic probabilistic risk assessment (SPRA), or a seismic margin assessment (SMA). Based upon the risk assessment results, the NRC staff will determine whether additional regulatory actions are necessary.

This report provides the information requested in items (1) through (7) of the "Requested Information" section and Attachment 1 of the 50.54(f) letter pertaining to NTTF Recommendation 2.1 for the Vogtle Electric Generating Plant (Plant Vogtle) Units 1 and 2, located in Burke County, Georgia. In providing this information, Southern Nuclear Operating Company (SNC) followed the guidance provided in the Seismic Evaluation Guidance: Screening, Prioritization, and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic (EPRI 1025287, 2013a). The Augmented Approach, Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic (EPRI 3002000704, 2013b), has been developed as the process for evaluating critical plant equipment as an interim action to demonstrate additional plant safety margin, prior to performing the complete plant seismic risk evaluations.

The original geologic and seismic siting investigations for Plant Vogtle Units 1 and 2 were performed in accordance with Appendix A to 10 CFR Part 100 and meet General Design Criterion 2 in Appendix A to 10 CFR Part 50. The Safe Shutdown Earthquake Ground Motion (SSE) was developed in accordance with Appendix A to 10 CFR Part 100 and used for the design of seismic Category I systems, structures and components.

In response to the 50.54(f) letter and following the guidance provided in the SPID (EPRI 1025287, 2013a) with due consideration to the extensive site soil profile data available for the Vogtle site, a seismic hazard reevaluation was performed. For screening purposes, a Ground Motion Response Spectrum (GMRS) was developed.

Based on the results of the screening evaluation, Plant Vogtle Units 1 and 2 screens in for a risk evaluation, a Spent Fuel Pool evaluation, and a High Frequency evaluation as part of the risk evaluation.

2.0 Seismic Hazard Reevaluation

The Vogtle site is located approximately 15 miles east-northeast of Waynesboro, Georgia and 26 miles southeast of Augusta, Georgia, adjacent to the Savannah River. Plant Vogtle Units 1 and 2 lies in the Upper Coastal Plain of the Coastal Plain Physiographic Province. The Upper Coastal Plain is essentially flat-lying section of unconsolidated fluvial and marine sediments overlying a basement complex of Paleozoic crystalline metamorphic and igneous rock as well as Triassic-Jurassic basin sediments. The principal plant structures are founded on compacted granular structural fill overlying the heavily overconsolidated Blue Bluff Marl of the Lisbon Formation. Bedrock at the site is at a depth of approximately 1,050 feet.

The potential for tectonic deformation at the site is negligible. The presence of the Pen Branch fault west of Plant Vogtle Units 3 and 4 footprint and beneath the monocline in the Blue Bluff Marl suggests that past deformation of the Eocene strata has occurred in the form of non-brittle folding. However, this type of deformation associated with the non-capable Pen Branch fault is no longer active and will not impact the ground surface in the future. Since the original site studies in the early 1970s, no new information has been reported to suggest the existence of any Quaternary surface faults or capable tectonic sources within the site area.

The original investigation of historical seismic activity in the region is described in the Plant Vogtle Units 1 and 2 FSAR (SNC, 2014c) section 2.5. In that reference it states that detail studies have revealed no seismological or geological evidence for capable faults within 200 miles of the site. It further states the source of seismicity most affecting the site, both in maximum historical intensity and number of earthquakes, is the Charleston-Summerville, South Carolina, area. The main shocks of August 31, 1886, probably produced an intensity of VI (Modified Mercalli Scale) at the site. The maximum credible site intensity is VI-VII to VIII. For conservatism a safe shutdown earthquake site intensity of VII-VIII was chosen. This intensity is associated with approximately 0.2 g peak horizontal acceleration (PGA). This PGA with the NRC RG 1.60 spectral shape defined the safe shutdown earthquake (SSE) for Plant Vogtle Units 1 and 2.

2.1 Regional and Local Geology

The regional and site (local) geology is described in detail in the Vogtle FSAR (SNC, 2014c).

The site area lies in the Atlantic Coastal Plain (Coastal Plain) Physiographic Province and is bordered by the Savannah River to the east. The topography consists of gently rolling hills with a principally dendritic drainage pattern. Surficial soils are typically well drained. All major streams are tributary to the Savannah River.

The site area lies at the northern extent of a broad westward migrating meander in the Savannah River. Incision of the river has formed steep bluffs and topographic relief of nearly 150 feet from the river surface to the plant site. The river level adjacent to the plant site is at an elevation of approximately 80 feet mean sea level (msl), with a gradient of less than about 1 foot/mile. The flood plain is a broad alluvial surface that is 4 to 10 feet above the channel. The youngest alluvium lies along the western side of the river, while older terraces are preserved on the east side of the flood plain. Stream valleys are predominantly symmetrical, with slopes ranging from 0.2 to 0.6 percent. The surface topography ranges from an elevation of about 90 to nearly 300 feet msl across the Vogtle site.

The Coastal Plain is essentially a flat-lying section of unconsolidated fluvial and marine sediments overlying a basement complex of Paleozoic crystalline metamorphic and igneous rock as well as Triassic–Jurassic basin sediments. Evolution of the basement complex and the effect on the Coastal Plain section is regional in nature.

The Paleozoic rocks and the Triassic sediments were beveled by erosion, forming the base for Coastal Plain sediment deposition. The erosional surface dips southeast approximately 50 foot/mile. The Coastal Plain section consists of stratified sand, clay, limestone, and gravel that dip gently seaward. The oldest Coastal Plain sediments beneath the site area are Late Cretaceous and consist of predominantly siliciclastics deposited in an upper deltaic, fluvial setting that continued throughout the Late Cretaceous. Paleocene sedimentation continued, with a strong fluvial influence changing to more marginal marine to shallow shelf deposition well into the Middle Eocene, marked by deposition of mixed clastic-carbonate sediments. Upper Eocene sedimentation occurred in more marginal and inner-tidal settings.

Miocene (or younger) high energy fluvial deposits are present at higher topographic locations and in some areas incised deeply into the underlying Eocene section. A thin veneer of late Miocene to early Pliocene eolian sands overlies some of the higher topographic areas. The youngest sediments consist of Quaternary alluvium present within the stream and river valleys.

In the site vicinity, the basement rock beneath the Coastal Plain consists of Paleozoic crystalline rock as well as Triassic–Jurassic sedimentary rock of the Dunbarton Basin. The Vogtle site lies near the buried northwest margin of the approximately 9-mi-wide (15-km-wide) Dunbarton Basin, which formed during Mesozoic rifting and opening of the Atlantic Ocean. Deep boreholes within and adjacent to the Savannah River Site (SRS) that penetrate basement indicate that the Paleozoic crystalline rock northwest of the Dunbarton basement has been overprinted with a foliation that dips about 40 to 60 degrees. Based on regional correlations, the foliation strikes northeast and dips to the southeast.

The upper surface of the basement has been leveled by erosion and dips to the southeast between about 48 feet/mile and 37 feet/mile. In the site area, the regional basement surface is unconformably overlain by loosely consolidated, fluvial, deltaic, and shallow marine Coastal Plain sediments. The depth to the Triassic–Jurassic basement rock beneath the site is about 1,049 feet (El. -826 feet msl), based on borehole B-1003 drilled for Plant Vogtle Units 3 and 4 (SNC, 2013).

Within the 5-mile site area radius, a total of four basement-involved faults have been identified, namely the Pen Branch, Ellenton, Steel Creek, and Upper Three Runs faults. The Ellenton fault does not appear in the most recent SRS fault maps and, if it exists, is not considered a capable structure. The Upper Three Runs fault is restricted to basement rocks, with no evidence that it offsets Coastal Plain sediments. Similarly, the Steel Creek fault is not considered a capable tectonic source. The Pen Branch fault is thought to have been the northern bounding (normal) fault of the Mesozoic Dunbarton extensional basin, subsequently reactivated as a reverse or reverse-dextral slip fault, as documented by post-extension, reverse offsets of Late Cretaceous and younger horizons. Based on analysis of data presented for Plant Vogtle Units 3 and 4 (SNC, 2013), the Pen Branch fault is also not considered a capable tectonic source.

2.2 Probabilistic Seismic Hazard Analysis

2.2.1 Probabilistic Seismic Hazard Analysis Results

LCI (2013) is the source of the information presented in the following section.

The analysis presented here is a base case calculation of rock seismic hazard using the 2012 Central and Eastern United States Seismic Source Characterization (CEUS-SCC) sources (NRC, 2012) and the 2013-EPRI ground motions (EPRI, 2013c). A cumulative absolute velocity filter was not applied in this calculation and no site amplification factors are used. Results are consistent with hard-rock conditions (shear-wave velocities of 2800 m/s). The methodology for seismic hazard calculations is well established in the technical literature (e.g. McGuire, 2004).

Seismic source inputs to the hazard calculations consist of background sources (large regions representing earthquakes not associated with a specific tectonic structure) and Repeated Large Magnitude Earthquake (RLME) sources. Specific background sources included in the hazard calculations consist of the following:

1. Atlantic Highly Extended Crust (AHEX)
2. Extended Continental Crust-Atlantic Margin (ECC-AM)
3. Extended Continental Crust-Gulf Coast (ECC-GC)
4. Illinois Basin Extended Basement (IBEB)
5. Mesozoic Extended-narrow (MESE-N)
6. Mesozoic Extended-wide (MESE-W)
7. Midcontinent-Craton (MIDC-A)
8. Midcontinent-Craton (MIDC-B)
9. Midcontinent-Craton (MIDC-C)
10. Midcontinent-Craton (MIDC-D)
11. Non-Mesozoic Extended-narrow (NMESE-N)
12. Non-Mesozoic Extended-wide (NMESE-W)
13. Paleozoic Extended Crust-narrow (PEZ-N)
14. Paleozoic Extended Crust-wide (PEZ-W)
15. Reelfoot Rift-Rough Creek Graben (RR_RCG)
16. Study Region (Study_R)

This list represents all background sources that lie within 400 miles (640 km) of Vogtle, which exceeds the 200 miles (320 km) recommendation in Section 1.1.1 of RG 1.208 (NRC, 2007) regarding the identification of seismic sources.

All background sources are represented with gridded seismicity parameters developed according to sections 5.3.1 and 5.3.2 of NUREG-2115 (NRC, 2012). These consist of 24 sets of rates and b-value parameters for each source. Eight equally likely realizations of parameters are used (NRC, 2012; pages 5-35 and 5-36) for each of three smoothing models (NRC, 2012; page 5-37 and Table 5.3.2-1). Each background source also has a distribution of maximum magnitude (NRC, 2012; Table 7.4.2-1), and the minimum magnitude considered is 5.0. Note that all magnitudes in this calculation are moment magnitudes.

RLMEs represent additional sources of seismic hazard to the background sources discussed above. Those that are within 625 miles (1,000 km) of Vogtle and included in the hazard calculations are:

1. Charleston
2. New Madrid Fault System (NMFS)
3. Commerce
4. Eastern Rift Margin Fault northern segment (ERM-N)
5. Eastern Rift Margin Fault southern segment (ERM-S)
6. Marianna
7. Wabash

Distributions of maximum magnitude, frequency of occurrence of large earthquakes, and governing logic trees for these RLME sources are found in NUREG-2115 (NRC, 2012) according to Table 2.2.1-1 below. Note that the minimum considered magnitude is 5.0, which is consistent with the background sources discussed above.

Table 2.2.1-1: RLME maximum magnitude, earthquake frequency, and governing logic tree locations (NRC, 2012)

Source	Max. Mag. data	Recurrence data	Logic tree
Charleston	Section 6.1.2.4	Tables 6.1.2-4, 6.1.2-5	Figures 6.1.2-1a, 6.1.2-1b
NMFS	Section 6.1.5.3	Tables 6.1.5-5, 6.1.5-5, 6.1.5-7	Figure 6.1.5-1
Commerce	Section 6.1.8.3	Table 6.1.8-2	Figure 6.1.8-1
ERM-N	Section 6.1.6.3	Table 6.1.6-4	Figure 6.1.6-1a
ERM-S	Section 6.1.6.3	Table 6.1.6-3	Figure 6.1.6-1b
Marianna	Section 6.1.7.3	Table 6.1.7-1	Figure 6.1.7-1
Wabash	Section 6.1.9.3	Table 6.1.9-2	Figure 6.1.9-1

The NMFS includes a model of earthquake clusters and the frequency of occurrence of those clusters, wherein all three New Madrid faults – Reelfoot, North, and South – cause earthquakes in a short period of time (effectively simultaneously). The NMFS cluster model is given a weight of 0.9 in the CEUS-SSC model (Figure 6.1.5-1 of NUREG-2115; NRC 2012). Alternative models are that the three faults are collectively in a period of quiescence (not in a cluster sequence) and that the Reelfoot fault alone is active (weight of 0.05), or that all faults are quiescent and the NMFS does not produce large earthquakes (weight of 0.05). For each configuration, the crustal thickness branch of the NMFS was collapsed to the central value (15 km) for expedience. This simplification should have no impact on the hazard given the large distance between this RLME and the site.

The Charleston RLME and remaining sources from the Mississippi embayment including Commerce, Marianna, Wabash, ERM-N, and ERM-S are modeled according to their governing logic trees referenced in Table 2.2.1-1.

Ground motions were modeled for seven spectral frequencies at which ground motion equations are available from EPRI 3002000717 (EPRI, 2013c). These spectral frequencies are PGA (equivalent to 100 Hz), 25 Hz, 10 Hz, 5 Hz, 2.5 Hz, 1 Hz, and 0.5 Hz. All ground motion equations represent spectral acceleration at 5% of critical damping. This level of damping also applies to all spectral amplitude results presented herein. The 9 general, non-rift ground motion models from EPRI 3002000717 (EPRI, 2013c) were applied to background sources, and the 12 non-general, rift ground motion models from EPRI 3002000717 (EPRI, 2013c) were applied to RLME sources. In addition, the correlation of ground motion equations between background sources and RLME sources are modeled as per EPRI 3002000717 (EPRI, 2013c).

2.2.2 Base Rock Seismic Hazard Curves

Hazard curves at Vogtle are calculated for base rock conditions (LCI, 2013).

The procedure to develop probabilistic seismic hazard curves for hard rock follows standard techniques documented in the technical literature (e.g., McGuire, 2004). Separate seismic hazard calculations are conducted for the 7 spectral frequencies for which ground motion equations are available (PGA (100 Hz), 25 Hz, 10 Hz, 5 Hz, 2.5 Hz, 1 Hz, and 0.5 Hz). As discussed in Section 2.2.1, ground motion equations from the updated EPRI Ground-Motion Model (GMM) for the CEUS (EPRI 3002000717, 2013c) were used for the calculation of base rock hazard. All spectral accelerations presented herein correspond to 5% of critical damping (LCI, 2013). Figure 2.2.2-1 shows the mean base rock seismic hazard curves for the 7 spectral frequencies. Table 2.2.2-1 lists the mean rock UHRS for MAFEs of 10^{-4}, 10^{-5}, and 10^{-6} for 40 frequencies. The digital values for the mean and fractile hazard curves are provided in Table 2.2.2-2a through Table 2.2.2-2g.

Deaggregation of seismic hazard is calculated by determining the contribution by moment magnitude (M_w), distance (R), and number of logarithmic standard deviations from the median spectral amplitude (ε), grouping the contributions by M_w, R, and ε bin (LCI, 2013). The contributions are calculated for individual seismic sources and are aggregated for all sources. The deaggregations are calculated by spectral frequency and mean annual frequency of exceedance (MAFE).

Deaggregation and determination of controlling M_w and R (LCI, 2013) follows the methodology presented in Regulation Guide 1.208 (NRC, 2007). Log-distance is used in the calculation of the controlling distances and linear- M_w is used in calculating the controlling magnitudes. When a substantial portion (> 5%) of the low frequency hazard (average of 1 and 2.5 Hz) is from distant sources (> 100 km), the controlling magnitude and distances are determined only from contributions from hazard at distances greater than 100 km. The resulting mean M_w and distance values from the controlling events are listed in Table 2.2.2-3 (LCI, 2013).

Table 2.2.2-1. Mean Rock UHRS for MAFEs of 10^{-4}, 10^{-5}, and 10^{-6}.

Freq. (Hz)	10^{-4} UHRS (g)	10^{-5} UHRS (g)	10^{-6} UHRS (g)
100	2.71E-01	7.46E-01	1.77E+00
90	2.93E-01	8.06E-01	1.92E+00
80	3.31E-01	9.13E-01	2.17E+00
70	3.89E-01	1.07E+00	2.57E+00
60	4.61E-01	1.28E+00	3.06E+00
50	5.26E-01	1.46E+00	3.51E+00
40	5.64E-01	1.57E+00	3.79E+00
35	5.70E-01	1.59E+00	3.85E+00
30	5.68E-01	1.58E+00	3.85E+00
25	5.56E-01	1.55E+00	3.78E+00
20	5.50E-01	1.51E+00	3.65E+00
15	5.25E-01	1.41E+00	3.36E+00
12.5	5.00E-01	1.32E+00	3.13E+00
10	4.64E-01	1.20E+00	2.81E+00
9	4.42E-01	1.13E+00	2.63E+00
8	4.18E-01	1.06E+00	2.44E+00
7	3.90E-01	9.80E-01	2.23E+00
6	3.59E-01	8.91E-01	2.01E+00
5	3.24E-01	7.92E-01	1.76E+00
4	2.85E-01	6.97E-01	1.53E+00
3.5	2.62E-01	6.43E-01	1.40E+00
3	2.38E-01	5.83E-01	1.26E+00
2.5	2.09E-01	5.13E-01	1.10E+00
2	1.81E-01	4.39E-01	9.40E-01
1.5	1.44E-01	3.45E-01	7.41E-01
1.25	1.22E-01	2.89E-01	6.21E-01
1	9.61E-02	2.26E-01	4.86E-01
0.9	8.98E-02	2.14E-01	4.62E-01
0.8	8.26E-02	1.99E-01	4.32E-01
0.7	7.45E-02	1.81E-01	3.96E-01
0.6	6.56E-02	1.61E-01	3.54E-01
0.5	5.59E-02	1.39E-01	3.06E-01
0.4	4.47E-02	1.11E-01	2.45E-01
0.35	3.91E-02	9.73E-02	2.14E-01
0.3	3.35E-02	8.34E-02	1.84E-01
0.25	2.80E-02	6.95E-02	1.53E-01
0.2	2.24E-02	5.56E-02	1.22E-01
0.15	1.68E-02	4.17E-02	9.18E-02
0.125	1.40E-02	3.48E-02	7.65E-02
0.1	8.94E-03	2.22E-02	4.90E-02

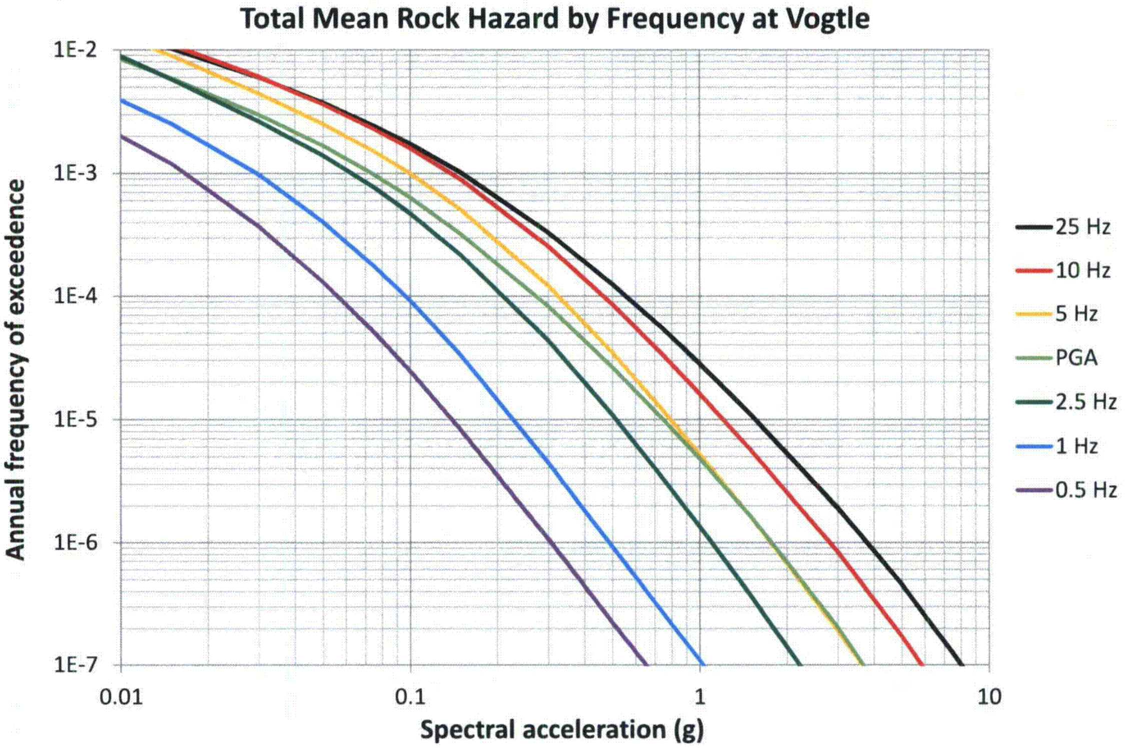

Figure 2.2.2-1. Mean base rock hazard curves for frequencies of 0.5, 1, 2.5, 5, 10, 25 and 100 (PGA) Hz at Vogtle at 5% spectral damping.

Table 2.2.2-2a. Mean and Fractile Base Rock Seismic Hazard Curves for PGA at Vogtle

SA (g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.26E-02	2.68E-02	3.57E-02	4.31E-02	4.98E-02	5.42E-02
0.001	3.39E-02	1.95E-02	2.76E-02	3.37E-02	4.13E-02	4.56E-02
0.005	1.42E-02	7.55E-03	1.02E-02	1.36E-02	1.77E-02	2.39E-02
0.01	8.33E-03	4.13E-03	5.42E-03	7.77E-03	1.05E-02	1.62E-02
0.015	5.84E-03	2.64E-03	3.52E-03	5.35E-03	7.66E-03	1.21E-02
0.03	2.98E-03	9.37E-04	1.40E-03	2.53E-03	4.37E-03	7.03E-03
0.05	1.67E-03	3.57E-04	5.91E-04	1.27E-03	2.72E-03	4.56E-03
0.075	9.74E-04	1.51E-04	2.64E-04	6.36E-04	1.67E-03	3.05E-03
0.1	6.33E-04	8.00E-05	1.44E-04	3.63E-04	1.07E-03	2.19E-03
0.15	3.20E-04	3.14E-05	6.26E-05	1.60E-04	5.12E-04	1.23E-03
0.3	8.22E-05	5.58E-06	1.55E-05	4.01E-05	1.15E-04	3.28E-04
0.5	2.62E-05	1.67E-06	4.77E-06	1.42E-05	3.63E-05	9.79E-05
0.75	9.87E-06	5.58E-07	1.69E-06	5.75E-06	1.46E-05	3.47E-05
1.	4.79E-06	2.35E-07	7.66E-07	2.84E-06	7.45E-06	1.64E-05
1.5	1.64E-06	6.09E-08	2.13E-07	9.24E-07	2.60E-06	5.83E-06
3.	2.05E-07	3.63E-09	1.60E-08	9.65E-08	3.23E-07	8.47E-07
5.	3.36E-08	3.73E-10	1.46E-09	1.20E-08	4.90E-08	1.60E-07
7.5	6.47E-09	1.51E-10	2.60E-10	1.77E-09	8.47E-09	3.42E-08
10.	1.78E-09	1.11E-10	1.53E-10	4.63E-10	2.29E-09	1.01E-08

Table 2.2.2-2b. Mean and Fractile Base Rock Seismic Hazard Curves for 25 Hz at Vogtle

SA (g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.64E-02	3.28E-02	4.01E-02	4.70E-02	5.27E-02	5.66E-02
0.001	3.92E-02	2.53E-02	3.28E-02	3.95E-02	4.56E-02	5.05E-02
0.005	1.99E-02	1.18E-02	1.51E-02	1.95E-02	2.42E-02	3.09E-02
0.01	1.34E-02	7.55E-03	9.79E-03	1.29E-02	1.64E-02	2.25E-02
0.015	1.02E-02	5.58E-03	7.23E-03	9.65E-03	1.27E-02	1.79E-02
0.03	5.97E-03	2.88E-03	3.84E-03	5.58E-03	7.77E-03	1.11E-02
0.05	3.72E-03	1.51E-03	2.13E-03	3.37E-03	5.20E-03	7.45E-03
0.075	2.43E-03	8.00E-04	1.18E-03	2.10E-03	3.63E-03	5.27E-03
0.1	1.73E-03	4.77E-04	7.45E-04	1.42E-03	2.68E-03	4.13E-03
0.15	1.01E-03	2.13E-04	3.52E-04	7.55E-04	1.64E-03	2.72E-03
0.3	3.31E-04	4.83E-05	8.98E-05	2.10E-04	5.35E-04	1.07E-03
0.5	1.25E-04	1.44E-05	3.23E-05	7.77E-05	1.90E-04	4.13E-04
0.75	5.32E-05	5.27E-06	1.38E-05	3.42E-05	7.89E-05	1.69E-04
1.	2.80E-05	2.60E-06	7.03E-06	1.87E-05	4.25E-05	8.60E-05
1.5	1.09E-05	9.37E-07	2.57E-06	7.66E-06	1.72E-05	3.23E-05
3.	1.91E-06	1.15E-07	3.57E-07	1.34E-06	3.28E-06	5.91E-06
5.	4.53E-07	1.90E-08	6.45E-08	2.92E-07	8.00E-07	1.53E-06
7.5	1.26E-07	3.73E-09	1.32E-08	7.03E-08	2.19E-07	4.63E-07
10.	4.64E-08	1.05E-09	3.90E-09	2.29E-08	7.89E-08	1.84E-07

Table 2.2.2-2c. Mean and Fractile Base Rock Seismic Hazard Curves for 10 Hz at Vogtle

SA (g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.95E-02	3.90E-02	4.37E-02	4.98E-02	5.50E-02	5.91E-02
0.001	4.34E-02	3.19E-02	3.73E-02	4.37E-02	4.98E-02	5.35E-02
0.005	2.27E-02	1.42E-02	1.77E-02	2.25E-02	2.76E-02	3.19E-02
0.01	1.47E-02	8.60E-03	1.08E-02	1.44E-02	1.82E-02	2.22E-02
0.015	1.09E-02	6.17E-03	7.89E-03	1.05E-02	1.36E-02	1.72E-02
0.03	6.01E-03	3.05E-03	4.01E-03	5.66E-03	7.89E-03	1.02E-02
0.05	3.62E-03	1.55E-03	2.16E-03	3.37E-03	4.98E-03	6.64E-03
0.075	2.29E-03	8.00E-04	1.20E-03	2.07E-03	3.37E-03	4.63E-03
0.1	1.59E-03	4.70E-04	7.34E-04	1.38E-03	2.42E-03	3.47E-03
0.15	8.82E-04	2.01E-04	3.37E-04	7.03E-04	1.42E-03	2.19E-03
0.3	2.55E-04	3.95E-05	7.34E-05	1.74E-04	4.19E-04	7.66E-04
0.5	8.50E-05	1.04E-05	2.19E-05	5.50E-05	1.34E-04	2.68E-04
0.75	3.26E-05	3.33E-06	8.12E-06	2.13E-05	5.12E-05	1.02E-04
1.	1.60E-05	1.46E-06	3.84E-06	1.07E-05	2.53E-05	4.90E-05
1.5	5.64E-06	4.31E-07	1.20E-06	3.90E-06	9.24E-06	1.72E-05
3.	8.34E-07	4.13E-08	1.32E-07	5.35E-07	1.42E-06	2.76E-06
5.	1.71E-07	5.42E-09	2.01E-08	9.79E-08	2.96E-07	6.17E-07
7.5	4.21E-08	9.65E-10	3.47E-09	2.04E-08	7.13E-08	1.67E-07
10.	1.42E-08	3.09E-10	9.65E-10	5.91E-09	2.32E-08	6.09E-08

Table 2.2.2-2d. Mean and Fractile Base Rock Seismic Hazard Curves for 5 Hz at Vogtle

SA (g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.98E-02	3.90E-02	4.37E-02	4.98E-02	5.58E-02	5.91E-02
0.001	4.37E-02	3.19E-02	3.68E-02	4.37E-02	5.05E-02	5.50E-02
0.005	2.15E-02	1.27E-02	1.62E-02	2.13E-02	2.68E-02	3.01E-02
0.01	1.28E-02	7.13E-03	9.24E-03	1.25E-02	1.64E-02	1.90E-02
0.015	8.88E-03	4.83E-03	6.26E-03	8.60E-03	1.15E-02	1.38E-02
0.03	4.42E-03	2.10E-03	2.84E-03	4.25E-03	6.00E-03	7.34E-03
0.05	2.51E-03	9.51E-04	1.40E-03	2.35E-03	3.63E-03	4.70E-03
0.075	1.51E-03	4.50E-04	7.13E-04	1.34E-03	2.29E-03	3.14E-03
0.1	9.95E-04	2.46E-04	4.07E-04	8.35E-04	1.57E-03	2.29E-03
0.15	5.06E-04	9.65E-05	1.69E-04	3.84E-04	8.35E-04	1.36E-03
0.3	1.21E-04	1.55E-05	3.01E-05	7.45E-05	1.95E-04	3.90E-04
0.5	3.45E-05	3.47E-06	7.55E-06	2.01E-05	5.27E-05	1.13E-04
0.75	1.17E-05	9.65E-07	2.32E-06	6.83E-06	1.79E-05	3.68E-05
1.	5.22E-06	3.68E-07	9.65E-07	3.14E-06	8.23E-06	1.62E-05
1.5	1.62E-06	8.85E-08	2.60E-07	9.65E-07	2.64E-06	5.20E-06
3.	1.93E-07	5.50E-09	2.04E-08	1.01E-07	3.33E-07	7.03E-07
5.	3.37E-08	5.50E-10	2.22E-09	1.36E-08	5.66E-08	1.36E-07
7.5	7.29E-09	1.72E-10	3.84E-10	2.29E-09	1.15E-08	3.19E-08
10.	2.25E-09	1.42E-10	1.74E-10	6.26E-10	3.33E-09	1.02E-08

Table 2.2.2-2e. Mean and Fractile Base Rock Seismic Hazard Curves for 2.5 Hz at Vogtle

SA (g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.76E-02	3.63E-02	4.07E-02	4.77E-02	5.42E-02	5.83E-02
0.001	3.98E-02	2.76E-02	3.23E-02	3.95E-02	4.77E-02	5.20E-02
0.005	1.63E-02	9.37E-03	1.20E-02	1.60E-02	2.10E-02	2.42E-02
0.01	8.79E-03	4.63E-03	6.00E-03	8.47E-03	1.15E-02	1.40E-02
0.015	5.75E-03	2.80E-03	3.79E-03	5.50E-03	7.66E-03	9.51E-03
0.03	2.63E-03	9.79E-04	1.46E-03	2.46E-03	3.79E-03	4.83E-03
0.05	1.39E-03	3.68E-04	6.26E-04	1.23E-03	2.16E-03	2.92E-03
0.075	7.68E-04	1.53E-04	2.76E-04	6.17E-04	1.25E-03	1.90E-03
0.1	4.73E-04	7.55E-05	1.40E-04	3.42E-04	7.89E-04	1.32E-03
0.15	2.16E-04	2.49E-05	4.83E-05	1.29E-04	3.63E-04	7.03E-04
0.3	4.31E-05	2.88E-06	6.26E-06	1.79E-05	6.45E-05	1.67E-04
0.5	1.08E-05	4.83E-07	1.21E-06	4.01E-06	1.46E-05	3.90E-05
0.75	3.27E-06	1.05E-07	3.05E-07	1.21E-06	4.43E-06	1.11E-05
1.	1.35E-06	3.23E-08	1.11E-07	5.05E-07	1.92E-06	4.56E-06
1.5	3.70E-07	5.58E-09	2.35E-08	1.32E-07	5.66E-07	1.38E-06
3.	3.57E-08	3.01E-10	1.23E-09	9.51E-09	5.66E-08	1.51E-07
5.	5.41E-09	1.42E-10	1.95E-10	1.05E-09	7.66E-09	2.46E-08
7.5	1.05E-09	1.01E-10	1.42E-10	2.25E-10	1.36E-09	4.83E-09
10.	2.99E-10	9.11E-11	1.04E-10	1.53E-10	4.25E-10	1.40E-09

Table 2.2.2-2f. Mean and Fractile Base Rock Seismic Hazard Curves for 1 Hz at Vogtle

SA (g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.35E-02	1.98E-02	2.53E-02	3.37E-02	4.13E-02	4.63E-02
0.001	2.33E-02	1.27E-02	1.67E-02	2.32E-02	2.92E-02	3.42E-02
0.005	7.26E-03	3.23E-03	4.50E-03	6.93E-03	9.93E-03	1.23E-02
0.01	3.90E-03	1.34E-03	2.10E-03	3.57E-03	5.66E-03	7.45E-03
0.015	2.51E-03	6.93E-04	1.18E-03	2.25E-03	3.79E-03	5.20E-03
0.03	9.72E-04	1.62E-04	3.37E-04	7.89E-04	1.60E-03	2.39E-03
0.05	4.03E-04	4.37E-05	9.93E-05	2.80E-04	7.03E-04	1.18E-03
0.075	1.76E-04	1.34E-05	3.19E-05	1.02E-04	3.14E-04	6.00E-04
0.1	9.13E-05	5.50E-06	1.32E-05	4.56E-05	1.57E-04	3.42E-04
0.15	3.25E-05	1.42E-06	3.57E-06	1.31E-05	5.35E-05	1.31E-04
0.3	4.42E-06	1.08E-07	3.19E-07	1.34E-06	6.54E-06	1.84E-05
0.5	9.17E-07	1.29E-08	4.56E-08	2.42E-07	1.32E-06	3.95E-06
0.75	2.62E-07	1.92E-09	8.35E-09	6.00E-08	3.73E-07	1.16E-06
1.	1.08E-07	5.35E-10	2.39E-09	2.07E-08	1.51E-07	5.05E-07
1.5	3.08E-08	1.69E-10	4.63E-10	4.13E-09	3.84E-08	1.46E-07
3.	3.10E-09	1.01E-10	1.42E-10	2.84E-10	2.72E-09	1.40E-08
5.	4.68E-10	9.11E-11	1.01E-10	1.46E-10	3.84E-10	1.92E-09
7.5	8.94E-11	9.11E-11	1.01E-10	1.42E-10	1.57E-10	4.31E-10
10.	2.52E-11	9.11E-11	9.37E-11	1.42E-10	1.53E-10	1.92E-10

Table 2.2.2-2g. Mean and Fractile Base Rock Seismic Hazard Curves for 0.5 Hz at Vogtle

SA (g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	1.85E-02	1.08E-02	1.40E-02	1.79E-02	2.29E-02	2.72E-02
0.001	1.19E-02	6.45E-03	8.35E-03	1.15E-02	1.53E-02	1.90E-02
0.005	3.95E-03	1.18E-03	1.92E-03	3.57E-03	6.00E-03	7.77E-03
0.01	2.01E-03	3.68E-04	7.23E-04	1.67E-03	3.28E-03	4.77E-03
0.015	1.18E-03	1.53E-04	3.37E-04	8.98E-04	2.01E-03	3.19E-03
0.03	3.70E-04	2.42E-05	6.26E-05	2.13E-04	6.64E-04	1.27E-03
0.05	1.29E-04	4.98E-06	1.36E-05	5.35E-05	2.25E-04	5.20E-04
0.075	5.05E-05	1.31E-06	3.63E-06	1.51E-05	7.89E-05	2.22E-04
0.1	2.45E-05	4.70E-07	1.32E-06	5.83E-06	3.47E-05	1.10E-04
0.15	8.18E-06	1.01E-07	3.09E-07	1.44E-06	1.02E-05	3.79E-05
0.3	1.06E-06	4.98E-09	2.07E-08	1.29E-07	1.08E-06	5.12E-06
0.5	2.22E-07	5.12E-10	2.42E-09	1.98E-08	2.04E-07	1.13E-06
0.75	6.52E-08	1.67E-10	4.77E-10	4.13E-09	5.20E-08	3.37E-07
1.	2.76E-08	1.42E-10	2.01E-10	1.34E-09	1.84E-08	1.42E-07
1.5	8.10E-09	1.01E-10	1.42E-10	3.05E-10	4.01E-09	3.95E-08
3.	8.64E-10	9.11E-11	1.01E-10	1.42E-10	3.05E-10	3.57E-09
5.	1.36E-10	9.11E-11	1.01E-10	1.42E-10	1.53E-10	5.35E-10
7.5	2.69E-11	9.11E-11	9.11E-11	1.42E-10	1.53E-10	1.74E-10
10.	7.79E-12	9.11E-11	9.11E-11	1.42E-10	1.53E-10	1.53E-10

Table 2.2.2-3 Mean magnitudes and distances for LF and HF rock spectra for MAFEs of 10^{-4}, 10^{-5}, and 10^{-6}.

	10^{-4} UHRS	10^{-5} UHRS	10^{-6} UHRS
Low Frequency M*	7.2	7.3	7.4
Low Frequency R* (km)	150	140	130
High Frequency M	6.6	6.4	6.4
High Frequency R (km)	54	26	15

* M and R calculated for R>100 km.

2.3 Site Response Evaluation

Following the guidance contained in Seismic Enclosure 1 of the 3/12/2012 50.54(f) Request for Information and in the SPID (EPRI 1025287, 2013a) for nuclear power plant sites that are not sited on hard rock (defined as 2.83 km/sec or 9,200 feet/sec), a site response analysis was performed for Plant Vogtle Units 1 and 2.

2.3.1 Description of Subsurface Material

Bechtel Report 23162-000-G65-GEK-00010 (Bechtel, 2012) is the source of the information presented in the following section.

The subsurface conditions at the Plant Vogtle Unit 1 and 2 site can be subdivided into three principal soil strata overlying bedrock. The top stratum consists of sands, silty sands, and clayey sands with occasional clay seams. This stratum, referred to hereinafter as the upper sand stratum (USS) (Barnwell Group), is about 90 feet thick. At the base of the USS is a shelly limestone (Utley Limestone), which is about 5 feet thick on an average and contains numerous vugs and voids. Below the USS is a stratum consisting of very hard calcareous overconsolidated clay marl (Blue Bluff marl [BBM]), ranging in thickness from 60 to 100 feet. This stratum is referred to as the marl bearing stratum. Laboratory test results on representative samples of these materials disclosed both low plasticity and high plasticity clay with varying amounts of sand. Underlying the BBM is a dense, coarse to fine sand with minor interbedded silty clay and clayey silt. This unit is called the lower sand stratum (LSS). The Lower Sands are further subdivided by geologic strata as shown in Table 2.3.1-1 and Figure 2.3.1-1. In particular, the upper portions of the Lower Sands (Still Branch, Congaree, and Snapp Formations) were sampled in several boreholes during the recent investigations for Plant Vogtle Units 3 and 4. The thickness of this stratum was determined to be about 900 feet based on borehole B-1003 drilled for Plant Vogtle Units 3 and 4 (SNC, 2013). Beneath the LSS lies the basement rock, which consists of Paleozoic crystalline rock as well as Triassic–Jurassic sedimentary rock of the Dunbarton Basin.

The USS and the Utley Limestone were removed and replaced with compacted select sand and silty sand backfill within the power block areas. With the exception of the auxiliary building, nuclear service cooling water towers, and instrumentation cavity of the containment which are founded on the BBM, all the power block structures including the containment basemat and the non-Category 1 turbine building are supported on Category 1 backfill. Table 2.3.1-2 shows the principal final stratigraphic column and unit thicknesses (after removal of the USS and Utley Limestone Units). The design groundwater level is Elevation 165 feet.

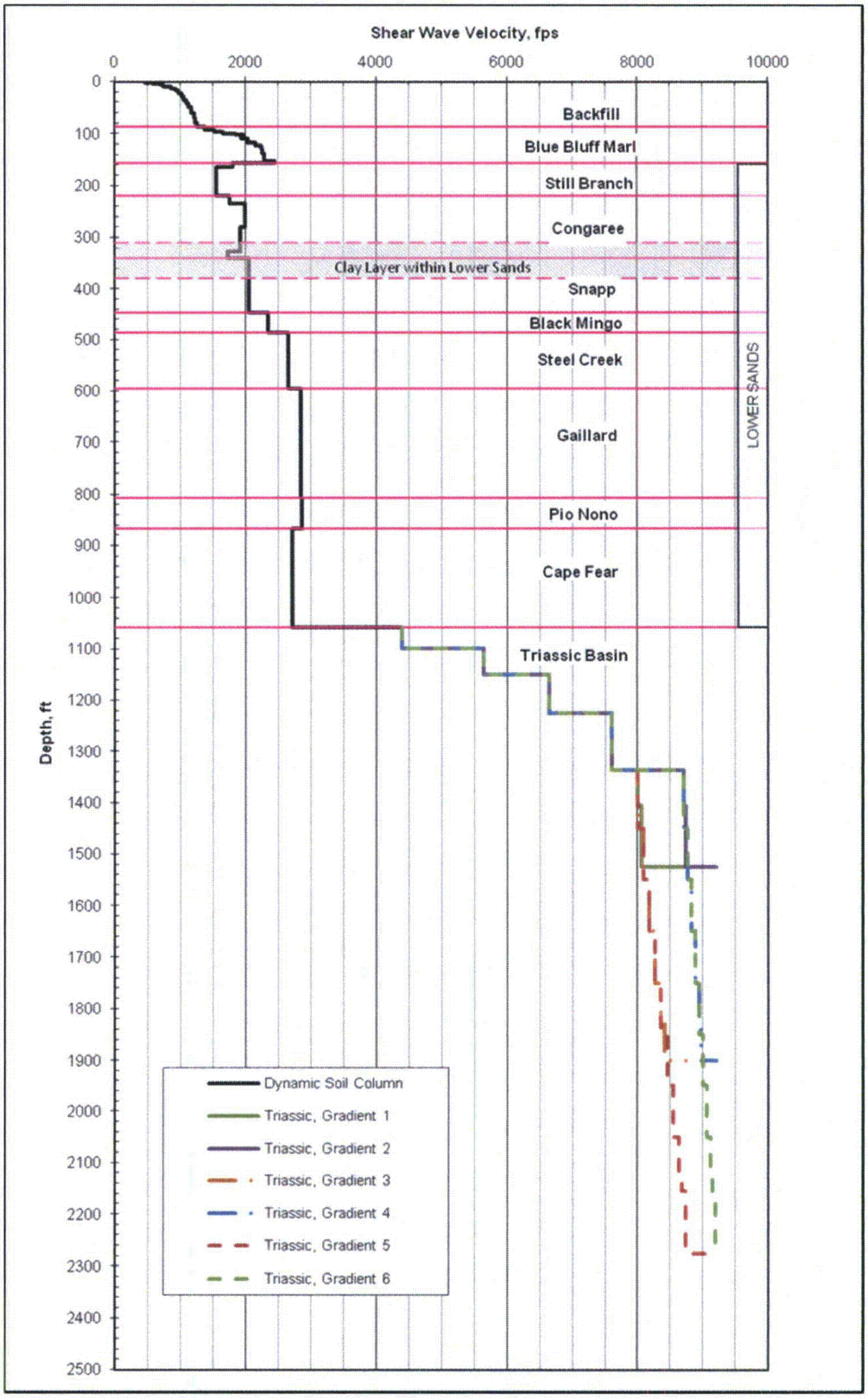

Figure 2.3.1-1. Shear Wave Velocity Profile, Dynamic Soil Column

Table 2.3.1-1. Dynamic Site Soil Column

Strata	Geologic Formation	Elevation	Depth, feet	Thickness, feet	Velocity, ft/sec	COV	Total Unit Wt, pcf	Poissons Ratio
	Ground Surface	220						
Backfill	Compacted Backfill (sand)	220	0 to 2	2	458	0.15	123	0.24
		218	2 to 4	2	586			
		216	4 to 6	2	705			
		214	6 to 10	4	744			
		210	10 to 14	4	855			
		206	14 to 18	4	933			
		202	18 to 23	5	977			
		197	23 to 29	6	1026			
		191	29 to 36	7	1050			
		184	36 to 43	7	1099			
		177	43 to 50	7	1124			
		170	50 to 55	5	1169			
		165	55 to 60	5	1169		133	0.45
		160	60 to 70	10	1211			
		150	70 to 80	10	1233			
		140	80 to 88	8	1258			
BBM	Lisbon Formation (clay/silt) R=59.5 to 76.9feet, M=68feet	132	88 to 93	5	1382	0.20	115	0.45
		127	93 to 96	3	1528			
		124	96 to 101	5	1663			
		119	101 to 106	5	1850			
		114	106 to 110	4	1931			
		110	110 to 118	8	2035			
		102	118 to 122	4	2161			
		98	122 to 128	6	2241			
		92	128 to 153	25	2292			
		67	153 to 156	3	2447			
Lower Sands	Still Branch (sand) R=52.2 to 78feet, M=64feet	64	156 to 164	8	1802	0.20	123	0.45
		56	164 to 220	56	1560			
	Congaree - sand R=115.5 to 129.5feet, M=120feet	0	220 to 236	16	1757	0.20	128	0.45
		-16	236 to 280	44	2000			
		-60	280 to 310	30	1926			
	- clay	-90	310 to 328	18	1926			
		-108	328 to 340	12	1727			
	Snapp - clay	-120	340 to 380	40	2050	0.20	127	0.45
	- sand (SP/SM)	-160	380 to 447	67	2050			
	Black Mingo (sand)	-227	447 to 486	39	2350	0.20	127	0.45
	Steel Creek (sand)	-266	486 to 596	110	2650	0.20	127	0.45
	Gaillard (sand)	-376	596 to 807	211	2850	0.20	127	0.45
	Pio Nono (sand)	-587	807 to 867	60	2870	0.20	127	0.45
	Cape Fear (sand)	-647	867 to 1058 2)	191	2710	0.20	127	0.45

Notes:
1) R = range of thickness of strata, M = average thickness
2) Total soil column depth based on average thickness of overlying strata, rather than solely on borehole B-1003.
3) Groundwater Level at Elevation 165 feet.

Table 2.3.1-2. Principal Final Stratigraphic Column

Stratum	Elevation (feet)		Thickness
	From	To	
SSE control point (at surface)	220		—
Backfill	220	132	88
BBM	132	64	68
Lower Sand (LSS)	64	-838	902
Basement Rock	-838	-	-

2.3.2 Development of Base Case Profiles and Nonlinear Material Properties

Bechtel Report 23162-000-G65-GEK-00010 (Bechtel, 2012) is the source of the information presented in the following section.

The base case profiles were based on existing subsurface information contained in the Plant Vogtle Units 1 and 2 FSAR (SNC, 2014c), as well as additional and more recent information obtained for Plant Vogtle Units 3 and 4, contained in the Plant Vogtle Units 3 and 4 UFSAR (SNC, 2013), and the investigation carried out for the Independent Spent Fuel Storage Installation (ISFSI) (Bechtel, 2011b). Where appropriate the data were combined, recognizing that Units 3 and 4 are about 1,500 feet west on Units 1 and 2. Where no data existed, data from the nearby Units 3 and 4 was relied upon. The following paragraphs summarize that information.

Material Classification

Representative samples of the subsurface materials were tested in the laboratory to determine their classification in accordance with the Unified Soil Classification System (USCS, ASTM D-2487) during the explorations for Plant Vogtle Units 1 and 2 and Plant Vogtle Units 3 and 4 (SNC, 2014c, SNC, 2013, and Bechtel, 2008b). In addition, representative samples of the backfill soils were tested to determine their classification, during backfill construction (Bechtel, 2011a). Table 2.3.1-1 provides a summary of the predominate soil type (e.g., sand or clay and silt) for each major unit.

Unit Weight

The densities of the various soil materials underlying the site were also evaluated during the laboratory testing programs as previously discussed. In addition, the densities of the compacted backfill were measured during backfill installation. Table 2.3.1-1 includes a summary of these total unit weight values. The unit weight of the Triassic Basin and crystalline bedrock is reported as 158 pounds/ft^3 (pcf) and 172 pcf, respectively (Bechtel, 2006a).

Groundwater Elevation

A design groundwater elevation of 165 feet, msl, from Plant Vogtle Units 1 and 2 FSAR (SNC, 2014c) and Bechtel dynamic properties calculation (Bechtel, 2007b), is used. This design level is used at both Plant Vogtle Units 1 and 2 and Plant Vogtle Units 3 and 4.

Shear-Wave Velocity

The shear wave velocity profile of the soil column was developed considering the reported data for Plant Vogtle Units 1 and 2, the reported data for Plant Vogtle Units 3 and 4 during the licensing phase, data collected as part of the recent ISFSI investigation, and recent data collected during the construction phase at Units 3 and 4. It is noted that the exploration depth for Plant Vogtle Units 1 and 2 was limited to 290 feet and crosshole methods were used to measure V_s in one borehole to this depth. Interpreted results were presented in the Vogtle Seismic Analysis Report (Bechtel, 1984). The exploration for Plant Vogtle Units 3 and 4 extended to a maximum depth of 1,338 feet (at one location, in the footprint of Unit 3). P-S velocity logging methods were used to measure V_s in this borehole and several other boreholes extending to depths of 200 to 420 feet (Bechtel, 2007a and Bechtel, 2007b). Table 2.3.1-1 presents the mean (best estimate) value for the V_s profile of the soil column at the site. Figure 2.3.1-1 also illustrates this profile.

The V_s profile of the compacted backfill was established using the results from design work on Plant Vogtle Units 1 and 2 as well as on Plant Vogtle Units 3 and 4. The design work on Plant Vogtle Units 3 and 4 included laboratory combined resonant column/torsional shear (RCTS) testing and a test pad evaluation with the non-intrusive spectral analysis of surface waves (SASW) technique and seismic crosshole measurements. SASW measurements in the constructed compacted backfill at a nominal elevation of 180 feet, msl at Unit 3 and Unit 4 (Mactec, 2011) were also used. A mean V_s profile was developed from these data and is summarized in Table 2.3.2-1 and illustrated in Figure 2.3.2-1. This mean profile was incorporated into Figure 2.3.1-1, the Dynamic Soil Column.

The coefficient of variation (COV), which is defined as the standard deviation (σ) divided by the mean, in the V_s backfill profile ranged from 0.04 to 0.3. A value of 0.15 was used to calculate the -1σ and $+1\sigma$ values. The -1σ and $+1\sigma$ profiles are plotted in Figure 2.3.2-1 with these values summarized in Table 2.3.2-1.

Table 2.3.2-1. Mean Vs Profile of Compacted Backfill

Stratum Depth, feet	Mean Velocity,ft/sec	-1 σ	+1 σ
0 - 2	458	390	527
2 - 4	586	498	674
4 – 6	705	599	810
6 - 10	744	633	856
10 - 14	855	727	984
14 -18	933	793	1073
18 - 23	977	830	1123
23 - 29	1026	872	1180
29 - 36	1050	893	1208
36 - 43	1099	934	1264
43 - 50	1124	956	1293
50 - 60	1169	993	1344
60 - 70	1211	1029	1393
70 - 80	1233	1048	1418
80 - 88	1258	1069	1447

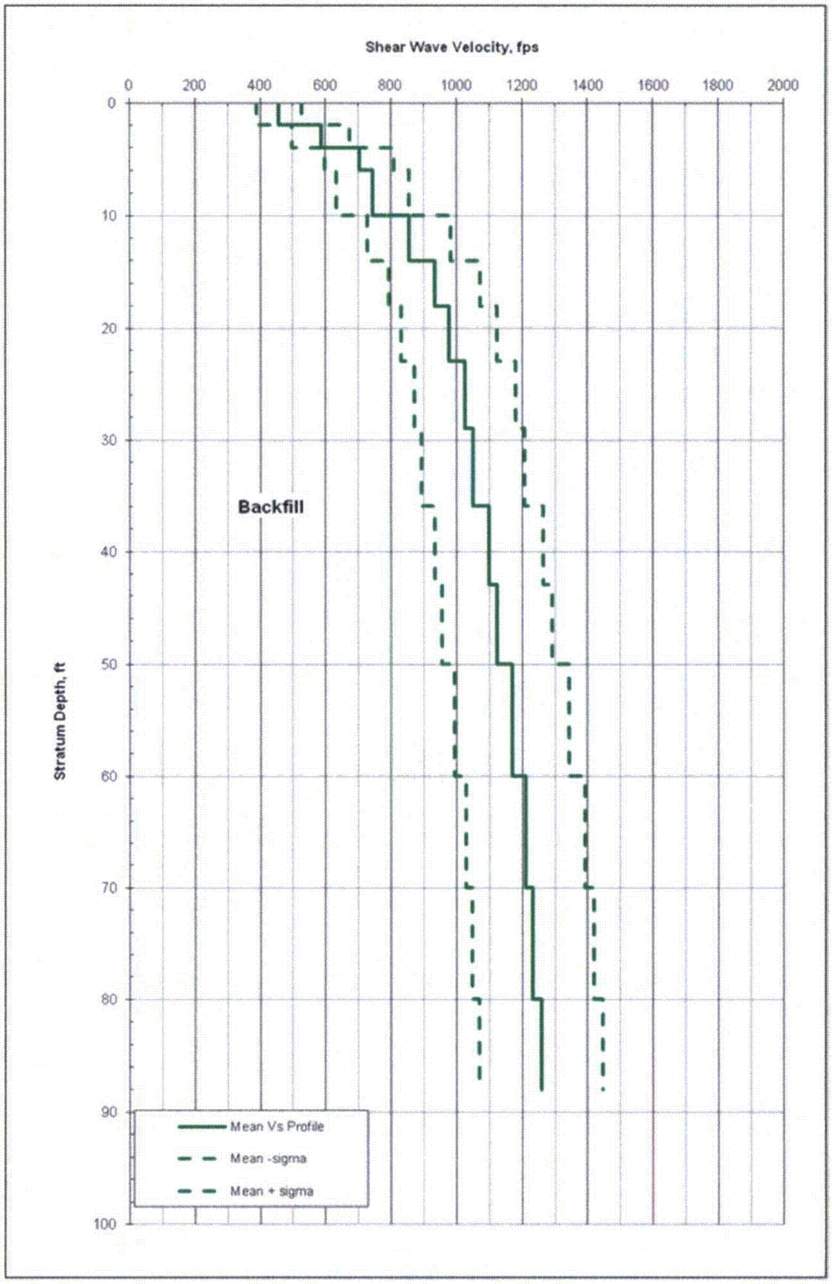

Figure 2.3.2-1. Summary of Vs Profiles of Compacted Backfill

The V_s profile through the BBM was developed using data from Plant Vogtle Units 3 and 4, Plant Vogtle Units 1 and 2, and the proposed ISFSI area. While the Units 1 and 2 and Units 3 and 4 areas are about 2,500 feet apart (center to center), the ISFSI area is about 2,500 feet southeast of Units 1 and 2 and about 5,000 feet east-southeast of Units 3 and 4 (Bechtel, 2011b). Documentation from Units 1 and 2 provided a nearly uniform V_s of 1,700 ft/sec; while the recent data from Units 3 and 4 provides a linearly increasing average V_s profile (from 1,350 to 2,550 ft/sec) in the BBM. The V_s data from the ISFSI area were similar to the Units 3 and 4 data with average velocities increasing from about 1,200 ft/sec at the top of the stratum to about

3,000 ft/sec at the base of the stratum. Some of the differences between the Units 1 and 2 data and the more recent data may be attributed to the methods (crosshole versus P-S velocity logging) used to collect the V_s data. Therefore, the data from each of the three areas (Units 1 and 2, Units 3 and 4, and ISFSI) were treated as equally likely to occur. These data were summarized by taking a mean of each of the three areas and taking the average V_s profile from these mean values. This mean of means profile for the BBM is provided in Table 2.3.1-1 and was incorporated into Figure 2.3.1-1.

An average COV of 0.2 was determined from the measured V_s data for the BBM, Still Branch, Congaree, and Snapp Formations (Bechtel, 2008a). This value was used for the entire soil column below the compacted backfill.

The V_s profile through the LSS was developed using the recent data acquired for Plant Vogtle Units 3 and 4. The velocities ranged from about 930 ft/sec to 4,670 ft/sec, with an average value of 2,282 ft/sec. Typical values for the shear wave velocities of each geologic formation contained within the LSS are as follows: 1,700 ft/sec for the Still Branch, 1,950 ft/sec for the Congaree, 2,050 ft/sec for the Snapp, 2,350 ft/sec for the Black Mingo, 2,650 ft/sec for the Steel Creek, 2,850 ft/sec for the Gaillard/Black Creek, 2,870 ft/sec for the Pio Nono, and 2,710 ft/sec for the Cape Fear. The selected V_s, along with the COV, for each formation within the LSS is given in Table 2.3.1-1 and shown on Figure 2.3.1-1.

The V_s profile through the Triassic Basin to the crystalline bedrock, where a velocity of 9,200 ft/sec is measured, was evaluated with 6 profiles or gradients as presented in Table 2.3.2-2. These data were taken from V_s measurements in several deep holes (drilled into rock) at the nearby Savannah River Site (SRS) (Bechtel, 2007c). Only limited site specific V_s measurements were taken in the upper portion (289 feet) of the Triassic Basin, from boring B-1003 (SNC, 2013). The site specific data were consistent with the gradients presented in Table 2.3.2-2. For the purpose of site response analysis, starting from the six rock profiles, an average shear wave velocity profile is calculated, see Table 2.3.2-2. Using a COV of 10%, the lower bound (16th percentile) and upper bound (84th percentile) shear wave velocity profiles cover the range of all six suggested rock profiles (SNC, 2014d), see Figure 2.3.2-2. Therefore for the Triassic Basin strata, this average profile is used with a COV of 10%.

Table 2.3.2-2. Rock Profiles

	Elevation	Depth, feet	Thickness, feet	Velocity, ft/sec
Dunbarton Triassic Basin Bedrock (Gradient 1)	-878.0	1058 to 1100	42	4400
	-928.0	1100 to 1150	50	5650
	-1003.0	1150 to 1225	75	6650
	-1116.0	1225 to 1338	113	7600
	-1181.0	1338 to 1403	65	8000
	-1183.0	1403 to 1405	2	8005
	-1303.0	1405 to 1525	120	8059
		> 1525		9200
Dunbarton Triassic Basin Bedrock (Gradient 2)	-878.0	1058 to 1100	42	4400
	-928.0	1100 to 1150	50	5650
	-1003.0	1150 to 1225	75	6650
	-1116.0	1225 to 1338	113	7600
	-1181.0	1338 to 1403	65	8700
	-1183.0	1403 to 1405	2	8703
	-1303.0	1405 to 1525	120	8739

		> 1525		9200
Dunbarton Triassic Basin Bedrock (Gradient 3)	-878	1058 to 1100	42	4400
	-928	1100 to 1150	50	5650
	-1003	1150 to 1225	75	6650
	-1116	1225 to 1338	113	7600
	-1228	1338 to 1450	112	8000
	-1328	1450 to 1550	100	8090
	-1428	1550 to 1650	100	8180
	-1528	1650 to 1750	100	8270
	-1608	1750 to 1830	80	8360
	-1678	1830 to 1900	70	8414
		> 1900		9200
Dunbarton Triassic Basin Bedrock (Gradient 4)	-878	1058 to 1100	42	4400
	-928	1100 to 1150	50	5650
	-1003	1150 to 1225	75	6650
	-1116	1225 to 1338	113	7600
	-1228	1338 to 1450	112	8700
	-1328	1450 to 1550	100	8760
	-1428	1550 to 1650	100	8820
	-1528	1650 to 1750	100	8880
	-1608	1750 to 1830	80	8940
	-1678	1830 to 1900	70	8976
		> 1900		9200
Dunbarton Triassic Basin Bedrock (Gradient 5)	-878	1058 to 1100	42	4400
	-928	1100 to 1150	50	5650
	-1003	1150 to 1225	75	6650
	-1116	1225 to 1338	113	7600
	-1228	1338 to 1450	112	8000
	-1328	1450 to 1550	100	8090
	-1428	1550 to 1650	100	8180
	-1528	1650 to 1750	100	8270
	-1628	1750 to 1850	100	8360
	-1728	1850 to 1950	100	8450
	-1828	1950 to 2050	100	8540
	-1906	2050 to 2128	78	8630
	-1933	2128 to 2155	27	8680
	-2053	2155 to 2275	120	8734
		> 2275		9200
Dunbarton Triassic Basin Bedrock (Gradient 6)	-878	1058 to 1100	42	4400
	-928	1100 to 1150	50	5650
	-1003	1150 to 1225	75	6650
	-1116	1225 to 1338	113	7600
	-1228	1338 to 1450	112	8700
	-1328	1450 to 1550	100	8760
	-1428	1550 to 1650	100	8820
	-1528	1650 to 1750	100	8880
	-1628	1750 to 1850	100	8940
	-1728	1850 to 1950	100	9000
	-1828	1950 to 2050	100	9060
	-1906	2050 to 2128	78	9120
	-1933	2128 to 2155	27	9153
	-2053	2155 to 2275	120	9189
		> 2275		9200
Average Profile for Triassic Basin Bedrock	-878	1058 to 1100	42	4400
	-928	1100 to 1150	50	5650
	-1003	1150 to 1225	75	6650
	-1116	1225 to 1338	113	7600
	-1228	1338 to 1450	112	8357
	-1328	1450 to 1550	100	8418
	-1428	1550 to 1650	100	8500
	-1528	1650 to 1750	100	8575
	-1628	1750 to 1850	100	8654
	-1728	1850 to 1950	100	8717
	-1828	1950 to 2050	100	8800
	-1906	2050 to 2155	105	8886
	-2053	2155 to 2275	120	8962
		> 2275		9200

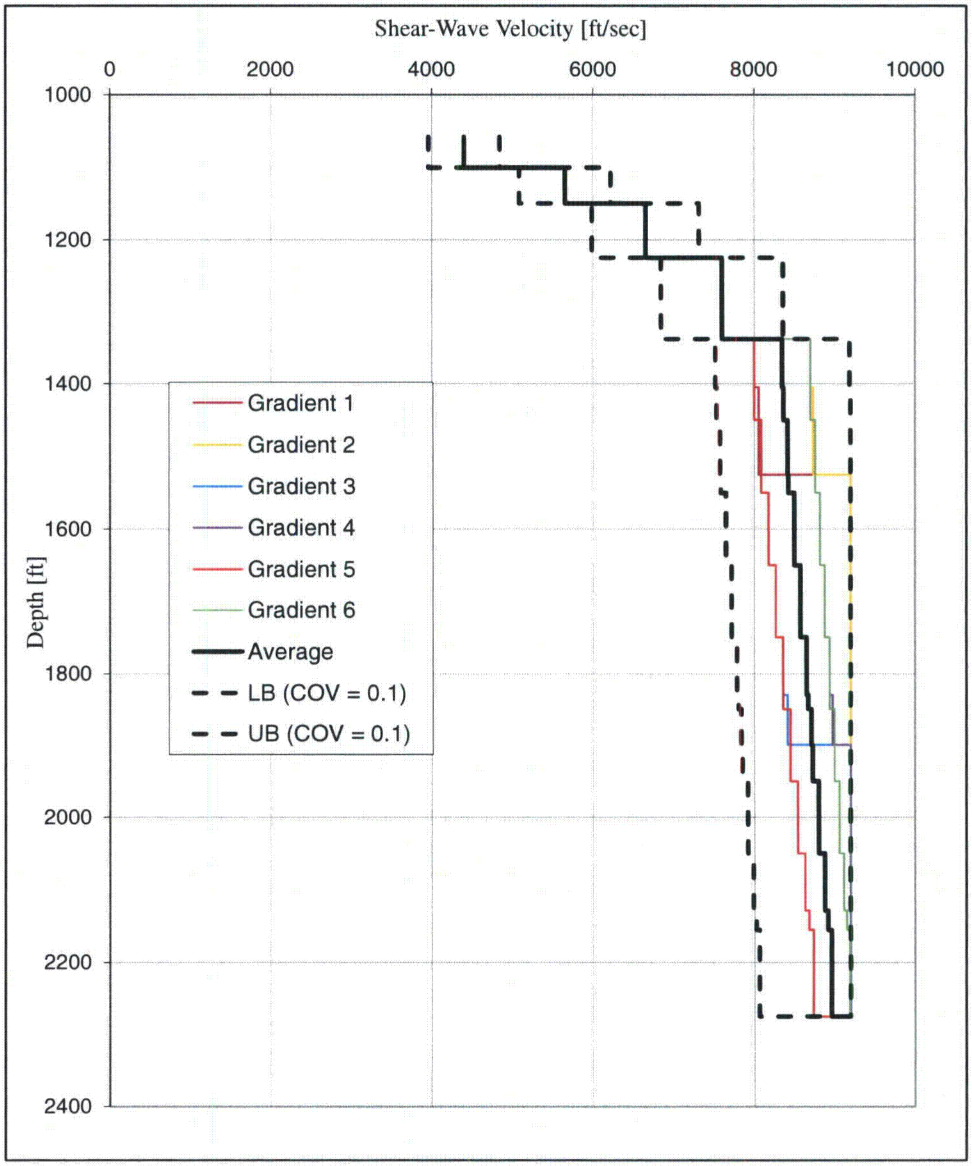

Figure 2.3.2-2. Shear Wave Velocity Profile, Triassic Basin Soil Column

Poisson's Ratio

The Poisson's ratio (υ) of the soil column was determined from site specific shear and compression (V_p) wave velocity measurements of the compacted backfill and materials below and was adopted from Bechtel calculation (Bechtel, 2008a) as summarized in Table 2.3.1-1. Site specific V_s and V_p measurements of the Triassic Basin bedrock were limited to a depth of about 289 feet into bedrock, in one deep borehole. The calculated Poisson's ratio from these data, in the bedrock, ranged from 0.10 to 0.46 (Bechtel, 2007a). An average value of 0.25 is recommended for the Triassic Basin bedrock (Bechtel, 2006b).

2.3.2.1 Shear Modulus and Damping Curves

Bechtel Report 23162-000-G65-GEK-00010 (Bechtel, 2012) is the source of the information presented in the following section.

During the investigations for Plant Vogtle Units 3 and 4, site specific shear modulus reduction and damping versus cyclic shear strain relationships were determined for the backfill, the BBM, and the Lower Sands using combined RCTS test methods (Bechtel, 2008a). Within the backfill, these relationships are designated by depth. Within the BBM, relationships are provided for both Low PI and High PI soils, where PI is plasticity index. These low and high plasticity soils were encountered throughout the BBM, thus both sets of relationships should be considered. Within the LSS, these relationships are designated by material type. Table 2.3.2-3 provides a summary of these values and Figure 2.3.2-3 and Figure 2.3.2-4 illustrate these relationships. These results are considered appropriate for both Units 3 and 4 and Units 1 and 2. Note that the data in Figure 2.3.2-4 are capped at 15 percent damping as this is the upper limit of damping used in the site response analysis.

Table 2.3.2-3. Shear Modulus Reduction and Damping versus Shearing Strain Relationships

Stratum	**Backfill**				**Blue Bluff Marl**				**Lower Sands**			
Sub strata	**<25ft**		**>25ft**		**Low PI**		**High PI**		**Sands**		**Clay (Congaree/ Snapp)**	
Shear Strain (%)	**G/G_{max}**	**Damping Ratio**	**G/G_{max}**	**Damping Ratio**	**G/G_{max}**	**Damping Ratio**	**G/G_{max}**	**Damping Ratio**	**G/G_{max}**	**Damping Ratio**	**G/G_{max}**	**Damping Ratio**
0.00010	1	0.97	1	0.62	1	1.44	1	1	1	0.62	1	0.86
0.00032	1	1.05	1	0.62	1	1.56	1	1.05	1	0.62	1	0.87
0.00100	0.998	1.05	1	0.7	1	1.67	1	1.32	1	0.7	1	0.93
0.00359	0.942	1.44	0.975	0.89	0.96	2.34	0.9965	1.71	0.997	0.89	0.99	1.21
0.01019	0.826	2.26	0.902	1.3	0.867	3.23	0.97	2.3	0.954	1.32	0.928	1.8
0.03170	0.603	4.55	0.748	2.6	0.673	5.75	0.88	3.97	0.858	2.6	0.8	3.62
0.10000	0.355	8.97	0.495	5.64	0.395	10.63	0.679	6.715	0.649	5.59	0.56	7.54
0.30690	0.172	14.94	0.269	10.65	0.187	16.39	0.433	11.115	0.411	10.65	0.327	13
0.65313	0.089	19.38	0.158	14.73	0.1	19.08	0.2785	14.545	0.263	14.68	0.198	17.42
1.00000	0.072	22.12	0.117	17.11	0.068	19.12	0.217	15.77	0.209	17.11	0.154	19.87

For the Triassic Basin and crystalline bedrock at the site, the shear modulus is assumed to remain constant with strain with a damping value of 1 percent (Bechtel, 2007c). A log-normal standard deviation of 0.4 is used in randomization to model the uncertainty in the strain-independent damping ratio.

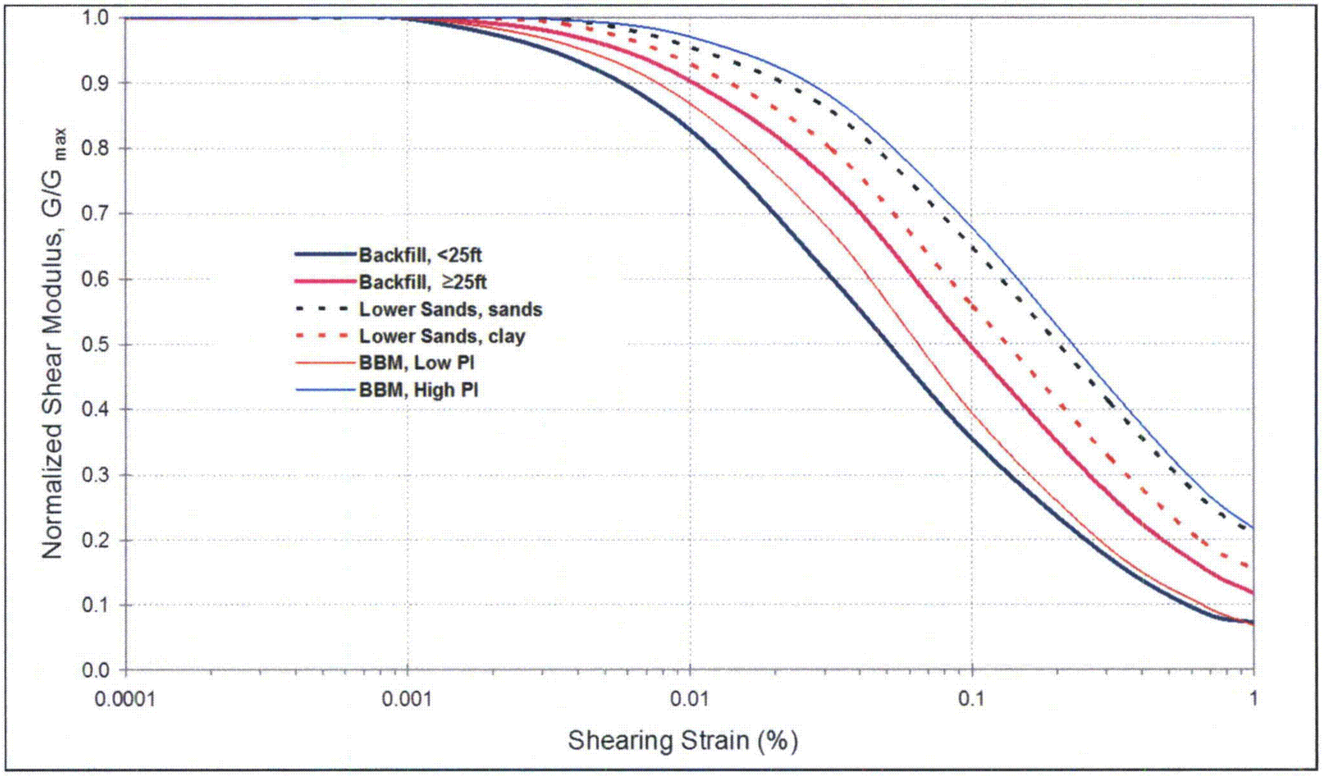

Figure 2.3.2-3. Shear Modulus Reduction Curves

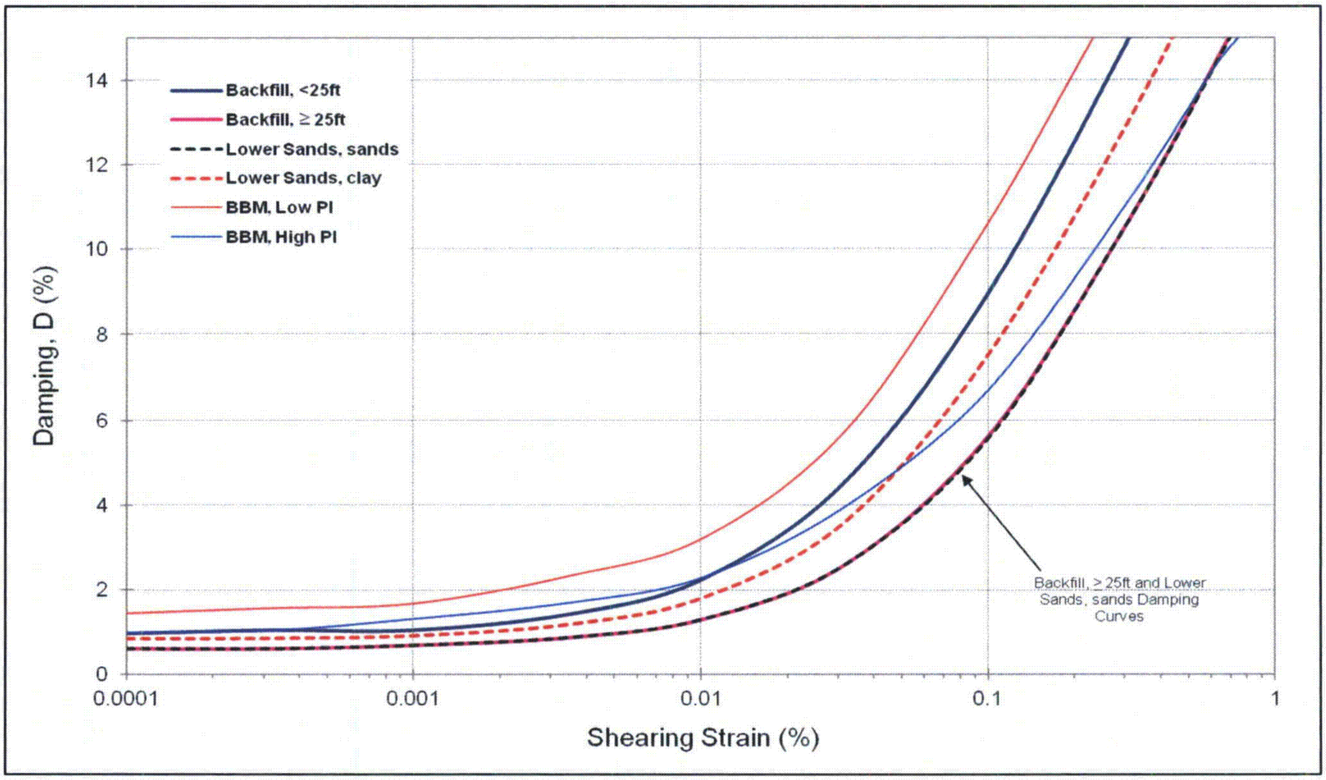

Figure 2.3.2-4. Damping Curves

2.3.2.2 Kappa

Bechtel Report 23162-000-G65-GEK-00010 (Bechtel, 2012) and SNC Calculation X2CFS129 (SNC, 2014b) are the source of the information presented in the following section.

Due to availability of deep soil column data from the Plant Vogtle Units 3 and 4, damping values are directly assigned to each layer in the profile, rather than obtaining damping from kappa estimates per the SPID (EPRI 1025287, 2013a). Damping above a depth of 1058 ft is accounted for explicitly in the damping curves as discussed above in Section 2.3.2.1. For the underlying Triassic Basin and crystalline bedrock down to a depth of 2275 feet, a strain-independent damping ratio of 1 percent is adopted (Bechtel, 2007c). The adopted damping ratios amount to a kappa 0.01 second for the entire soil column (SNC, 2014b). In the case of the Vogtle deep soil site, following the recommendations of the SPID (EPRI 1025287, 2013a), a kappa of 0.04 second can be used. However, in light of the evaluation of site-specific data, it is judged that the kappa of 0.01 second is more appropriate for the site. A log-normal standard deviation of 0.4 is used in randomization to model the uncertainty in the strain-independent damping ratios.

2.3.2.3 Summary

The Vogtle site is a well-investigated and well-characterized site. Through the investigations carried out for Plant Vogtle Units 1 and 2, the recent investigations for Plant Vogtle Units 3 and 4, and the other referenced investigations for other critical facilities (e.g. ISFSI) at the site, the Vogtle site is well understood. The resulting subsurface data from various explorations for Units 1 and 2 and Units 3 and 4 were evaluated to develop a dynamic soil/rock column for the site. Shear wave velocity data in the BBM from the recent ISFSI exploration were also utilized. The most comprehensive data set was from Units 3 and 4. These data included a deep borehole down to bedrock as well as numerous V_s profiles and site specific degradation and damping curves. Dynamic properties of the compacted backfill were developed from the Units 3 and 4 studies as well as recently conducted *in situ* velocity measurements.

Table 2.3.1-1 presents the soil stratigraphy with thickness, recommended shear wave velocity and coefficient of variation (COV), layer unit weights, and Poisson's ratio. Table 2.3.2-2 presents the shear wave velocity recommendations for basement rock.

In utilizing this dynamic profile to evaluate ground response, the following considerations should be incorporated:

1. A single base case (best estimate) shear wave velocity profile along with COV values are provided in Table 2.3.1-1.
2. Six V_s profiles for Triassic Basin rock are presented in Table 2.3.2-2 and Figure 2.3.2-2. The average profile is adopted for site response analysis, as presented in Table 2.3.2-2 and Figure 2.3.2-2.
3. Shear modulus reduction and damping relationships are provided in Table 2.3.2-3, Figure 2.3.2-3 and Figure 2.3.2-4 for the compacted backfill with one set of curves for the shallower backfill (depth less than 25 feet) and one set of curves for the deeper backfill (depth greater than or equal to 25 feet).
4. Shear modulus reduction and damping relationships are provided in Table 2.3.2-3, Figure 2.3.2-3 and Figure 2.3.2-4 for the BBM with low plasticity and high plasticity. Both curves are equally likely for the BBM, and therefore are both analyzed and given equal weight.
5. Shear modulus reduction and damping relationships are provided in Table 2.3.2-3, Figure 2.3.2-3 and Figure 2.3.2-4 for the Lower Sands. A clay layer was identified in the Lower Sands, spanning the lower portion of the Congaree and the upper portion of the Snapp Formations. The shear modulus reduction and damping relationships for these clayey materials are identified as "Lower Sands, clay" in Figure 2.3.2-3 and Figure 2.3.2-4.

2.3.3 Randomization of Base Case Profiles

SNC Calculations X2CFS128 (SNC, 2014d) is the source of the information presented in the following section.

To account for the aleatory variability in material properties that is expected to occur across a site at the scale of a typical nuclear facility, variability in the assumed shear-wave velocity profiles has been incorporated in the site response calculations. For the Plant Vogtle Units 1 and 2 site, simulated shear wave velocity profiles were developed from the base case profile, as presented in Section 2.3.2. The simulation procedure generates a set of site-specific simulated (randomized) soil profiles to represent the dynamic properties of the site while considering the uncertainty associated with each of these properties, and correlations between different parameters (SNC, 2014d).

Note that epistemic uncertainty at the Vogtle site is limited given that it is well-investigated and well-characterized, refer to Section 2.3.2. One base case profile is adopted for shear-wave velocity, and two alternative sets of strain-dependent soil nonlinear curves (low PI and high PI) are used to model the strain-dependent behavior of the BBM layers representing low PI and high PI conditions, see Section 2.3.2.1. Two sets of sixty random profiles were therefore generated for the base case profile, where the only difference between the two sets is the adopted alternative strain-dependent property curves for the BBM layers (SNC, 2014d). The random velocity profiles, presented in Figure 2.3.3-1 and Figure 2.3.3-2, were generated using a natural log standard deviation of 0.15 to 0.2 over the upper 1058 ft (see Table 2.3.1-1) and a natural log standard deviation of 0.1 below that depth. As specified in the SPID (EPRI 1025287, 2013a), correlation of shear wave velocity between layers was modeled using the USGS B correlation model. In profile simulation, a limit of +/- 2 standard deviations about the median value in each layer was assumed for the limits on random velocity fluctuations, as well as on strain-dependent shear modulus reduction and damping ratios. All random velocities were limited to be less than or equal to 9,200 ft/sec.

In addition, based on the provided estimates for *in situ* soil layer thicknesses and the observed range of variations, in particular Blue Bluff Marl (59.5 to 76.9 ft and mean of 68 ft), Still Branch (52.2 to 78 ft and mean of 64 ft), and Congaree sand (115.5 to 129.5 ft and mean of 120 ft), the best estimate, minimum and maximum soil layer thicknesses were specified for the purpose of soil profile simulation (SNC, 2014d). In the case of the deeper strata, where the maximum and minimum thickness values are not available, the maximum and minimum thicknesses for each soil/rock formation were estimated by a 20% increase and decrease from the BE value, respectively. Based on the information provided in Table 2.3.2-2, the total soil column depth to 9200 ft/sec rock for the six suggested rock profiles ranges from 1525 ft to 2275 ft, with a best estimate soil column depth of 1900 ft. This information was used to specify the mean soil column depth of the randomized profiles and their variation.

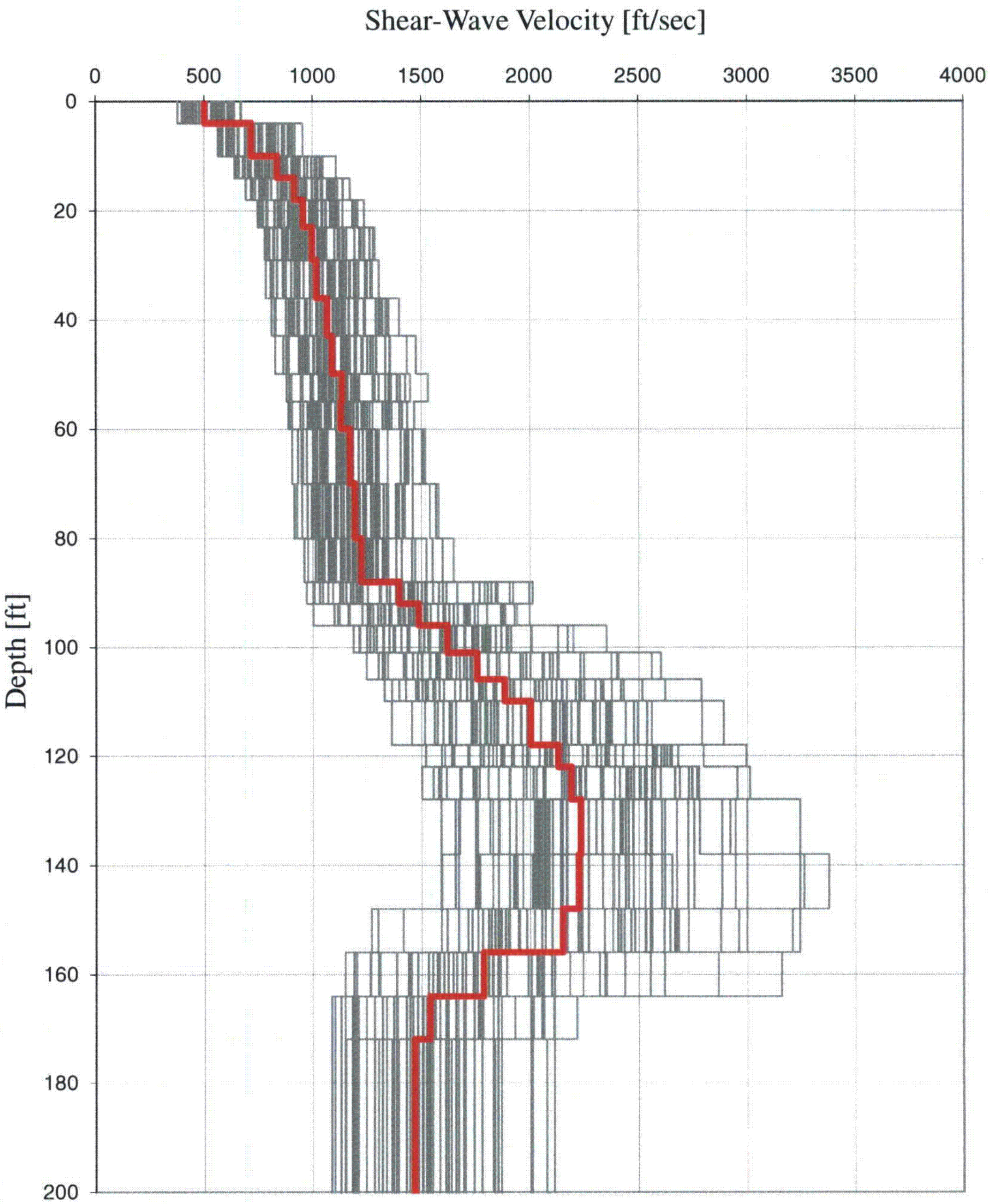

Figure 2.3.3-1. Shear Wave Velocity for 60 Simulated Profiles (Top 200 ft)

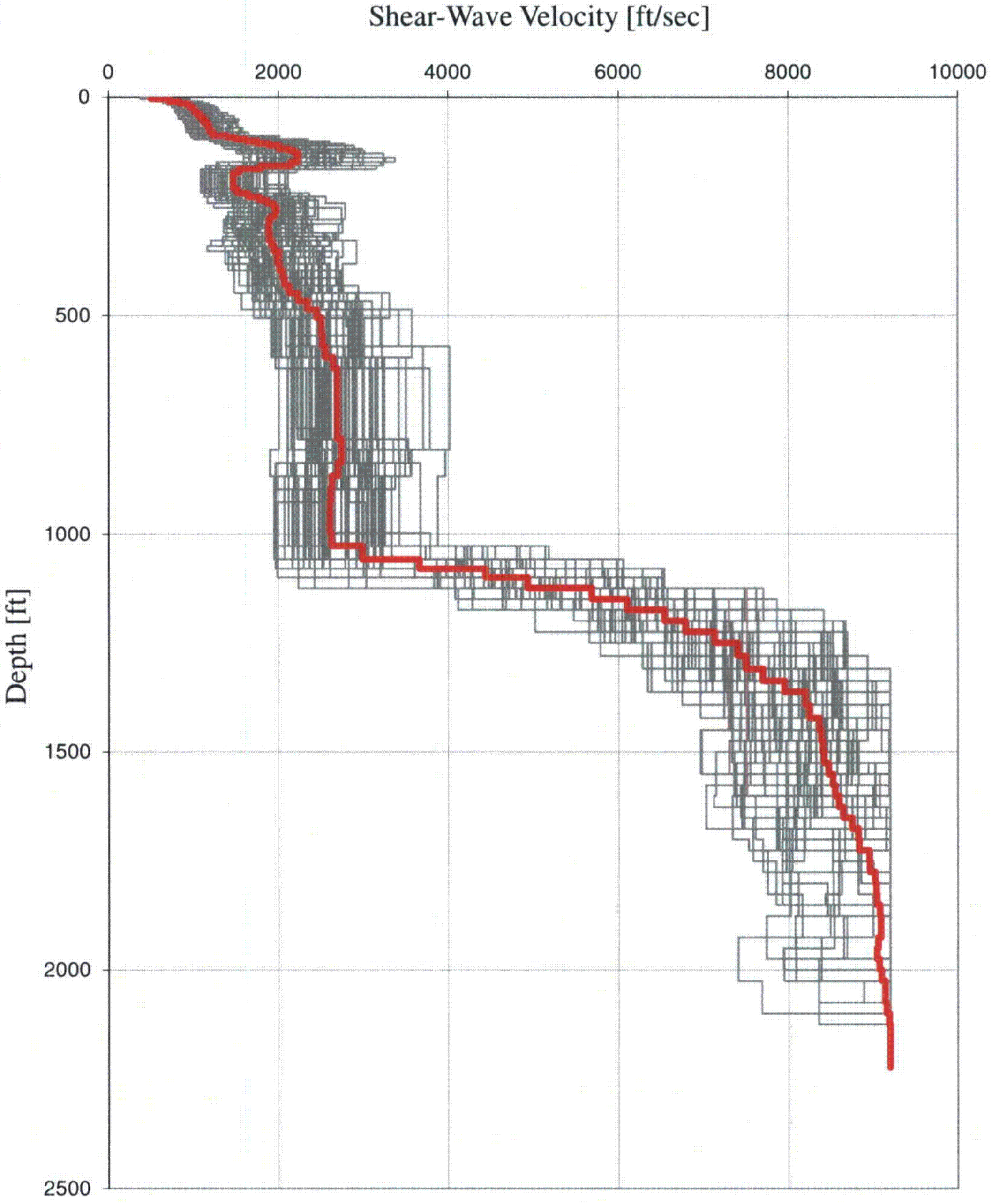

Figure 2.3.3-2. Shear Wave Velocity for 60 Simulated Profiles (Full Soil Column)

2.3.4 Input Spectra

SNC Calculation X2CS18 (SNC, 2014a), SNC Calculation X2CFS129 (SNC, 2014b), and LCI (2013) are the source of the information presented in the following section.

Input base rock acceleration response spectra for the site amplification analysis are developed for a suite of high frequency (HF) and low frequency (LF) cases. These cases correspond to the UHRS ground motion values for MAFE levels of 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7}, and 10^{-8}, as developed from the hard rock hazard curves of Section 2.2.2.

The controlling magnitudes and distances are deaggregated following the methodology presented in Reg. Guide 1.208 (NRC, 2007) for the 1E-4, 1E-5 and 1E-6 MAFE (LCI, 2013). The resulting controlling magnitudes and distances are presented in Table 2.3.4-1. Note that the controlling magnitudes and distances for the 1E-4 MAFE motions are adopted for the 1E-3 motions, and similarly, the controlling magnitudes and distances for the 1E-6 MAFE motions are adopted for the 1E-7 and 1E-8 motions (SNC, 2014a). Other associated parameters such as effective strain ratios and durations are needed for the purpose of site response analysis, and are also presented in Table 2.3.4-1. Effective strain ratios are calculated as [(Magnitude-1)/10] (Idriss and Sun, 1992), and durations are estimated according to the controlling magnitude and distance following the recommended values in Table 3-2 in NUREG/CR-6728 (McGuire et al., 2001).

The spectral shapes from NUREG/CR-6728 are developed using the magnitude and distance controlling high-frequency hazard for spectral frequencies above 2.5 Hz, and using the magnitude and distance controlling low-frequency hazard for spectral frequencies below 2.5 Hz (LCI, 2013). For spectral frequencies between 0.5 Hz and 0.125 Hz, 1/T scaling is used (where T is spectral period). Note that the long-period transition period at Vogtle is 8 seconds, which corresponds to a frequency of 0.125 Hz. For spectral frequencies below 0.125 Hz, $1/T^2$ scaling is used. The resulting hard rock input spectra are presented in Figure 2.3.4-1. The digital values corresponding to the 1E-4, 1E-5 and 1E-6 HF and LF spectra are listed in Table 2.3.4-2.

Table 2.3.4-1. Input Rock Motions and Associated Parameters

Rock Motion	Magnitude [M]	Distance [km]	Duration [sec]	Effective Strain Ratio	Name abbreviation
HF 1E-3	6.6	54	7	0.56	HF3
LF 1E-3	7.2	150	15	0.62	LF3
HF 1E-4	6.6	54	7	0.56	HF4
LF 1E-4	7.2	150	15	0.62	LF4
HF 1E-5	6.4	26	5	0.54	HF5
LF 1E-5	7.3	140	15	0.63	LF5
HF 1E-6	6.4	15	4	0.54	HF6
LF 1E-6	7.4	130	15	0.64	LF6
HF 1E-7	6.4	15	4	0.54	HF7
LF 1E-7	7.4	130	15	0.64	LF7
HF 1E-8	6.4	15	4	0.54	HF8
LF 1E-8	7.4	130	15	0.64	LF8

Table 2.3.4-2. Input HF and LF spectra for MAFE levels of 1E-4, 1E-5, and 1E-6

Frequency (Hz)	1E-4 HF (g)	1E-4 LF (g)	1E-5 HF (g)	1E-5 LF (g)	1E-6 HF (g)	1E-6 LF (g)
0.1	4.95E-03	8.94E-03	1.09E-02	2.22E-02	2.31E-02	4.90E-02
0.125	7.69E-03	1.39E-02	1.70E-02	3.46E-02	3.59E-02	7.61E-02
0.167	1.03E-02	1.87E-02	2.28E-02	4.64E-02	4.82E-02	1.02E-01
0.2	1.24E-02	2.24E-02	2.74E-02	5.56E-02	5.77E-02	1.22E-01
0.3	1.86E-02	3.35E-02	4.10E-02	8.34E-02	8.66E-02	1.84E-01
0.4	2.47E-02	4.47E-02	5.47E-02	1.11E-01	1.15E-01	2.45E-01
0.5	3.09E-02	5.59E-02	6.85E-02	1.39E-01	1.44E-01	3.06E-01
0.6	4.00E-02	6.56E-02	8.96E-02	1.61E-01	1.90E-01	3.54E-01
0.7	4.96E-02	7.45E-02	1.12E-01	1.81E-01	2.38E-01	3.96E-01
0.8	5.94E-02	8.26E-02	1.35E-01	1.99E-01	2.88E-01	4.32E-01
0.9	6.96E-02	8.98E-02	1.60E-01	2.14E-01	3.40E-01	4.62E-01
1	7.99E-02	9.61E-02	1.84E-01	2.26E-01	3.93E-01	4.86E-01
1.25	1.06E-01	1.22E-01	2.47E-01	2.89E-01	5.28E-01	6.21E-01
1.5	1.30E-01	1.44E-01	3.09E-01	3.45E-01	6.59E-01	7.40E-01
2	1.74E-01	1.81E-01	4.20E-01	4.39E-01	8.99E-01	9.40E-01
2.5	2.09E-01	2.09E-01	5.13E-01	5.13E-01	1.10E+00	1.10E+00
3	2.38E-01	2.33E-01	5.83E-01	5.71E-01	1.26E+00	1.22E+00
4	2.85E-01	2.72E-01	6.97E-01	6.64E-01	1.53E+00	1.42E+00
5	3.24E-01	3.04E-01	7.92E-01	7.39E-01	1.76E+00	1.57E+00
6	3.59E-01	3.31E-01	8.91E-01	8.03E-01	2.01E+00	1.71E+00
7	3.90E-01	3.54E-01	9.80E-01	8.58E-01	2.23E+00	1.82E+00
8	4.18E-01	3.73E-01	1.06E+00	9.05E-01	2.44E+00	1.92E+00
9	4.42E-01	3.91E-01	1.13E+00	9.46E-01	2.63E+00	2.01E+00
10	4.64E-01	4.06E-01	1.20E+00	9.82E-01	2.81E+00	2.08E+00
12.5	5.00E-01	4.35E-01	1.32E+00	1.05E+00	3.13E+00	2.23E+00
15	5.25E-01	4.56E-01	1.41E+00	1.10E+00	3.36E+00	2.34E+00
20	5.50E-01	4.81E-01	1.51E+00	1.16E+00	3.65E+00	2.46E+00
25	5.56E-01	4.92E-01	1.55E+00	1.19E+00	3.78E+00	2.51E+00
30	5.68E-01	4.94E-01	1.58E+00	1.19E+00	3.85E+00	2.53E+00
35	5.70E-01	4.90E-01	1.59E+00	1.18E+00	3.85E+00	2.51E+00
40	5.64E-01	4.80E-01	1.57E+00	1.16E+00	3.79E+00	2.45E+00
45	5.44E-01	4.59E-01	1.51E+00	1.11E+00	3.64E+00	2.34E+00
50	5.26E-01	4.41E-01	1.46E+00	1.07E+00	3.51E+00	2.25E+00
60	4.60E-01	3.81E-01	1.28E+00	9.22E-01	3.06E+00	1.95E+00
70	3.89E-01	3.19E-01	1.07E+00	7.71E-01	2.57E+00	1.63E+00
80	3.31E-01	2.69E-01	9.14E-01	6.52E-01	2.17E+00	1.38E+00
90	2.93E-01	2.37E-01	8.07E-01	5.73E-01	1.92E+00	1.21E+00
100	2.71E-01	2.18E-01	7.46E-01	5.26E-01	1.77E+00	1.11E+00

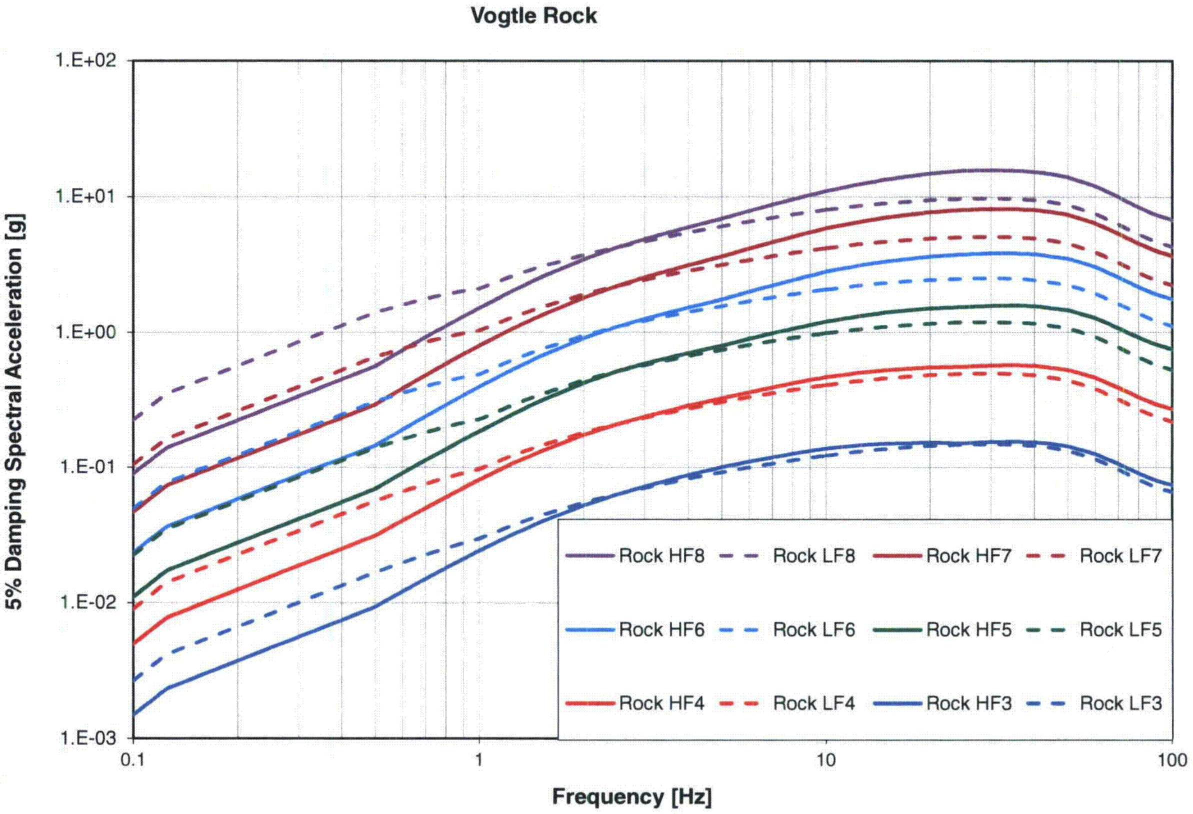

Figure 2.3.4-1. Input High Frequency (HF) and Low Frequency (LF) Hard Rock Spectra for a Spectral Damping of 5%

2.3.5 Methodology

SNC Calculation X2CFS129 (SNC, 2014b) is the source of the information presented in the following section.

To perform the site response analyses for the Plant Vogtle Units 1 and 2 site, a random vibration theory (RVT) approach was employed. This process utilizes a simple, efficient approach for computing site-specific amplification functions and is consistent with existing NRC guidance and the SPID (EPRI 1025287, 2013a). The two sets of simulated profiles, presented in Section 2.3.3, are subjected to the hard rock spectra, presented in Section 2.3.4, at the top of hard rock, which is characterized by a minimum shear wave velocity of 9,200 ft/sec.

The 5% damped acceleration response spectra at the ground surface (SSE control point) are computed, and the amplification functions are calculated as the ratio of the surface response spectra to the hard rock spectra. Natural log-mean (median) amplification functions and associated natural log-standard deviations are calculated for each of the two sets of 60 profiles. The total log-mean as a function of frequency, at each hard rock motion level, are calculated as:

$$\mu_T = \sum_i w_i \mu_i$$

In this equation, μ_T is the total log-mean amplification at each spectral frequency, μ_i is the log-mean amplification function for soil column *i*, and w_i is the weight assigned to soil column *i*. In the case of the Vogtle site, two soil columns are used with equal weight (0.5 each). Similarly, the total natural log-standard deviation σ_T of the amplification, is calculated by the equation below, where σ_i is the natural log-standard deviation of soil column *i*.

$$\sigma_T = \sqrt{\sum_i w_i \left[(\mu_i - \mu_T)^2 + \sigma_i^2 \right]}$$

2.3.6 Amplification Functions

SNC Calculation X2CFS129 (SNC, 2014b) is the source of the information presented in the following section.

The results of the site response analysis consist of amplification functions which describe the amplification (or de-amplification) of hard rock motions as a function of frequency. The amplification functions are represented in terms of a median amplification value, and an associated standard deviation (sigma), as a function of spectral frequency for each input hard rock motion.

Figure 2.3.6-1a illustrates the median amplification functions developed for the soil column using high PI strain-dependent property curves for the BBM formation. The variability in the amplification factors results from variability in shear-wave velocity, depth to hard rock, and modulus reduction and hysteretic damping curves, and is represented by the natural log-standard deviations illustrated in Figure 2.3.6-1b. Figure 2.3.6-2a and Figure 2.3.6-2b show similar results for the soil column using low PI strain-dependent property curves for the BBM formation. The total (weighted average) median amplification functions and corresponding standard deviations are presented in Figure 2.3.6-3a and Figure 2.3.6-3b, respectively.

At some frequencies, the calculated site amplification at high loading levels is less than the minimum value of 0.5 recommended by the SPID (EPRI 1025287, 2013a). The 0.5 limit is not considered in the calculation of the surface hazard, as the intended purpose of this calculation is quantification of mean and fractile levels of the seismic response for plant risk assessment that requires a best assessment of the response with no added conservatism.

Tabulated values of the amplification factors for the presented figures, at the 1E-4 and 1E-5 AFE, are provided in Tables 2.3.6-1, 2.3.6-2 and 2.3.6-3, corresponding to Figures 2.3.6-1, 2.3.6-2 and 2.3.6-3, respectively. Note the tables in this section are provided in lieu of the submittal template Tables A.2-b1 and A.2-b2.

Additionally, the weighted average amplification and total standard deviation is reported at the seven frequencies, for which the GMM is defined, in Table A-2 in the Appendix.

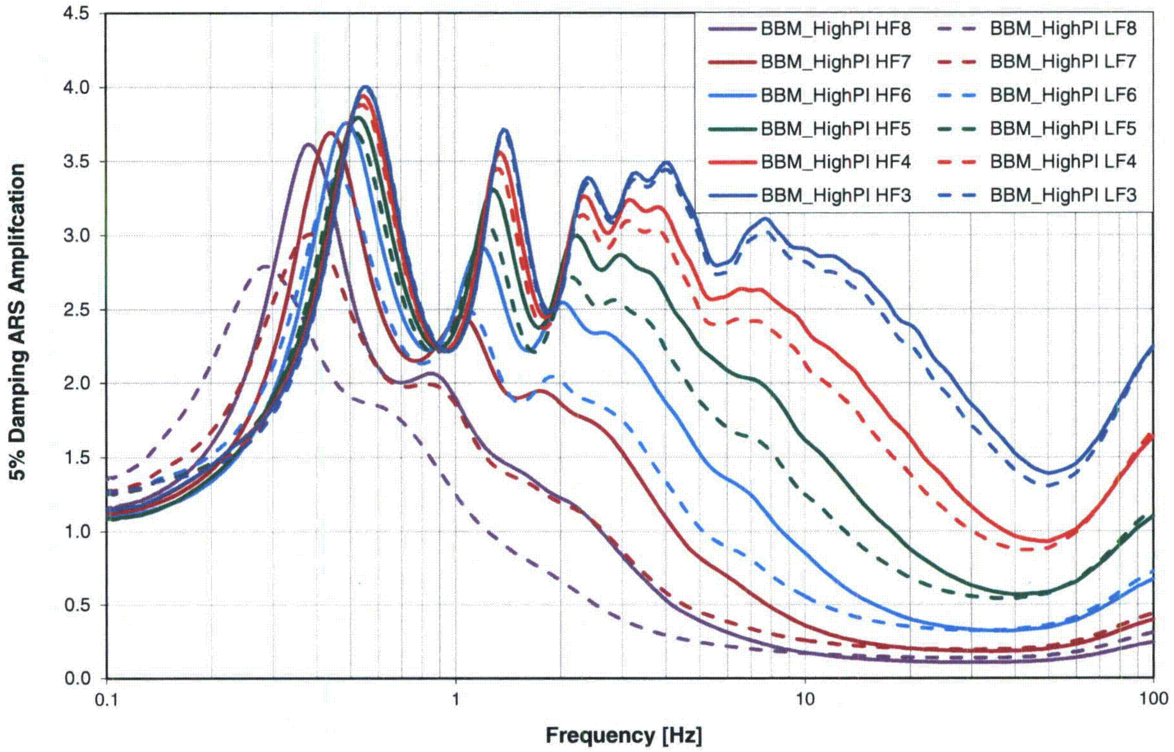

Figure 2.3.6-1a. **Natural log-mean amplification functions at ground surface for the soil column using high PI strain-dependent property curves for the BBM formation**

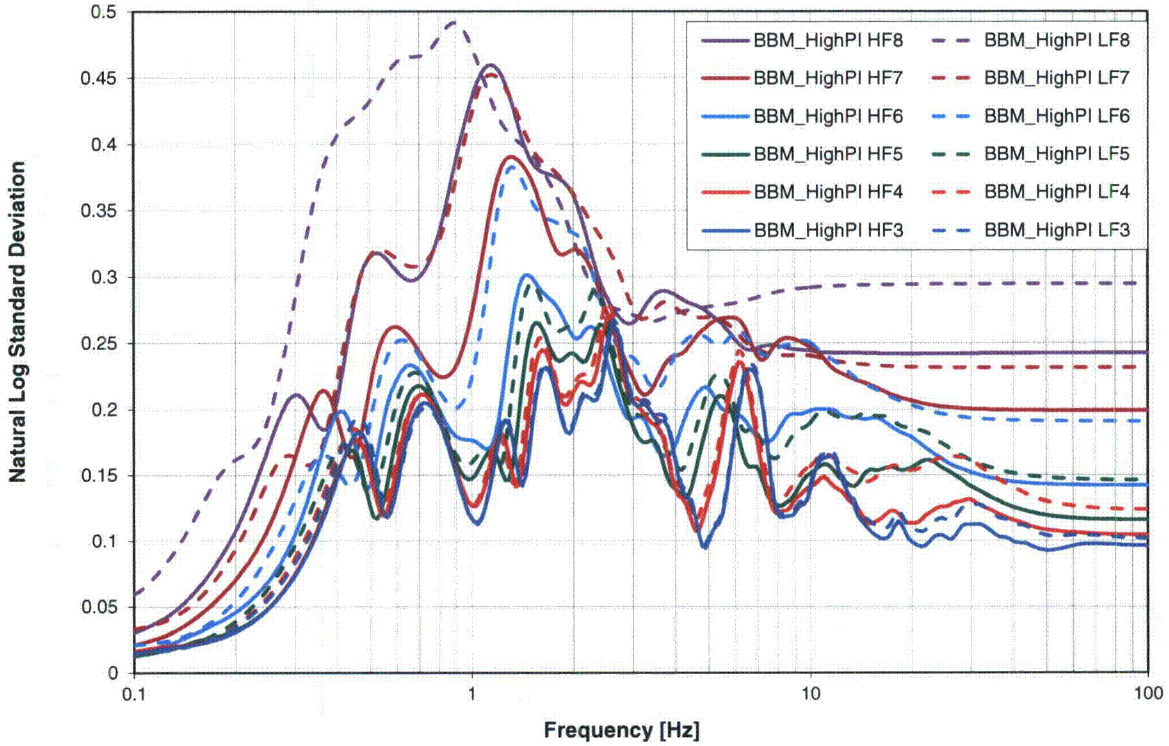

Figure 2.3.6-1b. **Natural log-standard deviations for amplification functions at ground surface for the soil column using high PI strain-dependent property curves for the BBM formation**

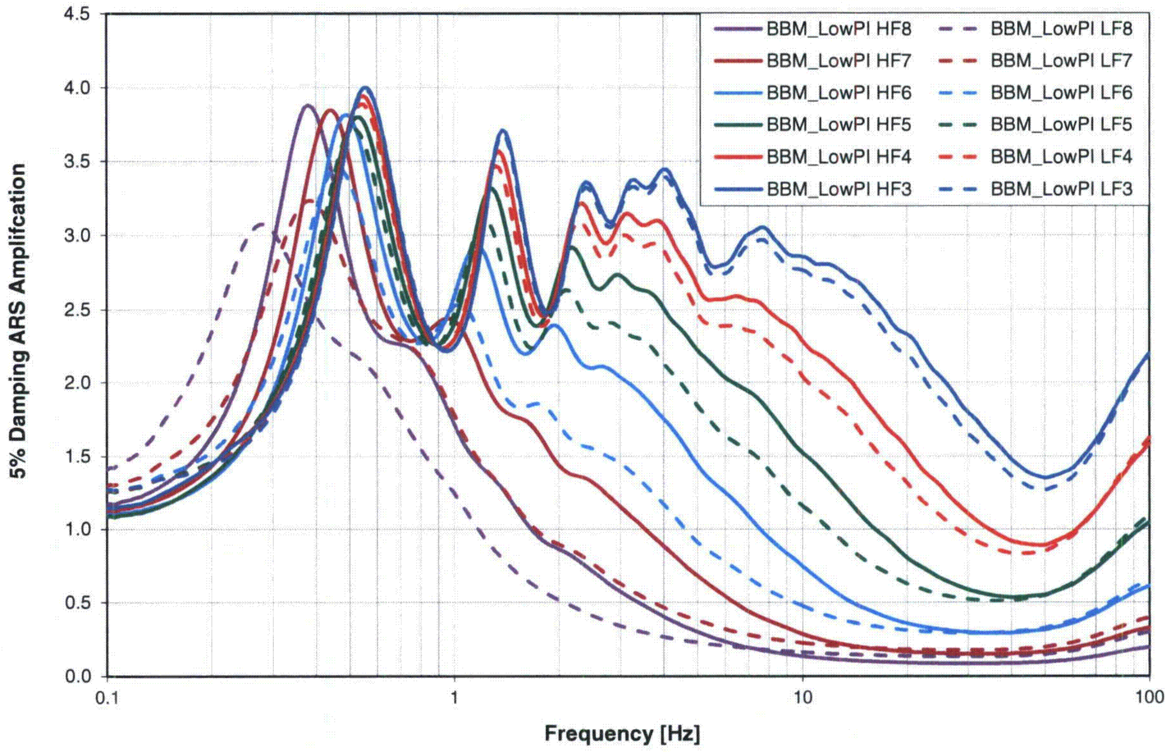

Figure 2.3.6-2a. **Natural log-mean amplification functions at ground surface for the soil column using low PI strain-dependent property curves for the BBM formation**

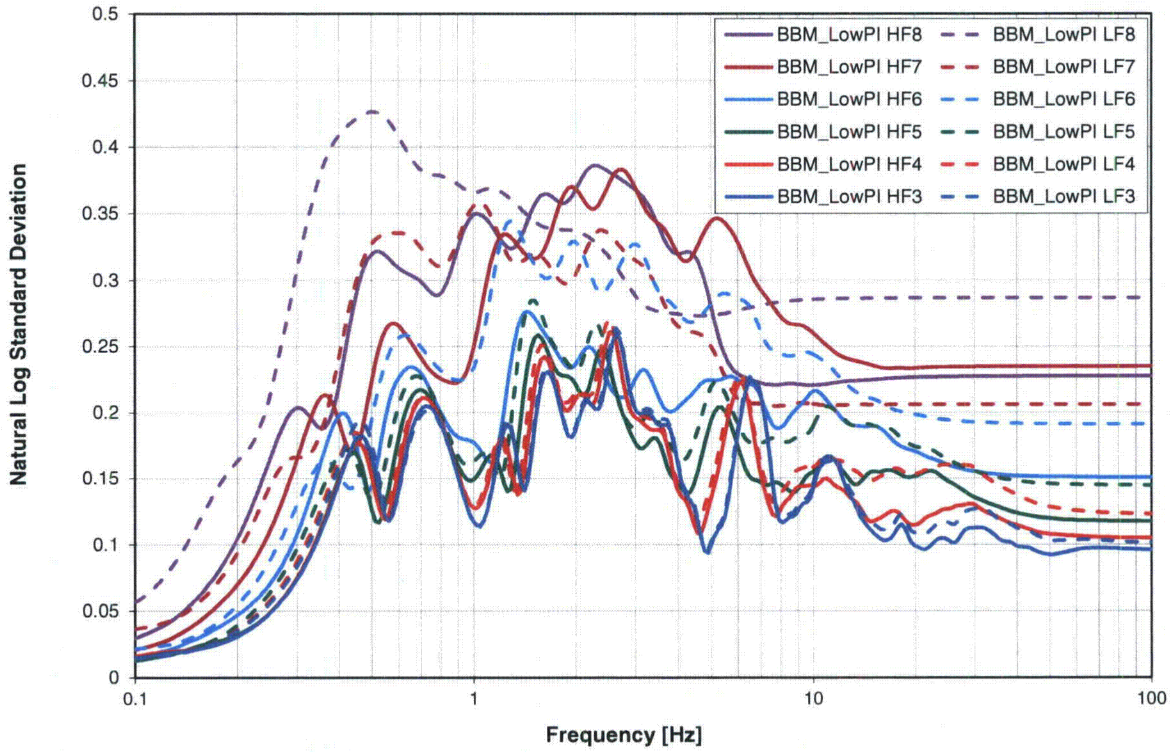

Figure 2.3.6-2b. **Natural log-standard deviations for amplification functions at ground surface for the soil column using low PI strain-dependent property curves for the BBM formation**

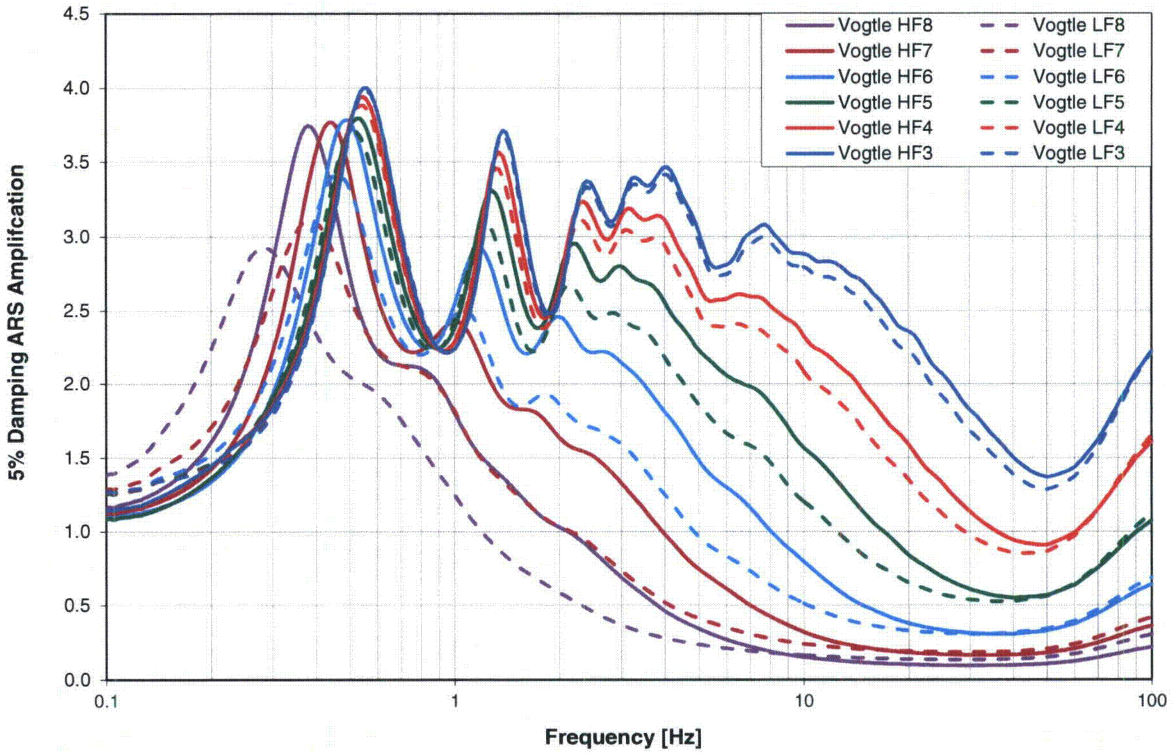

Figure 2.3.6-3a. Total (weighted average) natural log-mean amplification functions at ground surface

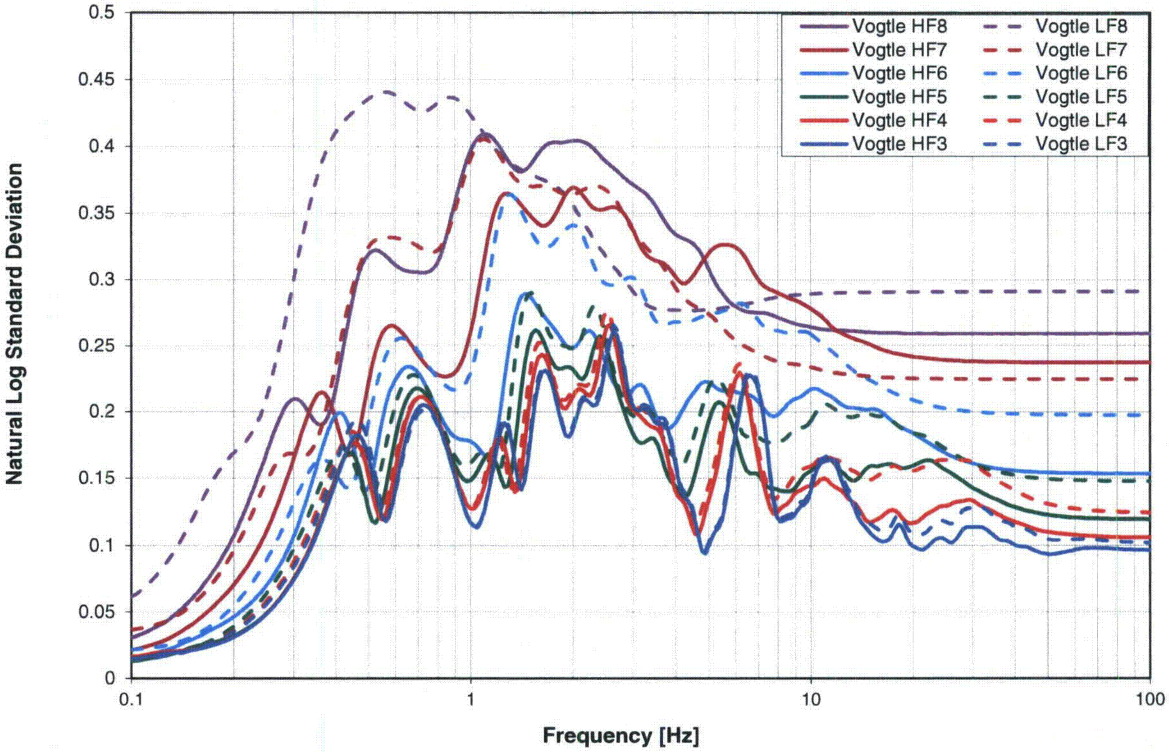

Figure 2.3.6-3b. **Total (weighted average) natural log-standard deviations for amplification functions at ground surface**

Table 2.3.6-1. Median and log-standard deviation of the 5% damped amplification function (AF) for the soil column using high PI strain-dependent property curves for the BBM formation and the HF 1E-4, LF 1E-4, HF 1E-5, and LF 1E-5 motions

	HF 1E-4		LF 1E-4		HF 1E-5		LF 1E-5	
Freq [Hz]	Mean AF	Ln (AF)	Mean AF	Ln (AF)	Mean AF	Ln (AF)	Mean AF	Ln (AF)
0.1	1.13E+00	1.64E-02	1.26E+00	1.48E-02	1.08E+00	1.28E-02	1.25E+00	1.63E-02
0.125	1.16E+00	1.99E-02	1.29E+00	1.67E-02	1.11E+00	1.68E-02	1.28E+00	1.81E-02
0.167	1.32E+00	2.39E-02	1.37E+00	2.52E-02	1.23E+00	2.61E-02	1.38E+00	2.70E-02
0.2	1.44E+00	3.10E-02	1.44E+00	3.58E-02	1.36E+00	3.21E-02	1.46E+00	3.89E-02
0.3	1.85E+00	7.48E-02	1.82E+00	8.72E-02	1.90E+00	7.45E-02	1.90E+00	9.68E-02
0.4	2.61E+00	1.50E-01	2.62E+00	1.65E-01	2.71E+00	1.51E-01	2.81E+00	1.69E-01
0.5	3.75E+00	1.52E-01	3.72E+00	1.55E-01	3.73E+00	1.26E-01	3.68E+00	1.34E-01
0.6	3.73E+00	1.56E-01	3.66E+00	1.64E-01	3.47E+00	1.80E-01	3.29E+00	2.05E-01
0.7	2.94E+00	2.10E-01	2.90E+00	2.11E-01	2.75E+00	2.17E-01	2.62E+00	2.26E-01
0.8	2.42E+00	1.94E-01	2.41E+00	1.94E-01	2.34E+00	1.94E-01	2.27E+00	1.99E-01
0.9	2.23E+00	1.53E-01	2.22E+00	1.54E-01	2.23E+00	1.59E-01	2.21E+00	1.65E-01
1	2.27E+00	1.27E-01	2.29E+00	1.27E-01	2.36E+00	1.47E-01	2.40E+00	1.59E-01
1.25	3.30E+00	1.77E-01	3.29E+00	1.70E-01	3.27E+00	1.48E-01	3.06E+00	1.68E-01
1.5	3.18E+00	2.12E-01	3.01E+00	2.31E-01	2.77E+00	2.58E-01	2.44E+00	2.94E-01
2	2.66E+00	2.12E-01	2.62E+00	2.18E-01	2.73E+00	2.42E-01	2.59E+00	2.63E-01
2.5	3.17E+00	2.66E-01	3.04E+00	2.80E-01	2.81E+00	2.58E-01	2.53E+00	2.69E-01
3	3.16E+00	2.06E-01	3.05E+00	2.10E-01	2.87E+00	1.87E-01	2.54E+00	1.99E-01
4	3.15E+00	1.39E-01	2.99E+00	1.45E-01	2.60E+00	1.39E-01	2.23E+00	1.58E-01
5	2.68E+00	1.32E-01	2.50E+00	1.42E-01	2.25E+00	1.91E-01	1.88E+00	2.16E-01
6	2.59E+00	2.27E-01	2.40E+00	2.37E-01	2.08E+00	1.89E-01	1.70E+00	2.01E-01
7	2.62E+00	1.72E-01	2.42E+00	1.81E-01	2.03E+00	1.54E-01	1.63E+00	1.81E-01
8	2.58E+00	1.21E-01	2.36E+00	1.32E-01	1.94E+00	1.27E-01	1.54E+00	1.63E-01
9	2.49E+00	1.31E-01	2.26E+00	1.45E-01	1.77E+00	1.35E-01	1.37E+00	1.81E-01
10	2.37E+00	1.41E-01	2.13E+00	1.56E-01	1.61E+00	1.51E-01	1.24E+00	1.90E-01
12.5	2.17E+00	1.36E-01	1.92E+00	1.59E-01	1.38E+00	1.46E-01	1.04E+00	1.93E-01
15	1.97E+00	1.13E-01	1.72E+00	1.45E-01	1.16E+00	1.53E-01	8.67E-01	1.96E-01
20	1.63E+00	1.13E-01	1.39E+00	1.53E-01	8.77E-01	1.56E-01	6.80E-01	1.85E-01
25	1.36E+00	1.26E-01	1.15E+00	1.62E-01	7.19E-01	1.54E-01	5.91E-01	1.73E-01
30	1.17E+00	1.31E-01	1.00E+00	1.61E-01	6.29E-01	1.41E-01	5.55E-01	1.61E-01
35	1.04E+00	1.22E-01	9.18E-01	1.49E-01	5.84E-01	1.32E-01	5.41E-01	1.54E-01
40	9.63E-01	1.16E-01	8.74E-01	1.40E-01	5.66E-01	1.25E-01	5.40E-01	1.51E-01
45	9.35E-01	1.11E-01	8.71E-01	1.34E-01	5.71E-01	1.22E-01	5.57E-01	1.49E-01
50	9.27E-01	1.08E-01	8.82E-01	1.30E-01	5.82E-01	1.19E-01	5.75E-01	1.48E-01
60	1.01E+00	1.06E-01	9.88E-01	1.27E-01	6.53E-01	1.17E-01	6.62E-01	1.47E-01
70	1.17E+00	1.05E-01	1.16E+00	1.25E-01	7.73E-01	1.16E-01	7.89E-01	1.46E-01
80	1.35E+00	1.04E-01	1.37E+00	1.24E-01	9.02E-01	1.16E-01	9.31E-01	1.46E-01
90	1.52E+00	1.04E-01	1.55E+00	1.24E-01	1.02E+00	1.16E-01	1.06E+00	1.46E-01
100	1.64E+00	1.04E-01	1.68E+00	1.24E-01	1.10E+00	1.16E-01	1.15E+00	1.46E-01

Table 2.3.6-2. Median and log-standard deviation of the 5% damped amplification function (AF) for the soil column using low PI strain-dependent property curves for the BBM formation and the HF 1E-4, LF 1E-4, HF 1E-5, and LF 1E-5 motions

	HF 1E-4		LF 1E-4		HF 1E-5		LF 1E-5	
Freq [Hz]	Mean AF	Ln (AF)	Mean AF	Ln (AF)	Mean AF	Ln (AF)	Mean AF	Ln (AF)
0.1	1.13E+00	1.63E-02	1.26E+00	1.47E-02	1.08E+00	1.28E-02	1.25E+00	1.62E-02
0.125	1.16E+00	1.97E-02	1.29E+00	1.67E-02	1.11E+00	1.67E-02	1.28E+00	1.80E-02
0.167	1.31E+00	2.37E-02	1.37E+00	2.51E-02	1.23E+00	2.58E-02	1.38E+00	2.70E-02
0.2	1.44E+00	3.08E-02	1.44E+00	3.58E-02	1.36E+00	3.19E-02	1.46E+00	3.89E-02
0.3	1.85E+00	7.47E-02	1.82E+00	8.72E-02	1.90E+00	7.43E-02	1.91E+00	9.66E-02
0.4	2.61E+00	1.49E-01	2.63E+00	1.64E-01	2.72E+00	1.50E-01	2.82E+00	1.68E-01
0.5	3.75E+00	1.51E-01	3.73E+00	1.54E-01	3.74E+00	1.26E-01	3.69E+00	1.33E-01
0.6	3.73E+00	1.56E-01	3.66E+00	1.64E-01	3.48E+00	1.80E-01	3.31E+00	2.04E-01
0.7	2.94E+00	2.10E-01	2.91E+00	2.10E-01	2.76E+00	2.17E-01	2.64E+00	2.26E-01
0.8	2.43E+00	1.93E-01	2.42E+00	1.94E-01	2.36E+00	1.93E-01	2.30E+00	1.98E-01
0.9	2.24E+00	1.53E-01	2.24E+00	1.54E-01	2.26E+00	1.59E-01	2.25E+00	1.67E-01
1	2.29E+00	1.27E-01	2.31E+00	1.29E-01	2.40E+00	1.49E-01	2.47E+00	1.62E-01
1.25	3.33E+00	1.75E-01	3.32E+00	1.67E-01	3.29E+00	1.42E-01	3.09E+00	1.67E-01
1.5	3.16E+00	2.12E-01	3.00E+00	2.30E-01	2.75E+00	2.53E-01	2.44E+00	2.85E-01
2	2.68E+00	2.10E-01	2.65E+00	2.14E-01	2.74E+00	2.21E-01	2.58E+00	2.32E-01
2.5	3.10E+00	2.58E-01	2.96E+00	2.70E-01	2.67E+00	2.38E-01	2.38E+00	2.38E-01
3	3.09E+00	1.96E-01	2.97E+00	1.99E-01	2.73E+00	1.76E-01	2.37E+00	1.88E-01
4	3.07E+00	1.40E-01	2.90E+00	1.46E-01	2.51E+00	1.46E-01	2.13E+00	1.67E-01
5	2.66E+00	1.34E-01	2.48E+00	1.45E-01	2.22E+00	1.93E-01	1.84E+00	2.19E-01
6	2.57E+00	2.20E-01	2.38E+00	2.27E-01	2.03E+00	1.74E-01	1.64E+00	1.91E-01
7	2.56E+00	1.54E-01	2.35E+00	1.61E-01	1.94E+00	1.47E-01	1.54E+00	1.76E-01
8	2.49E+00	1.26E-01	2.27E+00	1.37E-01	1.80E+00	1.45E-01	1.40E+00	1.79E-01
9	2.39E+00	1.43E-01	2.17E+00	1.56E-01	1.65E+00	1.41E-01	1.25E+00	1.81E-01
10	2.28E+00	1.44E-01	2.04E+00	1.58E-01	1.52E+00	1.55E-01	1.16E+00	1.89E-01
12.5	2.09E+00	1.39E-01	1.84E+00	1.60E-01	1.29E+00	1.52E-01	9.55E-01	1.93E-01
15	1.89E+00	1.17E-01	1.63E+00	1.48E-01	1.07E+00	1.55E-01	7.94E-01	1.90E-01
20	1.55E+00	1.15E-01	1.31E+00	1.52E-01	8.04E-01	1.51E-01	6.26E-01	1.74E-01
25	1.29E+00	1.27E-01	1.09E+00	1.60E-01	6.64E-01	1.48E-01	5.51E-01	1.64E-01
30	1.10E+00	1.30E-01	9.50E-01	1.58E-01	5.86E-01	1.35E-01	5.20E-01	1.55E-01
35	9.88E-01	1.21E-01	8.73E-01	1.45E-01	5.47E-01	1.29E-01	5.10E-01	1.50E-01
40	9.17E-01	1.14E-01	8.35E-01	1.37E-01	5.32E-01	1.24E-01	5.10E-01	1.48E-01
45	8.94E-01	1.10E-01	8.36E-01	1.31E-01	5.39E-01	1.21E-01	5.27E-01	1.46E-01
50	8.89E-01	1.08E-01	8.48E-01	1.28E-01	5.50E-01	1.20E-01	5.45E-01	1.46E-01
60	9.71E-01	1.06E-01	9.53E-01	1.25E-01	6.19E-01	1.18E-01	6.28E-01	1.45E-01
70	1.13E+00	1.06E-01	1.13E+00	1.24E-01	7.34E-01	1.18E-01	7.49E-01	1.45E-01
80	1.31E+00	1.05E-01	1.32E+00	1.23E-01	8.55E-01	1.18E-01	8.84E-01	1.45E-01
90	1.47E+00	1.05E-01	1.49E+00	1.23E-01	9.65E-01	1.18E-01	1.00E+00	1.45E-01
100	1.58E+00	1.05E-01	1.62E+00	1.23E-01	1.04E+00	1.18E-01	1.09E+00	1.45E-01

Table 2.3.6-3. Total (weighted average) Median and log-standard deviation of the 5% damped amplification function (AF) for the HF 1E-4, LF 1E-4, HF 1E-5, and LF 1E-5 motions

	HF 1E-4		LF 1E-4		HF 1E-5		LF 1E-5	
Freq [Hz]	Mean AF	Ln (AF)	Mean AF	Ln (AF)	Mean AF	Ln (AF)	Mean AF	Ln (AF)
0.1	1.13E+00	1.64E-02	1.26E+00	1.48E-02	1.08E+00	1.28E-02	1.25E+00	1.63E-02
0.125	1.16E+00	1.98E-02	1.29E+00	1.67E-02	1.11E+00	1.68E-02	1.28E+00	1.81E-02
0.167	1.31E+00	2.38E-02	1.37E+00	2.51E-02	1.23E+00	2.60E-02	1.38E+00	2.70E-02
0.2	1.44E+00	3.09E-02	1.44E+00	3.58E-02	1.36E+00	3.20E-02	1.46E+00	3.89E-02
0.3	1.85E+00	7.47E-02	1.82E+00	8.72E-02	1.90E+00	7.44E-02	1.90E+00	9.67E-02
0.4	2.61E+00	1.49E-01	2.63E+00	1.65E-01	2.71E+00	1.50E-01	2.81E+00	1.68E-01
0.5	3.75E+00	1.52E-01	3.73E+00	1.54E-01	3.73E+00	1.26E-01	3.69E+00	1.34E-01
0.6	3.73E+00	1.56E-01	3.66E+00	1.64E-01	3.47E+00	1.80E-01	3.30E+00	2.04E-01
0.7	2.94E+00	2.10E-01	2.90E+00	2.10E-01	2.75E+00	2.17E-01	2.63E+00	2.26E-01
0.8	2.43E+00	1.94E-01	2.41E+00	1.94E-01	2.35E+00	1.94E-01	2.29E+00	1.99E-01
0.9	2.23E+00	1.53E-01	2.23E+00	1.54E-01	2.24E+00	1.59E-01	2.23E+00	1.66E-01
1	2.28E+00	1.27E-01	2.30E+00	1.28E-01	2.38E+00	1.48E-01	2.44E+00	1.61E-01
1.25	3.32E+00	1.76E-01	3.30E+00	1.68E-01	3.28E+00	1.45E-01	3.08E+00	1.67E-01
1.5	3.17E+00	2.12E-01	3.01E+00	2.30E-01	2.76E+00	2.56E-01	2.44E+00	2.90E-01
2	2.67E+00	2.11E-01	2.63E+00	2.16E-01	2.73E+00	2.32E-01	2.59E+00	2.48E-01
2.5	3.14E+00	2.62E-01	3.00E+00	2.75E-01	2.74E+00	2.50E-01	2.45E+00	2.56E-01
3	3.12E+00	2.01E-01	3.01E+00	2.05E-01	2.80E+00	1.83E-01	2.45E+00	1.97E-01
4	3.11E+00	1.40E-01	2.94E+00	1.46E-01	2.55E+00	1.44E-01	2.18E+00	1.64E-01
5	2.67E+00	1.33E-01	2.49E+00	1.43E-01	2.23E+00	1.92E-01	1.86E+00	2.18E-01
6	2.58E+00	2.24E-01	2.39E+00	2.32E-01	2.06E+00	1.82E-01	1.67E+00	1.97E-01
7	2.59E+00	1.64E-01	2.38E+00	1.72E-01	1.98E+00	1.52E-01	1.58E+00	1.81E-01
8	2.53E+00	1.25E-01	2.31E+00	1.36E-01	1.87E+00	1.41E-01	1.47E+00	1.77E-01
9	2.44E+00	1.38E-01	2.21E+00	1.52E-01	1.71E+00	1.43E-01	1.31E+00	1.86E-01
10	2.33E+00	1.44E-01	2.09E+00	1.59E-01	1.57E+00	1.55E-01	1.20E+00	1.93E-01
12.5	2.13E+00	1.39E-01	1.88E+00	1.61E-01	1.34E+00	1.53E-01	9.96E-01	1.98E-01
15	1.93E+00	1.17E-01	1.67E+00	1.49E-01	1.12E+00	1.59E-01	8.30E-01	1.98E-01
20	1.59E+00	1.17E-01	1.35E+00	1.55E-01	8.40E-01	1.59E-01	6.52E-01	1.84E-01
25	1.33E+00	1.29E-01	1.12E+00	1.64E-01	6.91E-01	1.56E-01	5.71E-01	1.72E-01
30	1.13E+00	1.33E-01	9.76E-01	1.62E-01	6.07E-01	1.43E-01	5.37E-01	1.61E-01
35	1.01E+00	1.24E-01	8.95E-01	1.49E-01	5.65E-01	1.34E-01	5.25E-01	1.55E-01
40	9.40E-01	1.18E-01	8.54E-01	1.41E-01	5.49E-01	1.28E-01	5.25E-01	1.52E-01
45	9.14E-01	1.13E-01	8.53E-01	1.34E-01	5.55E-01	1.25E-01	5.42E-01	1.50E-01
50	9.08E-01	1.10E-01	8.65E-01	1.31E-01	5.66E-01	1.23E-01	5.60E-01	1.49E-01
60	9.90E-01	1.08E-01	9.70E-01	1.27E-01	6.36E-01	1.21E-01	6.45E-01	1.48E-01
70	1.15E+00	1.07E-01	1.14E+00	1.26E-01	7.53E-01	1.20E-01	7.69E-01	1.48E-01
80	1.33E+00	1.06E-01	1.35E+00	1.25E-01	8.78E-01	1.20E-01	9.07E-01	1.48E-01
90	1.49E+00	1.06E-01	1.52E+00	1.25E-01	9.91E-01	1.20E-01	1.03E+00	1.48E-01
100	1.61E+00	1.06E-01	1.65E+00	1.24E-01	1.07E+00	1.20E-01	1.12E+00	1.47E-01

2.3.7 Control Point Seismic Hazard Curves

LCI Calculation VAP001-PC-05 (LCI, 2014) is the source of the information presented in the following section.

The Control Point (power block) seismic hazard at the Plant Vogtle Units 1 and 2 site was calculated (LCI, 2014) using the 2012 CEUS seismic sources (NRC, 2012), the 2013-EPRI ground motions (EPRI, 2013c), and site amplification factors developed by Bechtel (SNC, 2014b). Method 3 was used to incorporate site amplification factors with the site rock hazard to calculate control point seismic hazard curves (LCI, 2014). The resulting control point mean seismic hazard curves for the Vogtle site is shown in Figure 2.3.7-1 for the seven oscillator frequencies. Table 2.3.7-1 provides a tabulation of the control point mean seismic hazard curves for the seven oscillator frequencies. The mean and fractile control point hazard curves are tabulated in Tables A-1a through A-1g of the Appendix.

Table 2.3.7-1 Mean Control Point Seismic Hazard Curves for Seven Frequencies at Vogtle

SA (g)	0.5 Hz	1 Hz	2.5 Hz	5 Hz	10 Hz	25 Hz	PGA
0.0005	3.63E-02	4.41E-02	5.33E-02	5.36E-02	5.34E-02	5.10E-02	4.94E-02
0.001	2.63E-02	3.52E-02	5.09E-02	5.19E-02	5.15E-02	4.66E-02	4.37E-02
0.005	9.81E-03	1.36E-02	3.38E-02	3.74E-02	3.67E-02	2.83E-02	2.32E-02
0.01	6.22E-03	8.00E-03	2.34E-02	2.75E-02	2.74E-02	2.03E-02	1.53E-02
0.015	4.67E-03	5.70E-03	1.77E-02	2.17E-02	2.22E-02	1.63E-02	1.14E-02
0.03	2.55E-03	2.88E-03	9.86E-03	1.30E-02	1.43E-02	1.05E-02	6.46E-03
0.05	1.39E-03	1.52E-03	5.88E-03	8.16E-03	9.74E-03	7.20E-03	4.04E-03
0.075	7.65E-04	8.34E-04	3.76E-03	5.46E-03	6.91E-03	5.13E-03	2.68E-03
0.1	4.68E-04	5.14E-04	2.70E-03	4.05E-03	5.30E-03	3.94E-03	1.93E-03
0.15	2.14E-04	2.39E-04	1.63E-03	2.58E-03	3.53E-03	2.60E-03	1.11E-03
0.3	4.46E-05	5.05E-05	5.70E-04	1.00E-03	1.52E-03	1.02E-03	2.87E-04
0.5	1.16E-05	1.33E-05	2.05E-04	3.90E-04	6.58E-04	3.47E-04	6.78E-05
0.75	3.50E-06	4.21E-06	7.53E-05	1.52E-04	2.77E-04	9.92E-05	1.49E-05
1	1.40E-06	1.78E-06	3.28E-05	7.00E-05	1.31E-04	2.80E-05	3.72E-06
1.5	3.46E-07	4.99E-07	8.20E-06	1.97E-05	3.51E-05	1.93E-06	2.50E-07
3	2.51E-08	4.31E-08	3.35E-07	1.10E-06	9.43E-07	3.89E-09	2.23E-10
5	3.15E-09	5.03E-09	1.35E-08	4.84E-08	1.95E-08	3.70E-11	9.81E-13
7.5	5.79E-10	7.21E-10	6.52E-10	2.29E-09	5.76E-10	2.51E-13	2.74E-14
10	1.73E-10	1.61E-10	6.05E-11	2.06E-10	3.73E-11	1.92E-15	2.21E-15

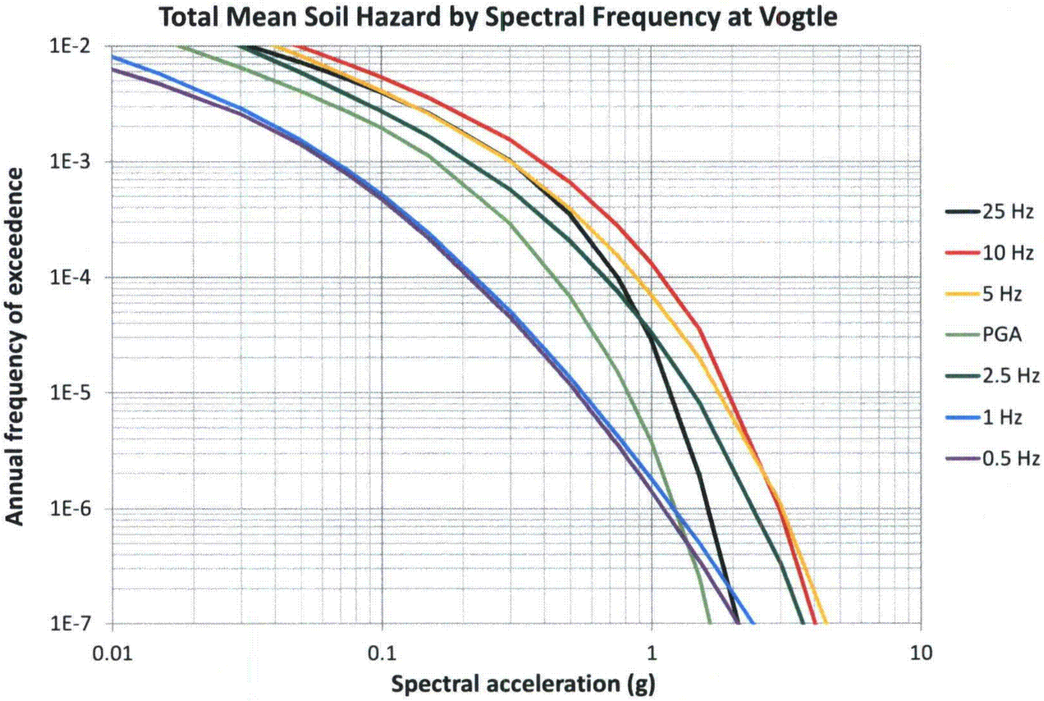

Figure 2.3.7-1. Control point mean hazard curves for seven spectral frequencies of 0.5, 1, 2.5, 5, 10, 25 and PGA (100 Hz) at Vogtle.

2.4 Control Point Response Spectra

LCI Calculation VAP001-PC-05 (LCI, 2014) is the source of the information presented in the following section.

The control point hazard curves described above have been used to develop uniform hazard response spectra (UHRS) and the ground motion response spectrum (GMRS). The UHRS were calculated using log-log interpolation to determine the spectral acceleration at each spectral frequency for the 10^{-4} and 10^{-5} per year hazard levels. The GMRS was calculated from the 10^{-4} and 10^{-5} UHRS at each spectral frequency using the equations in RG 1.208 (NRC, 2007). Table 2.4-1 shows the mean UHRS for 10^{-4} and 10^{-5} and GMRS accelerations for a range of spectral frequencies.

Table 2.4-1. UHRS 10^{-4} and 10^{-5} and GMRS at Control Point for Vogtle.

Freq. (Hz)	10^{-4} UHRS (g)	10^{-5} UHRS (g)	GMRS (g)
100	4.36E-01	8.14E-01	4.36E-01
90	4.38E-01	8.20E-01	4.38E-01
80	4.41E-01	8.27E-01	4.41E-01
70	4.47E-01	8.36E-01	4.47E-01
60	4.58E-01	8.49E-01	4.58E-01
50	4.80E-01	8.71E-01	4.80E-01
40	5.34E-01	9.18E-01	5.34E-01
35	5.83E-01	9.64E-01	5.83E-01
30	6.51E-01	1.04E+00	6.51E-01
25	7.48E-01	1.17E+00	7.48E-01
20	8.83E-01	1.36E+00	8.83E-01
15	1.02E+00	1.65E+00	1.02E+00
12.5	1.07E+00	1.82E+00	1.07E+00
10	1.09E+00	1.91E+00	1.09E+00
9	1.09E+00	1.95E+00	1.09E+00
8	1.07E+00	2.00E+00	1.07E+00
7	1.02E+00	1.95E+00	1.03E+00
6	9.36E-01	1.84E+00	9.64E-01
5	8.76E-01	1.77E+00	9.21E-01
4	9.03E-01	1.80E+00	9.39E-01
3.5	8.33E-01	1.76E+00	9.09E-01
3	7.62E-01	1.67E+00	8.55E-01
2.5	6.69E-01	1.42E+00	7.31E-01
2	4.87E-01	1.16E+00	5.87E-01
1.5	4.39E-01	8.55E-01	4.49E-01
1.25	4.06E-01	8.99E-01	4.60E-01
1	2.21E-01	5.53E-01	2.76E-01
0.9	2.00E-01	4.81E-01	2.42E-01
0.8	2.00E-01	4.60E-01	2.33E-01
0.7	2.17E-01	4.83E-01	2.47E-01
0.6	2.42E-01	5.41E-01	2.76E-01
0.5	2.10E-01	5.26E-01	2.62E-01
0.4	1.68E-01	4.20E-01	2.10E-01
0.35	1.47E-01	3.68E-01	1.84E-01
0.3	1.26E-01	3.15E-01	1.57E-01
0.25	1.05E-01	2.63E-01	1.31E-01
0.2	8.40E-02	2.10E-01	1.05E-01
0.15	6.30E-02	1.58E-01	7.87E-02
0.125	5.25E-02	1.31E-01	6.56E-02
0.1	3.36E-02	8.41E-02	4.20E-02

The 1E-4, 1E-5, and 1E-6 UHRS along with the GMRS at the control point are plotted in Figure 2.4-1.

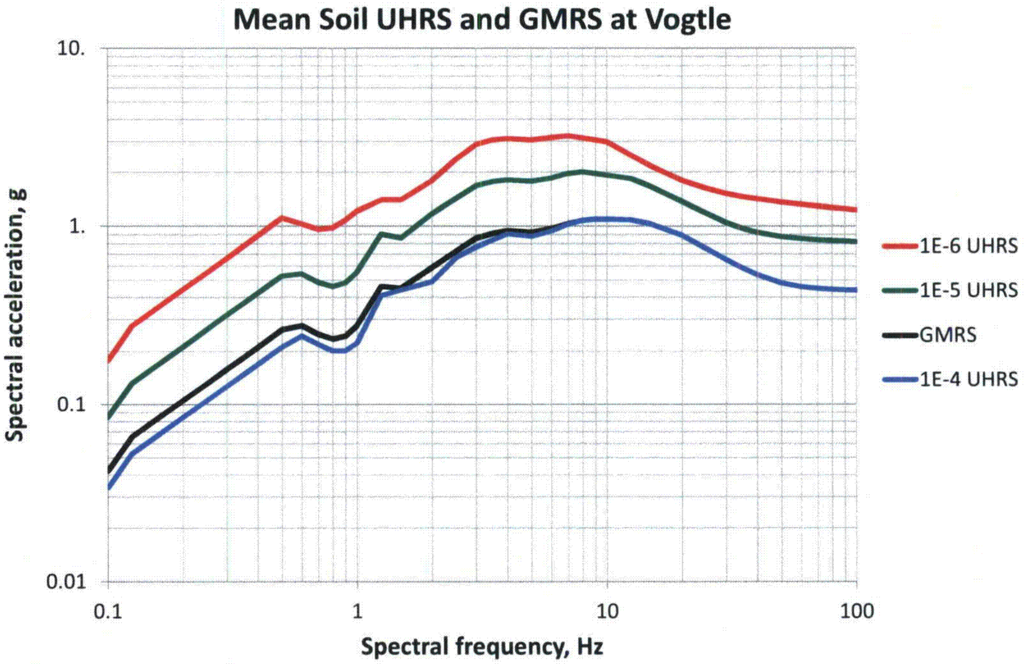

Figure 2.4-1. 10^{-4}, 10^{-5} and 10^{-6} uniform hazard spectra and GMRS at the Vogtle.

3.0 Plant Design Basis Ground Motion

The design basis for Plant Vogtle Units 1 and 2 is identified in the Updated Final Safely Evaluation Report (SNC, 2014c) and other pertinent documents (Bechtel, 1984).

3.1 SSE Description of Spectral Shape

The SSE was developed in accordance with 10 CFR Part 100, Appendix A through an evaluation of the maximum earthquake potential for the region surrounding the site. The original investigation of historical seismic activity in the region is described in the Plant Vogtle Units 1 and 2 FSAR (SNC, 2014c) Section 2.5. In that reference it states that detail studies have revealed no seismological or geological evidence for capable faults within 200 miles of the site. It further states the source of seismicity most affecting the site, both in maximum historical intensity and number of earthquakes, is the Charleston-Summerville, South Carolina, area. The main shocks of August 31, 1886, probably produced an intensity of VI (Modified Mercalli Scale) at the site. The maximum credible site intensity is VI-VII to VIII. For conservatism a safe shutdown earthquake site intensity of VII-VIII was chosen. This intensity is associated with approximately 0.2 g peak horizontal acceleration (PGA). This PGA with the NRC RG 1.60 spectral shape defined the safe shutdown earthquake (SSE) for Plant Vogtle Units 1 and 2.

The 5% damped horizontal SSE is shown in Table 3.1-1 and Figure 3.1-1.
(Figure 3.7.B.1-1; SNC, 2014c)

Table 3.1-1. SSE for Plant Vogtle Units 1 and 2.

Freq (Hz)	SSE (g)
0.25	0.09
1	0.3
2.5	0.626
9	0.522
10.0	0.46
33	0.2
100	0.2

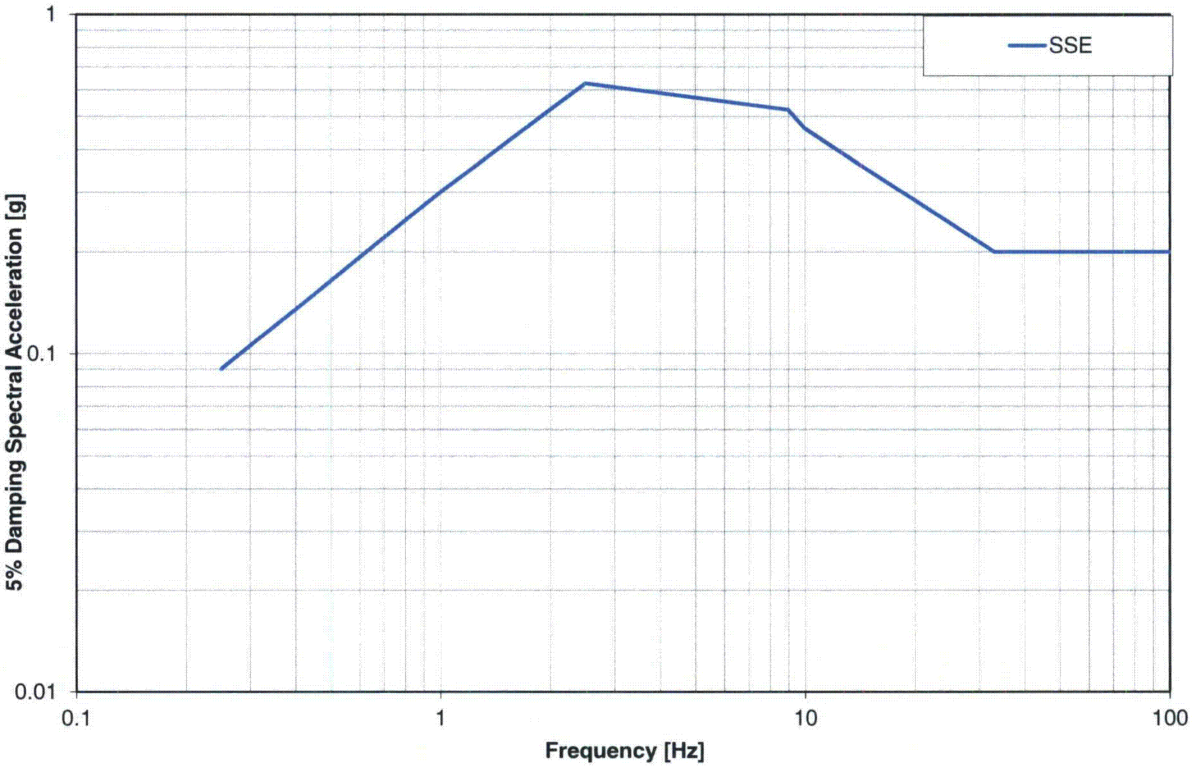

Figure 3.1-1. SSE for Plant Vogtle Units 1 and 2

3.2 Control Point Elevation

The SSE control point elevation is defined at plant grade at an elevation of 220 feet msl. The Plant Vogtle Units 1 and 2 FSAR (SNC, 2014c) and Vogtle Seismic Analysis Report (Bechtel, 1984) define the location of input motion at plant grade for seismic analysis of structures. For example Vogtle Seismic Analysis Report (Bechtel, 1984) states "The finite element method of soil-structure interaction analysis is used for deeply embedded structures with the control motion applied at the finish grade."

4.0 Screening Evaluation

In accordance with SPID (EPRI 1025287, 2013a) Section 3, a screening evaluation was performed as described below.

4.1 Risk Evaluation Screening (1 to 10 Hz)

In the 1 to 10 Hz part of the response spectrum, the GMRS exceeds the SSE. Therefore, Plant Vogtle Units 1 and 2 screen in for a risk evaluation.

4.2 High Frequency Screening (> 10 Hz)

For the range above 10 Hz, the GMRS exceeds the SSE. The high frequency exceedances can be addressed in the risk evaluation discussed in 4.1 above.

4.3 Spent Fuel Pool Evaluation Screening (1 to 10 Hz)

In the 1 to 10 Hz part of the response spectrum, the GMRS exceeds the SSE. Therefore, Plant Vogtle Units 1 and 2 screens in for a spent fuel evaluation.

5.0 Interim Actions

Based on the screening evaluation, the expedited seismic evaluation described in EPRI 3002000704 (EPRI, 2013b) is being performed as proposed in a letter to NRC dated April 9, 2013 (ML131 01A379) and agreed to by NRC in a letter dated May 7, 2013 (ML13106A331).

Consistent with NRC letter dated February 20, 2014, (ML14030A046) the seismic hazard reevaluations presented herein are distinct from the current design and licensing bases of Plant Vogtle Units 1 and 2. Therefore, the results do not call into question the operability or functionality of SSCs and are not reportable pursuant to10 CFR 50.72, "Immediate notification requirements for operating nuclear power reactors," and10 CFR 50.73, "Licensee event report system.

The NRC letter also requests that licensees provide an interim evaluation or actions to demonstrate that the plant can cope with the reevaluated hazard while the expedited approach and risk evaluations are conducted. In response to that request, NEI letter dated March 12, 2014 (NEI, 2014), provides seismic core damage risk estimates using the updated seismic hazards for the operating nuclear plants in the Central and Eastern United States. These risk estimates continue to support the following conclusions of the NRC GI-199 Safety/Risk Assessment:

> Overall seismic core damage risk estimates are consistent with the Commission's Safety Goal Policy Statement because they are within the subsidiary objective of 10^{-4}/year for core damage frequency. The GI-199 Safety/Risk Assessment, based in part on information from the U.S. Nuclear Regulatory Commission's (NRC's) Individual Plant Examination of External Events (IPEEE) program, indicates that no concern exists regarding adequate protection and that the current seismic design of operating reactors provides a safety margin to withstand potential earthquakes exceeding the original design basis.

Plant Vogtle Units 1 and 2 is included in the March 12, 2014 risk estimates (NEI, 2014). Using the methodology described in the NEI letter, all plants were shown to be below 10^{-4}/year; thus, the above conclusions apply.

Additional information is provided on status of ongoing seismic margin assessments and recent walkdowns, and historical seismic margin assessment that demonstrate Vogtle has significant seismic margin beyond its seismic design basis.

2.3 Seismic Walkdowns and IPEEE issues

In the 2012 to 2013 time frame the 2.3 Seismic Walkdowns were performed at Vogtle for a broad range of safety related equipment. The NRC, in letters ML14049A354 and ML14043A476 on February 24, 2014, determined that sufficient information was provided to be responsive to Enclosure 3 of the 50.54(f) letter. That concluded the NRC's efforts associated with 2.3 Seismic for Plant Vogtle Units 1 and 2.

It was reported Plant Vogtle Units 1 and 2 had no significant degraded, non-conforming or unanalyzed conditions that warranted modification to the plant. Plant Vogtle Units 1 and 2 had no-as found conditions that would prevent SSCs from performing their required safety functions.

In addition, the 2.3 Seismic Walkdown Equipment List for Unit 1 included 6 components that had seismic issues previously identified during the IPEEE program. The 2.3 Seismic walkdown teams verified that the recommended resolutions to the IPEEE issues associated with these six items had been implemented. The 2.3 Seismic Walkdown Equipment List for Unit 2 included 5 components that had seismic issues previously identified during the IPEEE program. Implementation of these modifications was verified during the 2.3 Seismic walkdowns.

Expedited Seismic Evaluation Process

The ESEP walkdowns and seismic margin evaluations of the Plant Vogtle Units 1 and 2 ESEL were initiated the later part of last year. The seismic demand used in the ESEP is 2 x Vogtle SSE in-structure response spectra (ISRS). It should be noted the Plant Vogtle Units 1 and 2 ISRS have been conservatively developed; e.g., enveloping multiple locations on a given floor level (SNC, 2014c and Bechtel, 1984). This provides additional seismic margin not explicitly required in these assessments. The ESEP is complete except for a few items that require an outage for the walkdown. These margin assessments have shown no modifications are required which demonstrate that there is seismic margin up to at least 2 x SSE ISRS.

IPEEE-Seismic Margin Assessment

As part of the response to IPEEE-Seismic, Vogtle performed a focus scope seismic margin assessment (SMA) (SNC, 1995) in the mid 1990's. This assessment was to ground motion defined as NUREG-0098 median soil spectra with a PGA of 0.3g. This ground motion is up to 1.5 times the Vogtle SSE. This seismic margin assessment resulted in a limited number of modifications which were mainly seismic interactions due in part to housekeeping and maintenance activities. Changes were made at that time to correct issues identified to assure Vogtle had at least a seismic HCLPF spectrum of 0.3 g. In support of SNC's 10 CFR 50.69 Seismic Probabilistic Risk Assessment, the Plant Vogtle Units 1 and 2 SMA was updated to ensure that the safe shutdown paths are still valid and to ensure that the equipment identified in the shutdown equipment list are updated. The SSELs were updated and seismic capacity walkdowns were performed.

Seismic Probabilistic Risk Assessment

A fully integrated risk evaluation; i.e., a Seismic Probabilistic Risk Assessment (SPRA), for Plant Vogtle Units 1 and 2 is already in progress to support risk-informed initiatives being pursued by Southern Nuclear Operating Co. The seismic hazard being used for this SPRA is conservatively higher than the currently reported seismic hazard. The insights and results from this SPRA can be applicable to the Vogtle 2.1 seismic risk evaluation.

6.0 Conclusions

In accordance with the 50.54(f) request for information, a seismic hazard and screening evaluation was performed for Plant Vogtle Units 1 and 2. A GMRS was developed solely for purpose of screening for additional evaluations in accordance with the SPID (EPRI 1025287, 2013a).

Based on the results of the screening evaluation, Plant Vogtle Units 1 and 2 screens in for a risk evaluation, a Spent Fuel Pool evaluation, and a High Frequency evaluation as part of the risk evaluation.

7.0 References

Bechtel Power Corporation (1984). Seismic Analysis Report Vogtle Electric Generating Plant for Georgia Power Company, Los Angeles CA, October 1984.

Bechtel Power Corporation (2006a). "Site Response Analyses of Randomized Soil Profiles", Calc. No. 25144-K-011, Rev 000, prepared for the Southern ALWR ESP Project, San Francisco, CA, August 2006.

Bechtel Power Corporation (2006b). "Basement Rock Shear-Wave Velocities", Calc. No. 25144-K-010, prepared for the Southern ALWR ESP Project, San Francisco, CA, Rev 000, August 2006.

Bechtel Power Corporation (2007a). "Dynamic Properties of Soils for SHAKE Analyses", Calc. No. 25144-K-005, Rev 000, prepared for the Southern ALWR ESP Project, Frederick, MD, October 2007.

Bechtel Power Corporation (2007b). "Dynamic Properties of Soils for SHAKE Analyses", Calc. No. 23162-K-014, Rev. 001, prepared for the Southern ALWR COL Project, Frederick, MD, November 2007.

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Appendix A

Table A-1a. Mean and fractile hazard curves for PGA at Vogtle

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.94E-02	3.52E-02	4.31E-02	4.98E-02	5.58E-02	5.91E-02
0.001	4.37E-02	2.80E-02	3.68E-02	4.43E-02	5.12E-02	5.50E-02
0.005	2.32E-02	1.29E-02	1.79E-02	2.29E-02	2.84E-02	3.42E-02
0.01	1.53E-02	8.23E-03	1.10E-02	1.49E-02	1.90E-02	2.53E-02
0.015	1.14E-02	6.00E-03	7.89E-03	1.08E-02	1.42E-02	2.04E-02
0.03	6.46E-03	3.01E-03	4.01E-03	5.91E-03	8.35E-03	1.32E-02
0.05	4.04E-03	1.51E-03	2.16E-03	3.57E-03	5.66E-03	8.98E-03
0.075	2.68E-03	7.66E-04	1.18E-03	2.22E-03	4.07E-03	6.54E-03
0.1	1.93E-03	4.43E-04	7.23E-04	1.49E-03	3.09E-03	5.12E-03
0.15	1.11E-03	1.87E-04	3.19E-04	7.45E-04	1.87E-03	3.42E-03
0.3	2.87E-04	3.14E-05	6.09E-05	1.49E-04	4.50E-04	1.10E-03
0.5	6.78E-05	5.50E-06	1.36E-05	3.52E-05	9.51E-05	2.60E-04
0.75	1.49E-05	1.02E-06	2.76E-06	8.35E-06	2.13E-05	5.50E-05
1.	3.72E-06	2.22E-07	6.36E-07	2.16E-06	5.58E-06	1.32E-05
1.5	2.50E-07	1.27E-08	3.84E-08	1.42E-07	3.84E-07	9.24E-07
3.	2.23E-10	1.23E-10	1.53E-10	2.19E-10	4.43E-10	9.93E-10
5.	9.81E-13	9.11E-11	9.11E-11	1.42E-10	1.53E-10	1.53E-10
7.5	2.74E-14	9.11E-11	9.11E-11	1.42E-10	1.53E-10	1.53E-10
10.	2.21E-15	9.11E-11	9.11E-11	1.42E-10	1.53E-10	1.53E-10

Table A-1b. Mean and fractile hazard curves for 25 Hz at Vogtle

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	5.10E-02	3.90E-02	4.50E-02	5.12E-02	5.66E-02	6.00E-02
0.001	4.66E-02	3.28E-02	4.07E-02	4.70E-02	5.27E-02	5.66E-02
0.005	2.83E-02	1.72E-02	2.25E-02	2.80E-02	3.37E-02	4.01E-02
0.01	2.03E-02	1.20E-02	1.55E-02	1.98E-02	2.46E-02	3.14E-02
0.015	1.63E-02	9.37E-03	1.21E-02	1.57E-02	1.98E-02	2.64E-02
0.03	1.05E-02	5.75E-03	7.45E-03	9.93E-03	1.31E-02	1.82E-02
0.05	7.20E-03	3.63E-03	4.83E-03	6.73E-03	9.24E-03	1.32E-02
0.075	5.13E-03	2.35E-03	3.19E-03	4.77E-03	6.83E-03	9.79E-03
0.1	3.94E-03	1.62E-03	2.25E-03	3.57E-03	5.50E-03	7.77E-03
0.15	2.60E-03	8.60E-04	1.27E-03	2.25E-03	3.90E-03	5.66E-03
0.3	1.02E-03	2.19E-04	3.57E-04	7.55E-04	1.64E-03	2.76E-03
0.5	3.47E-04	5.91E-05	1.05E-04	2.32E-04	5.42E-04	1.07E-03
0.75	9.92E-05	1.53E-05	2.96E-05	6.64E-05	1.49E-04	3.05E-04
1.	2.80E-05	4.13E-06	8.35E-06	1.95E-05	4.25E-05	8.35E-05
1.5	1.93E-06	3.19E-07	6.09E-07	1.38E-06	2.92E-06	5.66E-06
3.	3.89E-09	1.18E-09	1.79E-09	3.28E-09	5.75E-09	1.02E-08
5.	3.70E-11	9.79E-11	1.10E-10	1.46E-10	1.72E-10	2.07E-10
7.5	2.51E-13	9.11E-11	9.11E-11	1.42E-10	1.53E-10	1.53E-10
10.	1.92E-15	9.11E-11	9.11E-11	1.42E-10	1.53E-10	1.53E-10

Table A-1c: Mean and fractile hazard curves for 10 Hz at Vogtle

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	5.34E-02	4.43E-02	4.83E-02	5.35E-02	5.91E-02	6.17E-02
0.001	5.15E-02	4.13E-02	4.56E-02	5.20E-02	5.75E-02	6.09E-02
0.005	3.67E-02	2.57E-02	3.05E-02	3.68E-02	4.31E-02	4.70E-02
0.01	2.74E-02	1.79E-02	2.19E-02	2.72E-02	3.28E-02	3.73E-02
0.015	2.22E-02	1.38E-02	1.72E-02	2.19E-02	2.68E-02	3.14E-02
0.03	1.43E-02	8.35E-03	1.05E-02	1.40E-02	1.77E-02	2.19E-02
0.05	9.74E-03	5.42E-03	6.93E-03	9.37E-03	1.23E-02	1.55E-02
0.075	6.91E-03	3.63E-03	4.70E-03	6.54E-03	8.85E-03	1.15E-02
0.1	5.30E-03	2.60E-03	3.47E-03	4.98E-03	7.03E-03	9.11E-03
0.15	3.53E-03	1.51E-03	2.07E-03	3.28E-03	4.90E-03	6.54E-03
0.3	1.52E-03	4.43E-04	6.83E-04	1.31E-03	2.35E-03	3.42E-03
0.5	6.58E-04	1.40E-04	2.35E-04	5.05E-04	1.05E-03	1.74E-03
0.75	2.77E-04	4.83E-05	8.60E-05	1.95E-04	4.43E-04	8.00E-04
1.	1.31E-04	2.04E-05	3.84E-05	8.85E-05	2.07E-04	3.90E-04
1.5	3.51E-05	4.70E-06	9.65E-06	2.39E-05	5.58E-05	1.07E-04
3.	9.43E-07	1.20E-07	2.64E-07	6.45E-07	1.49E-06	2.88E-06
5.	1.95E-08	3.05E-09	6.26E-09	1.38E-08	3.01E-08	5.75E-08
7.5	5.76E-10	2.13E-10	3.09E-10	5.35E-10	1.01E-09	1.69E-09
10.	3.73E-11	9.93E-11	1.11E-10	1.49E-10	1.77E-10	2.07E-10

Table A-1d: Mean and fractile hazard curves for 5 Hz at Vogtle

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	5.36E-02	4.43E-02	4.83E-02	5.35E-02	5.91E-02	6.17E-02
0.001	5.19E-02	4.25E-02	4.63E-02	5.20E-02	5.75E-02	6.09E-02
0.005	3.74E-02	2.53E-02	3.01E-02	3.73E-02	4.50E-02	4.90E-02
0.01	2.75E-02	1.72E-02	2.13E-02	2.72E-02	3.37E-02	3.73E-02
0.015	2.17E-02	1.29E-02	1.64E-02	2.16E-02	2.72E-02	3.05E-02
0.03	1.30E-02	7.23E-03	9.37E-03	1.27E-02	1.64E-02	1.92E-02
0.05	8.16E-03	4.43E-03	5.75E-03	7.89E-03	1.05E-02	1.29E-02
0.075	5.46E-03	2.76E-03	3.63E-03	5.27E-03	7.23E-03	8.85E-03
0.1	4.05E-03	1.87E-03	2.57E-03	3.84E-03	5.50E-03	6.83E-03
0.15	2.58E-03	9.93E-04	1.44E-03	2.39E-03	3.68E-03	4.77E-03
0.3	1.00E-03	2.49E-04	4.13E-04	8.47E-04	1.60E-03	2.32E-03
0.5	3.90E-04	7.13E-05	1.25E-04	2.84E-04	6.36E-04	1.10E-03
0.75	1.52E-04	2.22E-05	4.13E-05	9.93E-05	2.46E-04	4.70E-04
1.	7.00E-05	8.85E-06	1.74E-05	4.31E-05	1.10E-04	2.25E-04
1.5	1.97E-05	2.07E-06	4.37E-06	1.18E-05	3.05E-05	6.36E-05
3.	1.10E-06	8.60E-08	2.13E-07	6.64E-07	1.74E-06	3.42E-06
5.	4.84E-08	3.95E-09	1.04E-08	3.05E-08	7.66E-08	1.46E-07
7.5	2.29E-09	3.19E-10	6.64E-10	1.64E-09	3.68E-09	6.54E-09
10.	2.06E-10	1.42E-10	1.67E-10	2.60E-10	4.50E-10	6.73E-10

Table A-1e: Mean and fractile hazard curves for 2.5 Hz at Vogtle

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	5.33E-02	4.43E-02	4.83E-02	5.35E-02	5.83E-02	6.17E-02
0.001	5.09E-02	4.13E-02	4.50E-02	5.12E-02	5.66E-02	6.00E-02
0.005	3.38E-02	2.22E-02	2.64E-02	3.33E-02	4.13E-02	4.56E-02
0.01	2.34E-02	1.42E-02	1.77E-02	2.29E-02	2.92E-02	3.33E-02
0.015	1.77E-02	1.04E-02	1.31E-02	1.74E-02	2.25E-02	2.60E-02
0.03	9.86E-03	5.35E-03	6.93E-03	9.51E-03	1.29E-02	1.53E-02
0.05	5.88E-03	2.92E-03	3.90E-03	5.58E-03	7.89E-03	9.79E-03
0.075	3.76E-03	1.64E-03	2.29E-03	3.57E-03	5.20E-03	6.54E-03
0.1	2.70E-03	1.04E-03	1.53E-03	2.53E-03	3.84E-03	4.98E-03
0.15	1.63E-03	4.90E-04	7.89E-04	1.46E-03	2.46E-03	3.33E-03
0.3	5.70E-04	1.07E-04	1.92E-04	4.37E-04	9.37E-04	1.51E-03
0.5	2.05E-04	2.68E-05	5.05E-05	1.27E-04	3.37E-04	6.45E-04
0.75	7.53E-05	7.45E-06	1.46E-05	3.90E-05	1.18E-04	2.72E-04
1.	3.28E-05	2.64E-06	5.50E-06	1.51E-05	4.98E-05	1.21E-04
1.5	8.20E-06	5.20E-07	1.15E-06	3.42E-06	1.20E-05	3.01E-05
3.	3.35E-07	1.64E-08	4.07E-08	1.34E-07	4.83E-07	1.21E-06
5.	1.35E-08	8.00E-10	1.87E-09	5.91E-09	1.95E-08	4.90E-08
7.5	6.52E-10	1.55E-10	2.10E-10	4.25E-10	1.07E-09	2.39E-09
10.	6.05E-11	9.79E-11	1.13E-10	1.53E-10	2.04E-10	3.14E-10

Table A-1f: Mean and fractile hazard curves for 1 Hz at Vogtle

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.41E-02	3.05E-02	3.57E-02	4.43E-02	5.20E-02	5.58E-02
0.001	3.52E-02	2.13E-02	2.68E-02	3.57E-02	4.31E-02	4.77E-02
0.005	1.36E-02	7.03E-03	9.37E-03	1.34E-02	1.77E-02	2.10E-02
0.01	8.00E-03	3.68E-03	5.12E-03	7.66E-03	1.08E-02	1.34E-02
0.015	5.70E-03	2.32E-03	3.37E-03	5.35E-03	8.00E-03	1.02E-02
0.03	2.88E-03	8.60E-04	1.42E-03	2.60E-03	4.31E-03	5.83E-03
0.05	1.52E-03	3.28E-04	6.17E-04	1.31E-03	2.39E-03	3.42E-03
0.075	8.34E-04	1.31E-04	2.76E-04	6.64E-04	1.38E-03	2.10E-03
0.1	5.14E-04	6.26E-05	1.40E-04	3.73E-04	8.85E-04	1.42E-03
0.15	2.39E-04	2.07E-05	4.77E-05	1.49E-04	4.25E-04	7.66E-04
0.3	5.05E-05	2.46E-06	6.00E-06	2.19E-05	8.47E-05	1.98E-04
0.5	1.33E-05	4.37E-07	1.15E-06	4.50E-06	2.10E-05	5.50E-05
0.75	4.21E-06	9.65E-08	2.88E-07	1.23E-06	6.26E-06	1.77E-05
1.	1.78E-06	3.14E-08	1.04E-07	4.90E-07	2.57E-06	7.55E-06
1.5	4.99E-07	5.66E-09	2.19E-08	1.25E-07	7.03E-07	2.16E-06
3.	4.31E-08	3.23E-10	1.31E-09	9.51E-09	6.00E-08	1.92E-07
5.	5.03E-09	1.42E-10	2.19E-10	1.11E-09	6.73E-09	2.19E-08
7.5	7.21E-10	1.02E-10	1.42E-10	2.42E-10	1.01E-09	3.01E-09
10.	1.61E-10	9.11E-11	1.08E-10	1.53E-10	3.01E-10	7.03E-10

Table A-1g: Mean and fractile hazard curves for 0.5 Hz at Vogtle

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.63E-02	2.46E-02	3.01E-02	3.63E-02	4.25E-02	4.70E-02
0.001	2.63E-02	1.64E-02	2.10E-02	2.60E-02	3.19E-02	3.63E-02
0.005	9.81E-03	4.98E-03	6.64E-03	9.37E-03	1.31E-02	1.60E-02
0.01	6.22E-03	2.53E-03	3.68E-03	5.91E-03	8.72E-03	1.10E-02
0.015	4.67E-03	1.57E-03	2.46E-03	4.31E-03	6.83E-03	8.85E-03
0.03	2.55E-03	5.66E-04	1.04E-03	2.19E-03	4.07E-03	5.66E-03
0.05	1.39E-03	2.07E-04	4.31E-04	1.08E-03	2.35E-03	3.57E-03
0.075	7.65E-04	7.89E-05	1.82E-04	5.35E-04	1.32E-03	2.25E-03
0.1	4.68E-04	3.63E-05	8.98E-05	2.92E-04	8.35E-04	1.53E-03
0.15	2.14E-04	1.10E-05	2.92E-05	1.07E-04	3.79E-04	7.89E-04
0.3	4.46E-05	1.16E-06	3.23E-06	1.34E-05	7.03E-05	1.95E-04
0.5	1.16E-05	1.84E-07	5.35E-07	2.42E-06	1.55E-05	5.27E-05
0.75	3.50E-06	3.63E-08	1.15E-07	5.75E-07	4.25E-06	1.64E-05
1.	1.40E-06	1.04E-08	3.63E-08	1.98E-07	1.57E-06	6.54E-06
1.5	3.46E-07	1.55E-09	6.45E-09	4.07E-08	3.57E-07	1.72E-06
3.	2.51E-08	1.57E-10	3.42E-10	2.04E-09	2.04E-08	1.29E-07
5.	3.15E-09	1.01E-10	1.42E-10	2.60E-10	1.84E-09	1.44E-08
7.5	5.79E-10	9.11E-11	1.01E-10	1.44E-10	3.05E-10	2.10E-09
10.	1.73E-10	9.11E-11	1.01E-10	1.42E-10	1.57E-10	5.58E-10

Table A-2. Median and logarithmic standard deviation of amplification factors for Plant Vogtle Units 1 and 2

PGA	Median AF	Sigma ln(AF)	25 Hz	Median AF	Sigma ln(AF)	10 Hz	Median AF	Sigma ln(AF)	5 Hz	Median AF	Sigma ln(AF)
1.00E-03	2.22E+00	9.66E-02	1.00E-03	2.07E+00	1.04E-01	1.00E-03	2.88E+00	1.41E-01	1.00E-03	3.04E+00	9.90E-02
7.35E-02	2.22E+00	9.66E-02	1.51E-01	2.07E+00	1.04E-01	1.38E-01	2.88E+00	1.41E-01	9.96E-02	3.04E+00	9.90E-02
2.71E-01	1.61E+00	1.06E-01	5.56E-01	1.33E+00	1.29E-01	4.64E-01	2.33E+00	1.44E-01	3.24E-01	2.67E+00	1.33E-01
7.46E-01	1.07E+00	1.20E-01	1.55E+00	6.91E-01	1.56E-01	1.20E+00	1.57E+00	1.55E-01	7.92E-01	2.23E+00	1.92E-01
1.77E+00	6.40E-01	1.53E-01	3.78E+00	3.31E-01	1.69E-01	2.81E+00	7.97E-01	2.17E-01	1.76E+00	1.48E+00	2.22E-01
3.67E+00	3.60E-01	2.37E-01	8.01E+00	1.70E-01	2.39E-01	5.84E+00	3.18E-01	2.78E-01	3.64E+00	7.46E-01	3.19E-01
6.74E+00	2.18E-01	2.59E-01	1.55E+01	9.53E-02	2.59E-01	1.10E+01	1.51E-01	2.64E-01	6.90E+00	3.41E-01	3.08E-01
2.00E+01	2.18E-01	2.59E-01	2.00E+01	9.53E-02	2.59E-01	2.00E+01	1.51E-01	2.64E-01	2.00E+01	3.41E-01	3.08E-01
2.5 Hz	**Median AF**	**Sigma ln(AF)**	**1 Hz**	**Median AF**	**Sigma ln(AF)**	**0.5 Hz**	**Median AF**	**Sigma ln(AF)**			
1.00E-03	3.29E+00	2.43E-01	1.00E-03	2.25E+00	1.16E-01	1.00E-03	3.69E+00	1.76E-01			
6.26E-02	3.29E+00	2.43E-01	2.94E-02	2.25E+00	1.16E-01	1.66E-02	3.69E+00	1.76E-01			
2.09E-01	3.00E+00	2.75E-01	9.61E-02	2.30E+00	1.28E-01	5.59E-02	3.73E+00	1.54E-01			
5.13E-01	2.45E+00	2.56E-01	2.26E-01	2.44E+00	1.61E-01	1.39E-01	3.69E+00	1.34E-01			
1.10E+00	1.70E+00	2.97E-01	4.86E-01	2.46E+00	2.29E-01	3.06E-01	3.32E+00	1.92E-01			
2.21E+00	8.98E-01	3.67E-01	1.03E+00	1.82E+00	3.90E-01	6.51E-01	2.60E+00	3.24E-01			
4.23E+00	4.53E-01	3.17E-01	2.11E+00	1.25E+00	4.23E-01	1.40E+00	2.05E+00	4.35E-01			
2.00E+01	4.53E-01	3.17E-01	2.00E+01	1.25E+00	4.23E-01	2.00E+01	2.05E+00	4.35E-01			