DUKE ENERGY.

George T. Hamrick
Vice President
Brunswick Nuclear Plant
P.O. Box 10429
Southport, NC 28461

o: 910.457.3698

10 CFR 50.54(f)

Serial: BSEP 14-0028
March 31, 2014

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Duke Energy Progress, Inc. (Duke Energy)
Brunswick Steam Electric Plant, Unit Nos. 1 and 2
Docket Nos. 50-325 and 50-324
Renewed License Nos. DPR-71 and DPR-62

Subject: Seismic Hazard and Screening Report (CEUS Sites), Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Seismic Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident

References:

1. NRC Letter, *Request for Information Pursuant to Title 10 of the Code of Federal Regulations 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, ADAMS Accession No. ML12053A340
2. Electric Power Research Institute (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,* dated November 2012, ADAMS Accession No. ML12333A170
3. NRC Letter, *Endorsement of EPRI Final Draft Report 1025287: "Seismic Evaluation Guidance,"* dated February 15, 2013, ADAMS Accession No. ML12319A074
4. NEI Letter, *Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations*, dated April 9, 2013, ADAMS Accession No. ML13101A379
5. NRC Letter, *Electric Power Research Institute Final Draft Report XXXXXX, "Seismic Evaluation Guidance: Augmented Approach for the Resolution of 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, ADAMS Accession No. ML 13106A331

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 located in the Central and Eastern United States

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(CEUS) to submit a Seismic Hazard Evaluation and Screening Report within 1.5 years from the date of Reference 1.
Reference 2 contains industry guidance and detailed information to be included in the Seismic Hazard Evaluation and Screening Report submittals. The industry guidance was endorsed by the NRC in Reference 3.

The Nuclear Energy Institute (NEI) submitted Reference 4 requesting NRC agreement to delay submittal of the CEUS Seismic Hazard Evaluation and Screening Report 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 September 12, 2013, with the remaining seismic hazard and screening information submitted by March 31, 2014. The NRC agreed with the proposed path forward in Reference 5.

The enclosure to this letter provides the Seismic Hazard Evaluation and Screening Report for the Brunswick Steam Electric Plant (BSEP), Unit Nos. 1 and 2, as directed by Section 4 of Reference 2 and in accordance with the schedule provided in Reference 4.

This letter contains no new regulatory commitments and no revision to existing regulatory commitments.

Should you have any questions regarding this submittal, please contact Lee Grzeck, Manager-Regulatory Affairs, at (910) 457-2487.

I declare under penalty of perjury that the foregoing is true and correct. Executed on March 31, 2014.

Sincerely,

George T. Hamrick

George T. Hamrick

Enclosure:

Seismic Hazard and Screening Report for Brunswick Steam Electric Plant (BSEP), Unit Nos. 1 and 2

xc:

U. S. Nuclear Regulatory Commission, Region II
ATTN: Mr. Victor M. McCree, Regional Administrator
245 Peachtree Center Ave, NE, Suite 1200
Atlanta, GA 30303-1257

U. S. Nuclear Regulatory Commission
ATTN: Mr. Siva P. Lingam (Mail Stop OWFN 8G9A)
11555 Rockville Pike
Rockville, MD 20852-2738

U. S. Nuclear Regulatory Commission
ATTN: Ms. Michelle P. Catts, NRC Senior Resident Inspector
8470 River Road
Southport, NC 28461-8869

Chair - North Carolina Utilities Commission
P.O. Box 29510
Raleigh, NC 27626-0510

Seismic Hazard and Screening Report for Brunswick Steam Electric Plant (BSEP), Unit Nos. 1 and 2

1.0 Introduction

Following the accident at the Fukushima Dai-ichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the Nuclear Regulatory Commission (NRC) 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 on March 12, 2012, (i.e., Reference 7.1) requesting 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. If the reevaluated seismic hazard is bounded by the current design basis, no further risk evaluation will be necessary. If this is not the case, the performance of a seismic risk assessment will be required. 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 Brunswick Steam Electric Plant (BSEP) Unit Nos. 1 and 2. The plant is located on approximately 1,200 acres in Brunswick County in southeastern North Carolina (NC). In providing this information, BSEP followed the guidance provided in the Electric Power Research Institute (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* (i.e., Reference 7.2). EPRI Report 3002000704, *Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic* (i.e., Reference 7.3), has been developed as the process for evaluating, if necessary, critical plant equipment prior to performing the complete plant seismic risk evaluations.

The original geologic and seismic siting investigations for BSEP 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 Class I systems, structures and components.

In response to the 50.54(f) letter and following the guidance provided in the SPID, a seismic hazard reevaluation was performed for BSEP. For screening purposes, a Ground Motion Response Spectrum (GMRS) was developed. Based on the results of the screening evaluation and the Individual Plant Examination for External Events (IPEEE) Adequacy Review and

upgrade from a focused scope to a full scope plant, BSEP screens in for a Spent Fuel Pool evaluation and a High Frequency Confirmation.

2.0 Seismic Hazard Reevaluation

The BSEP site is located approximately 2.5 miles north of Southport, NC, and 1.5 miles west of the Cape Fear River in southeastern NC. Physiographically, the site is located on the Atlantic Coastal Plain about 90 miles southeast of the boundary between the flat lying deposits of the Coastal Plain and the folded formations of the Piedmont and Appalachian regions. This boundary is known as the Fall Line. In the vicinity of the site, the Coastal Plain consists of approximately 1,500 ft of Cretaceous and younger deposits. In general, hard limestone exists from a depth of approximately 70 ft below existing ground surface and extends to a depth of 230 feet or more. The crystalline or metamorphic basement rock has been broadly warped into a tectonic feature known as the Cape Fear Arch.

Earthquakes in the vicinity of the BSEP are relatively infrequent. This is attributable to presence of broad coastal plains and mountains of ancient geologic origin occurring 100 miles inland, physiographic conditions generally indicative of relative seismic stability. Based on the seismic history of the site, the Operating Basis Earthquake (OBE) for the site was chosen as a high intensity VI on the Modified Mercalli Scale with a ground acceleration of 0.08 g. The SSE was considered to be a high intensity VII on the Modified Mercalli Scale. For BSEP, the site response spectra are based on peak horizontal ground accelerations of 0.08 g and 0.16 g, for an OBE and an SSE respectively.

2.1 Regional and Local Geology

Regional Geology

North Carolina and adjacent states along the Atlantic Seaboard contain a crystalline basement that extends from the Blue Ridge Mountains on the west to the edge of the continental shelf on the east. During the Precambrian and Paleozoic Eras, the rocks that constitute this crystalline basement were formed, folded, faulted, and metamorphosed. At the end of the Paleozoic Era, the Appalachian Revolution built the Appalachian Mountains and elevated the region to the east. During this disturbance, faulting took place on a major scale in the Southern Appalachians and to a lesser degree in the present Piedmont Plateau.

Two areas of faulted Triassic sediments occur in the NC Piedmont. One, known as the Deep River Basin, begins at the NC-SC line near Wadesboro, Anson County, NC, and extends northeastward across the Deep River to near Oxford, Granville County, NC. The other, known as the Dan River Basin, begins near Germanton, Stokes County, NC, and continues northeastward along the Dan River into Virginia. The northeast trend of these down-faulted Triassic basins is approximately parallel to the Blue Ridge Mountains, the Fall Zone, and the Atlantic coastline. There are three interesting physical features in the crystalline floor of the present Coastal Plain that appear to have controlled the thickness and distribution of post-Triassic sediments in NC. These are the Great Carolina Ridge, the Hatteras basin or trough, and the hinge line along the 2,500-foot subsea contour.

Local Geology

The BSEP site consists of about 22 ft of dense sands overlying about 43 ft of stiff clays and sands. The shallow soils overlie about 1,400 ft of clayey limestone below which lies Precambrian basement. Detailed information is presented in Section 2.3.1, *Description of Subsurface Material.*

2.2 Probabilistic Seismic Hazard Analysis

2.2.1 Probabilistic Seismic Hazard Analysis Results

In accordance with the 50.54(f) letter and following the guidance in the SPID, a probabilistic seismic hazard analysis (PSHA) was completed using the recently developed Central and Eastern United States Seismic Source Characterization (CEUS-SSC) for Nuclear Facilities (i.e., Reference 7.4) together with the updated EPRI Ground-Motion Model (GMM) for the CEUS (i.e., Reference 7.5). For the PSHA, a minimum moment magnitude cutoff of 5.0 was used, as specified in the 50.54(f) letter.

For the PSHA, the CEUS-SSC background seismic source zones out to a distance of 400 miles (640 km) around the BSEP site were included. Background sources included in the site analysis are the following:

1. Atlantic Highly Extended Crust
2. Extended Continental Crust—Atlantic Margin
3. Extended Continental Crust—Gulf Coast
4. Mesozoic and younger extended prior – narrow
5. Mesozoic and younger extended prior – wide
6. Midcontinent-Craton alternative A
7. Midcontinent-Craton alternative B
8. Midcontinent-Craton alternative C
9. Midcontinent-Craton alternative D
10. Non-Mesozoic and younger extended prior – narrow
11. Non-Mesozoic and younger extended prior – wide
12. Paleozoic Extended Crust narrow
13. Paleozoic Extended Crust wide
14. Study region

For sources of large magnitude earthquakes, designated Repeated Large Magnitude Earthquake (RLME) sources in the CEUS-SSC, the following sources lie within 625 miles (1,000 km) of the site and were included in the analysis:

1. Charleston
2. Wabash Valley

For each of the above background and RLME sources, the mid-continent version of the updated CEUS EPRI GMM was used.

2.2.2 Base Rock Seismic Hazard Curves

Consistent with the SPID, base rock seismic hazard curves are not provided as the site amplification approach, referred to as Method 3, has been used. Seismic hazard curves are shown in Section 3 at the SSE control point elevation.

2.3 Site Response Evaluation

Following the guidance for nuclear power plant sites that are not sited on hard rock (defined as 2.83 km/sec), contained in Seismic Enclosure 1 of the 50.54(f) Request for Information and in the SPID, a site response analysis was performed for BSEP.

2.3.1 Description of Subsurface Material

Detailed information on the geology of the BSEP site was obtained from cores and cuttings recovered from 11 holes drilled on the site to depths ranging from 82 ft to 325 ft.

The major geologic features, beginning with the overlying formation, are as follows:

1. Recent deposits and undifferentiated Pleistocene/Pliocene deposits - At the plant site, the recent deposits consist chiefly of fine-grained argillaceous sands, sandy clays, and clay in which sand predominates. The color of the material varies from light yellow through tan to brown. The thickness of the recent deposits varies from 5 ft to 20 ft. The undifferentiated Pleistocene/Pliocene deposits are approximately 65 ft thick. The unit begins at a depth of 5 ft to 20 ft below the surface of the ground, has a thickness of approximately 35 ft, and extends to a depth of 48 ft to 50 ft. It is composed of dark blue-gray, very plastic clay and fine-grained sand, with clay predominating. It varies from 100 percent clay to mixtures of sand and clay in which the sand may amount to as much as 15 to 25 percent. Small amounts of shell marl occur at different horizons in different drill holes.

2. Castle Hayne Formation - The Castle Hayne formation begins at depths of 48 ft to 50 ft below the surface, has a thickness of approximately 30 ft, and extends to a depth of approximately 80 ft. Near the top there are minor lenses of clay in the sand, but the major part of this lower unit is composed of medium to coarse grained, well compacted sand.

3. Peedee Confining Unit - At the plant site, the Peedee Confining Unit, which is approximately 35 ft thick, begins at a depth of approximately 80 ft below the surface of the ground and continues to a depth of approximately 115 ft. This unit consists of lenses of dark blue-gray clay and fine-grained sand, more or less compacted, and of lenses of well-consolidated limestone composed in part of shells and in general, light gray in color. In some areas, lenses of limestone are present, while in adjacent areas lenses of clay and sand may be present.

An eight-inch core of well consolidated limestone was recovered in hole 1 at a depth of 85 ft to 85.8 ft. Beneath this depth, the remainder of the unit to a depth of 114 ft is composed of well-compacted dark gray clay and sand. In hole 2 at a depth of 77 ft to 83.6 ft, a core of light gray limestone 3.5 ft long was recovered. Beneath this limestone, dark gray clay and sand extended to a depth of 115 ft. In hole 3 at a depth of 82.9 ft to 83.7 ft, a core nine inches long which consisted of well consolidated sandstone and limestone was recovered. Below this limestone, dark gray clay and sand, which was more or less compacted, continued to 100 ft, the depth of the hole.

In hole 6, at a depth of 70.7 ft to 74.4 ft, a core of limestone 3.6 ft long was recovered. Below this limestone to a depth of 110 ft, dark gray clay and sand which was more or less compacted was present. Similar results were obtained from holes 5 and 7.

In hole 8, (located along the road to the northeast about 1,200 ft from hole 1), at a depth of 78.2 ft to 82.2 ft, a core of well consolidated limestone 2 ft long was recovered. This limestone continued unbroken to a depth of 114 ft where it lies on the Castle Hayne limestone. In hole 9, (located along the road to the southwest about 2,100 ft from hole 1), at a depth of 76 ft to 77 ft, a core one foot long of well consolidated light gray limestone composed in part of shells was recovered. This limestone continues uninterrupted to a depth of 107 ft, where it lies on the Castle Hayne limestone. Similar results were obtained for the top of Oligocene limestone in holes 10, 11, and 12 which are located in the vicinity of hole 9. The bottom was not determined since the three holes, 10, 11, and 12, were not drilled through it.

4. Peedee limestone - The Peedee limestone is approximately 115 ft thick, begins at a depth of approximately 114 ft below the surface, and continues to a depth of approximately 230 ft. The upper portion of the Peedee is composed of well consolidated shell limestone that varies from blue gray to tan or brown in color and of light to dark gray sandstone that contains varying amounts of clay. It is well compacted to semi-consolidated. The Peedee formation continues to a depth of approximately 530 ft where it is underlain by the Black Creek formation. At approximately 230 ft below the surface, the Peedee formation stratigraphy changes to dark gray calcareous clay and sand which is uniformly semi-consolidated.

The crystalline basement is estimated at a depth of approximately 1,500 ft.

Table 2.3.1-1 provides a brief description of the subsurface material in terms of the geologic units and layer thicknesses.

Table 2.3.1-1. Geologic profile and estimated layer thicknesses for BSEP

Elevation Range (feet)	Soil/Rock Description	Density (pcf)	Shear Wave Velocity (fps)	N Blow Count
19.5	Surface	---	---	---
+19.5 – -7	Fill - Confined Compacted Sand	115	750	6 to > 100 blows per foot
-7 – -25	Upper Yorktown - Unconfined Compacted Sand	115	750	Weight of Hammer to 4 blows per foot
-25 – -50	SSE control point - Lower Yorktown - Natural Dense Sand	130	900 - 1400	23 > 100 blows per foot
-50 – -93	Oligocene Sediments - Stiff Clay	145	5500	20 > 100 blows per foot
-93 – -220	Castle Hayne - Limestone	138	4500	---
-220 – -1510	Cretaceous: Peedee Limestone – Well consolidated shell limestone that contains varying amounts of clay	130	3000	---
-1510*	Crystalline basement	165	10000*	---

* Estimated values.

2.3.2 Development of Base Case Profiles and Nonlinear Material Properties

Table 2.3.1-1 shows the recommended shear-wave velocities and unit weights along with elevations and corresponding stratigraphy. The SSE control point is at Elevation - 28.33 ft (below Mean Sea Level) within the dense sands of the Yorktown Formation at an average shear-wave velocity of 1,122 ft/s and a range of 900 ft/s to 1,400 ft/s. Shear-wave velocities were based on refraction measurements as well as early borehole measurements, likely sampling only the shallow portion of the Peedee Limestone. A depth to Crystalline basement of approximately 1,500 ft was estimated.

Uncertainty in shear-wave velocities was taken as 1.25 for the Yorktown Formation and Oligocene Sediments below the SSE control point, based on the range (about 1.25) recommended in Table 2.3.1-1 for the Yorktown shear-wave velocity. The range of 1.25 was also assumed to be appropriate for the layer below of Oligocene Sediments. However, for the deeper Limestone and early time frame for the measurements, an uncertainty of 1.57 was assumed to be more appropriate. The scale factors of 1.25 and 1.57 reflect a profile epistemic uncertainty factor, σ_{ln}, of about 0.2 and 0.35 respectively, based on the SPID 10th and 90th

fractiles which implies a 1.28 scale factor on σ_μ.

Using the shear-wave velocities specified in Table 2.3.1-1, three base-profiles were developed using the scale factors of 1.25 for the sediments and 1.57 for the two Limestone layers. The specified shear-wave velocities were taken as the mean or best estimate base-case profile (P1) with lower and upper range base-cases profiles P2 and P3, respectively. Profiles extended to a depth (below the SSE control point) of 1,482 ft (452 m), randomized ± 445 ft (± 136 m). The base-case profiles (P1, P2, and P3) are shown in Figure 2.3.2-1 and listed in Table 2.3.2-1. The depth randomization reflects ± 30% of the depth and was included to provide a realistic broadening of the fundamental resonance at deep sites rather than reflect actual random variations to basement shear-wave velocities across a footprint.

Table 2.3.2-1. Layer thicknesses, depths, and shear-wave velocities (Vs) for 3 profiles for BSEP

Profile 1			Profile 2			Profile 3		
Thickness (ft)	Depth (ft)	Vs (ft/s)	Thickness (ft)	Depth (ft)	Vs (ft/s)	Thickness (ft)	Depth (ft)	Vs (ft/s)
	0	1122		0	898		0	1403
5.0	5.0	1122	5.0	5.0	898	5.0	5.0	1403
5.0	10.0	1122	5.0	10.0	898	5.0	10.0	1403
5.0	15.0	1122	5.0	15.0	898	5.0	15.0	1403
5.0	20.0	1122	5.0	20.0	898	5.0	20.0	1403
1.7	21.7	1122	1.7	21.7	898	1.7	21.7	1403
4.0	25.7	5500	4.0	25.7	4400	4.0	25.7	6875
5.0	30.7	5500	5.0	30.7	4400	5.0	30.7	6875
5.0	35.7	5500	5.0	35.7	4400	5.0	35.7	6875
5.0	40.7	5500	5.0	40.7	4400	5.0	40.7	6875
5.0	45.7	5500	5.0	45.7	4400	5.0	45.7	6875
5.0	50.7	5500	5.0	50.7	4400	5.0	50.7	6875
4.0	54.7	5500	4.0	54.7	4400	4.0	54.7	6875
5.0	59.7	5500	5.0	59.7	4400	5.0	59.7	6875
5.0	64.7	5500	5.0	64.7	4400	5.0	64.7	6875
27.7	92.3	4500	27.7	92.3	2866	27.7	92.3	7065
27.7	120.0	4500	27.7	120.0	2866	27.7	120.0	7065
35.8	155.8	4500	35.8	155.8	2866	35.8	155.8	7065
35.8	191.7	4500	35.8	191.7	2866	35.8	191.7	7065
19.4	211.1	3000	19.4	211.1	1911	19.4	211.1	4710
19.4	230.5	3000	19.4	230.5	1911	19.4	230.5	4710
19.4	250.0	3000	19.4	250.0	1911	19.4	250.0	4710
25.0	275.0	3000	25.0	275.0	1911	25.0	275.0	4710
25.0	300.0	3000	25.0	300.0	1911	25.0	300.0	4710
25.0	325.0	3000	25.0	325.0	1911	25.0	325.0	4710
25.0	350.0	3000	25.0	350.0	1911	25.0	350.0	4710
25.0	375.0	3000	25.0	375.0	1911	25.0	375.0	4710

Table 2.3.2-1. (cont.)

Profile 1			Profile 2			Profile 3		
Thickness (ft)	Depth (ft)	Vs (ft/s)	Thickness (ft)	Depth (ft)	Vs (ft/s)	Thickness (ft)	Depth (ft)	Vs (ft/s)
25.0	400.0	3000	25.0	400.0	1911	25.0	400.0	4710
25.0	425.0	3000	25.0	425.0	1911	25.0	425.0	4710
25.0	450.0	3000	25.0	450.0	1911	25.0	450.0	4710
25.0	475.0	3000	25.0	475.0	1911	25.0	475.0	4710
25.0	500.0	3000	25.0	500.0	1911	25.0	500.0	4710
32.7	532.7	3000	32.7	532.7	1911	32.7	532.7	4710
32.7	565.4	3000	32.7	565.4	1911	32.7	565.4	4710
32.7	598.1	3000	32.7	598.1	1911	32.7	598.1	4710
32.7	630.9	3000	32.7	630.9	1911	32.7	630.9	4710
32.7	663.6	3000	32.7	663.6	1911	32.7	663.6	4710
32.7	696.3	3000	32.7	696.3	1911	32.7	696.3	4710
32.7	729.0	3000	32.7	729.0	1911	32.7	729.0	4710
32.7	761.7	3000	32.7	761.7	1911	32.7	761.7	4710
32.7	794.5	3000	32.7	794.5	1911	32.7	794.5	4710
32.7	827.2	3000	32.7	827.2	1911	32.7	827.2	4710
32.7	859.9	3000	32.7	859.9	1911	32.7	859.9	4710
32.7	892.6	3000	32.7	892.6	1911	32.7	892.6	4710
32.7	925.3	3000	32.7	925.3	1911	32.7	925.3	4710
32.7	958.1	3000	32.7	958.1	1911	32.7	958.1	4710
32.7	990.8	3000	32.7	990.8	1911	32.7	990.8	4710
32.7	1023.5	3000	32.7	1023.5	1911	32.7	1023.5	4710
32.7	1056.2	3000	32.7	1056.2	1911	32.7	1056.2	4710
32.7	1088.9	3000	32.7	1088.9	1911	32.7	1088.9	4710
32.7	1121.7	3000	32.7	1121.7	1911	32.7	1121.7	4710
32.7	1154.4	3000	32.7	1154.4	1911	32.7	1154.4	4710
32.7	1187.1	3000	32.7	1187.1	1911	32.7	1187.1	4710
32.7	1219.8	3000	32.7	1219.8	1911	32.7	1219.8	4710
32.7	1252.5	3000	32.7	1252.5	1911	32.7	1252.5	4710
32.7	1285.3	3000	32.7	1285.3	1911	32.7	1285.3	4710
32.7	1318.0	3000	32.7	1318.0	1911	32.7	1318.0	4710
32.7	1350.7	3000	32.7	1350.7	1911	32.7	1350.7	4710
32.7	1383.4	3000	32.7	1383.4	1911	32.7	1383.4	4710
32.7	1416.1	3000	32.7	1416.1	1911	32.7	1416.1	4710
32.7	1448.9	3000	32.7	1448.9	1911	32.7	1448.9	4710
32.7	1481.6	3000	32.7	1481.6	1911	32.7	1481.6	4710
3280.8	4762.4	9285	3280.8	4762.4	9285	3280.8	4762.4	9285

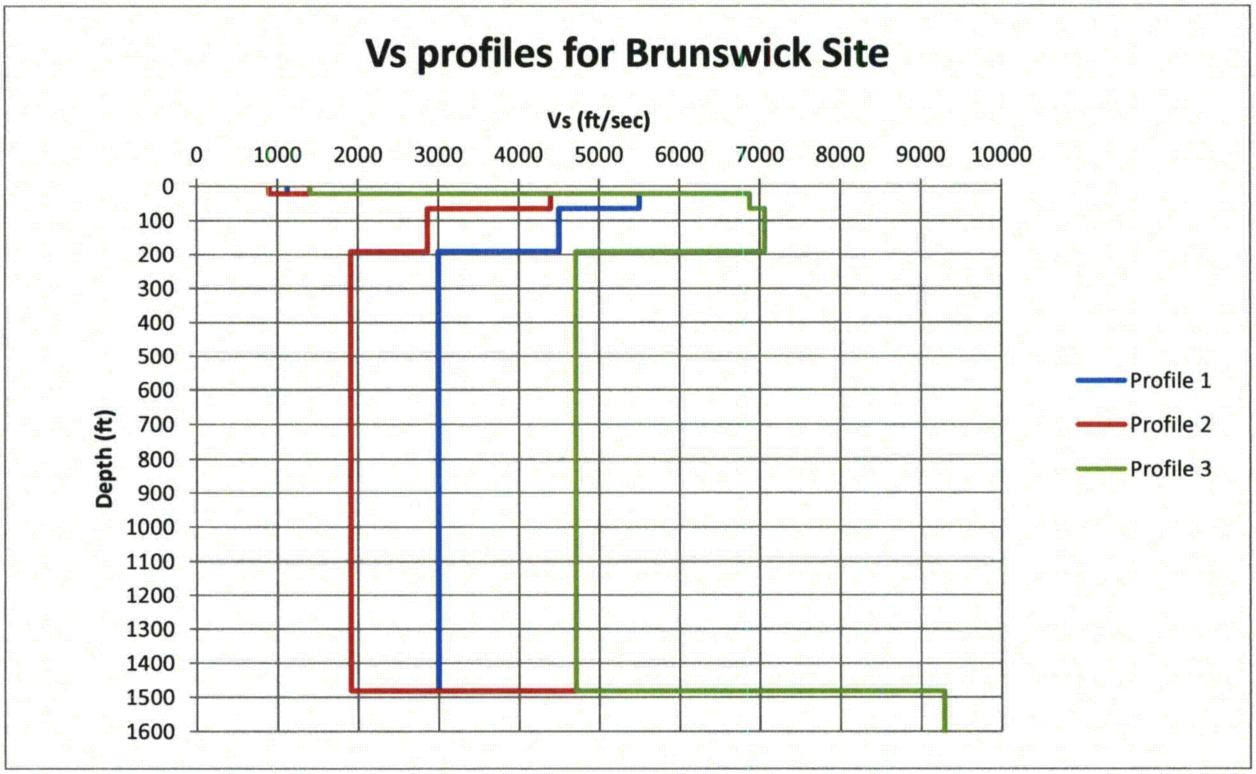


Figure 2.3.2-1. Shear-wave velocity profile used in site response calculations for BSEP

2.3.2.1 Shear Modulus and Damping Curves

No site-specific nonlinear dynamic material properties were determined in the initial siting of the BSEP. The rock material over the upper 500 ft (150 m) was assumed to have behavior that could be modeled as either linear or nonlinear. To accommodate the potential range in nonlinear dynamic properties, two sets of shear modulus reduction and hysteretic damping curves were used for both soil and firm rock. Consistent with the SPID, the EPRI soil and rock curves (model M1) were considered to be appropriate to represent the more nonlinear response likely to occur in the materials at this site. Peninsular Range (PR) curves for soils combined with linear analyses for firm rock (model M2) were assumed to represent an equally plausible, alternative linear response across loading level. For the linear firm rock analyses, the low strain damping values from the EPRI rock curves were used as the constant damping values for firm rock in the upper 500 ft (150 m).

2.3.2.2 Kappa

For the BSEP site, base-case kappa estimates were determined using Section B-5.1.3.1 of the SPID for a firm CEUS rock site. Kappa for a firm rock site with at least 3,000 ft (1 km) of sedimentary rock may be estimated from the average S-wave velocity over the upper 100 ft (V_{s100}) of the subsurface profile while for a site with less than 3,000 ft (1 km) of firm rock, kappa may be estimated with a Q_s of 40 below 500 ft combined with the low strain damping from the EPRI rock and or soil curves, and an additional kappa of 0.006s for the underlying hard rock.

For BSEP, with about 50 ft of soil and about 1,417 ft (432 m) of firm rock, the kappa estimates were 0.024s, 0.033s and 0.017s for profiles P1, P2 and P3, respectively (Table 2.3.2-2).

Table 2.3.2-2. Kappa values and weights used for BSEP Site response analyses

Velocity Profile	Kappa(s)
P1	0.024
P2	0.033
P3	0.017
	Weights
P1	0.4
P2	0.3
P3	0.3
G/G_{max} and Hysteretic Damping Curves	
M1	0.5
M2	0.5

2.3.3 Randomization of Base Case Profiles

To account for the aleatory variability in dynamic 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 BSEP, random shear wave velocity profiles were developed from base case profiles shown in Figure 2.3.2-1. Thirty random velocity profiles were generated for each base case profile. These random velocity profiles were generated using a natural log standard deviation of 0.25 over the upper 50 ft and 0.15 below that depth. As specified in the SPID, correlation of shear wave velocity between layers was modeled using the footprint correlation model. In the correlation model, a limit of +/- 2 standard deviations about the median value in each layer was assumed for the limits on random velocity fluctuations.

2.3.4 Input Spectra

Consistent with the guidance in Appendix B of the SPID, input Fourier amplitude spectra were defined for a single representative earthquake magnitude (**M** 6.5) using two different assumptions regarding the shape of the seismic source spectrum (single-corner and double-corner). A range of 11 different input amplitudes (median peak ground accelerations (PGA) ranging from 0.01 g to 1.50 g) were used in the site response analyses. The characteristics of the seismic source and upper crustal attenuation properties assumed for the analysis of the BSEP site were the same as those identified in Tables B-4, B-5, B-6 and B-7 of the SPID as appropriate for typical CEUS sites.

2.3.5 Methodology

To perform the site response analyses for the BSEP 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. The guidance contained in Appendix B of the SPID on incorporating epistemic uncertainty in shear-wave velocities, kappa, nonlinear dynamic properties and source spectra for plants with limited at-site information was followed for the BSEP site.

2.3.6 Amplification Functions

The results of the site response analysis consist of amplification factors (5% damped pseudo absolute response spectra) which describe the amplification (or de-amplification) of hard reference rock motion as a function of frequency and input reference rock amplitude. The amplification factors are represented in terms of a median amplification value and an associated standard deviation (sigma) for each oscillator frequency and input rock amplitude. Consistent with the SPID a minimum median amplification value of 0.5 was employed in the present analysis. Figure 2.3.6-1 illustrates the median and +/- 1 standard deviation in the predicted amplification factors developed for the eleven loading levels parameterized by the median reference (hard rock) peak acceleration (0.01 g to 1.50 g) for profile P1 and EPRI (i.e., Reference 7.6) soil and rock G/G_{max} and hysteretic damping curves. The variability in the amplification factors results from variability in shear-wave velocity, depth to hard rock, and modulus reduction and hysteretic damping curves. To illustrate the effects of nonlinearity at the BSEP soil and firm rock site, Figure 2.3.6-2 shows the corresponding amplification factors developed with Peninsular Range G/G_{max} and hysteretic damping curves for soil and linear site response analyses for firm rock (model M2). Figure 2.3.6-1 and Figure 2.3.6-2 show only a minor difference for frequencies below approximately 5 Hz and the 0.5 g loading level and below. Above about the 0.5 g loading level, the differences increase significantly, but only above approximately 5 Hz. Tabulated values of the amplification factors are provided in Appendix A.

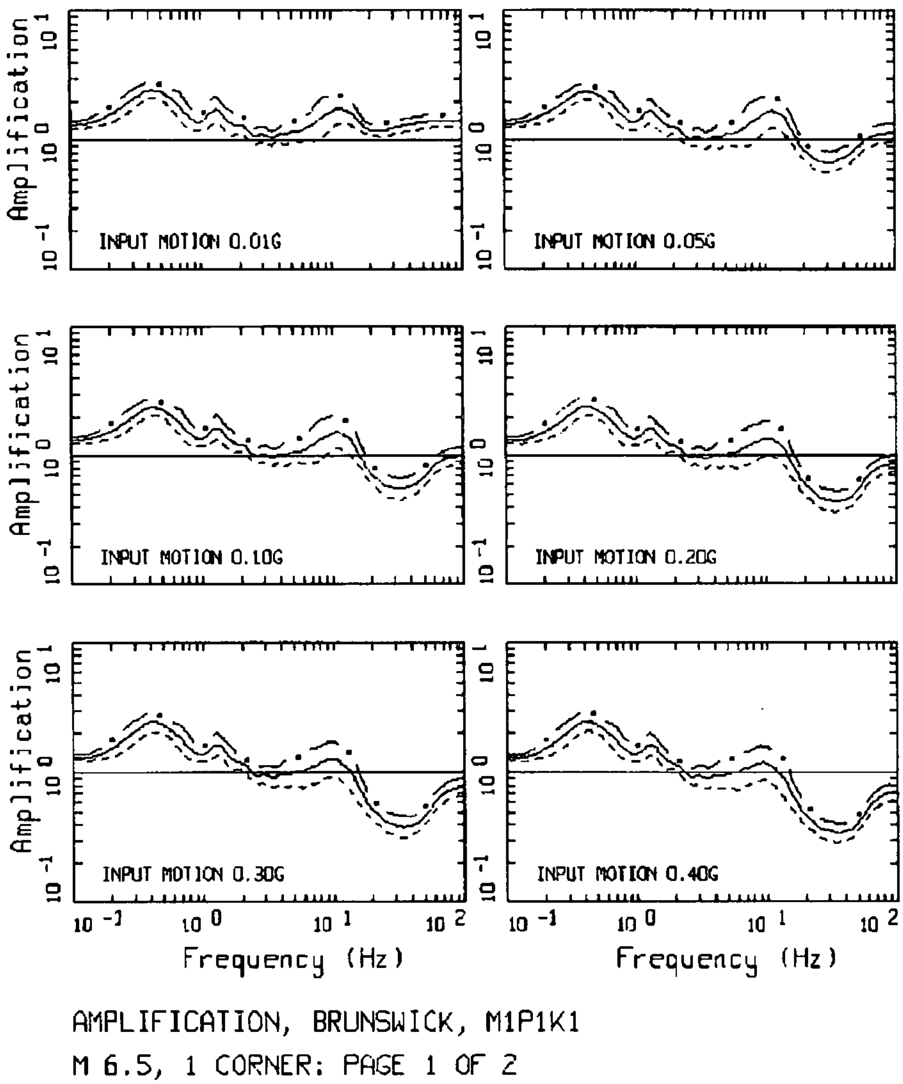
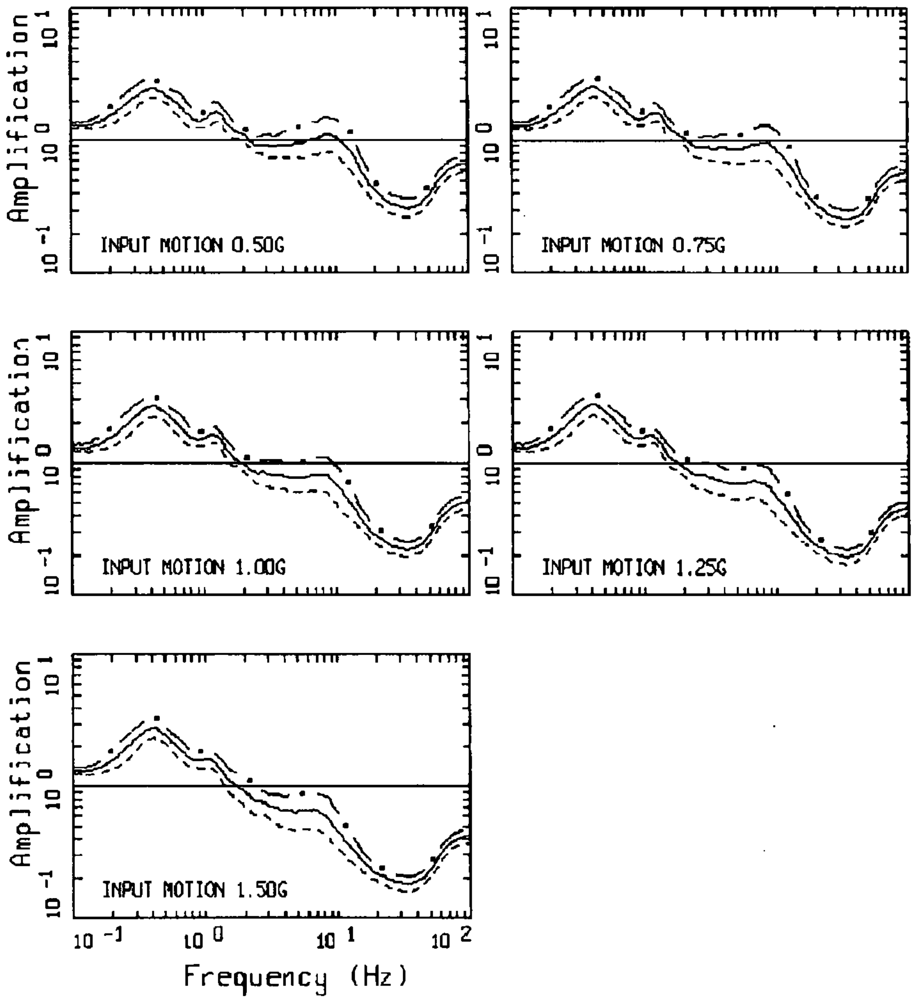


Figure 2.3.6-1. Example suite of amplification factors (5% damping pseudo absolute acceleration spectra) developed for the mean base-case profile (P1), EPRI soil and rock modulus reduction and hysteretic damping curves (model M1), and base-case kappa at eleven loading levels of hard rock median peak acceleration values from 0.01 g to 1.50 g. **M** 6.5 and single-corner source model (i.e., Reference 7.2).



AMPLIFICATION, BRUNSWICK, M1P1K1
M 6.5, 1 CORNER: PAGE 2 OF 2

Figure 2.3.6-1.(cont.)

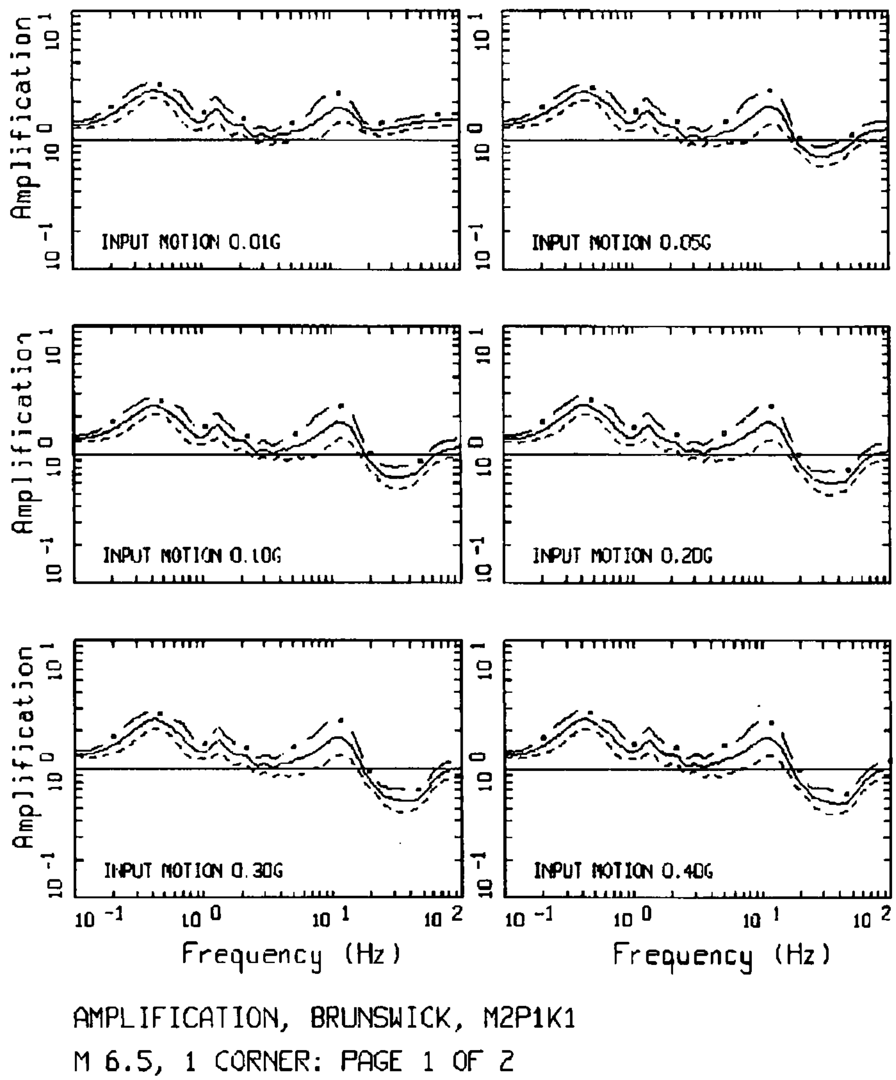
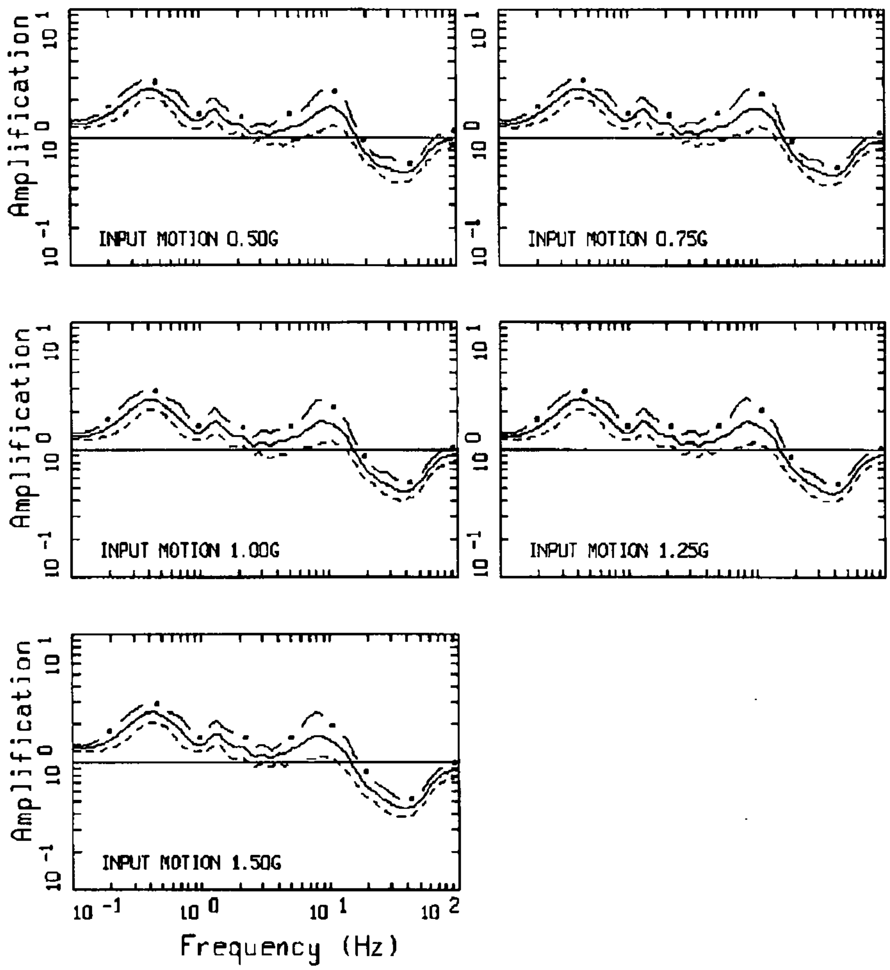


Figure 2.3.6-2. Example suite of amplification factors (5% damping pseudo absolute acceleration spectra) developed for the mean base-case profile (P1), Peninsular Range modulus reduction and hysteretic damping curves for soil and linear site response for rock (model M2), and base-case kappa at eleven loading levels of hard rock median peak acceleration values from 0.01 g to 1.50 g. **M** 6.5 and single-corner source model (i.e., Reference 7.2).



AMPLIFICATION, BRUNSWICK, M2P1K1
M 6.5, 1 CORNER: PAGE 2 OF 2

Figure 2.3.6-2.(cont.)

2.3.7 Control Point Seismic Hazard Curves

The procedure to develop probabilistic site-specific control point hazard curves used in the present analysis follows the methodology described in Section B-6.0 of the SPID. This procedure (referred to as Method 3) computes a site-specific control point hazard curve for a broad range of spectral accelerations given the site-specific bedrock hazard curve and site-specific estimates of soil or soft-rock response and associated uncertainties. This process is repeated for each of the seven spectral frequencies for which ground motion equations are available. The dynamic response of the materials below the control point was represented by the developed frequency and amplitude dependent amplification functions (median values and standard deviations) described in the previous section. The resulting control point mean hazard curves for BSEP are shown in Figure 2.3.7-1 for the seven spectral frequencies for which ground motion equations are defined. Tabulated values of mean and fractile seismic hazard curves and site response amplification functions are provided in Appendix A.

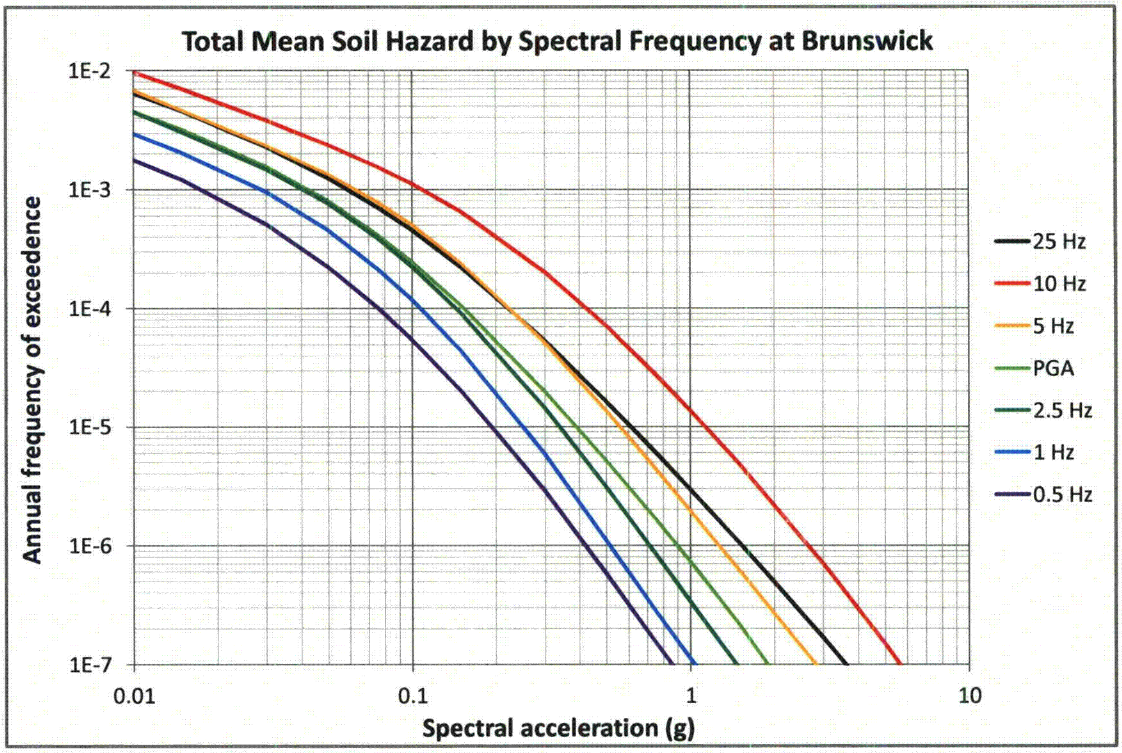


Figure 2.3.7-1. Control point mean hazard curves for spectral frequencies of 0.5, 1, 2.5, 5, 10, 25 and 100 Hz (PGA) at BSEP

2.4 Control Point Response Spectra

The control point hazard curves described above were used to develop uniform hazard response spectra (UHRS) and the GMRS. The UHRS were obtained through linear interpolation in log-log space to estimate the spectral acceleration at each spectral frequency for the 1E-4 and 1E-5 per year hazard levels.

The 1E-4 and 1E-5 UHRS, along with the design factor (DF), are used to compute the GMRS at the control point using the criteria in Regulatory Guide 1.208 (i.e., Reference 7.7). Table 2.4-1 shows the UHRS and GMRS spectral accelerations. Figure 2.4-1 shows the control point UHRS and GMRS.

Table 2.4-1. UHRS for 1E-4 and 1E-5 and GMRS at control point for BSEP

Freq. (Hz)	1E-4 UHRS (g)	1E-5 UHRS (g)	GMRS
100	1.53E-01	3.89E-01	1.94E-01
90	1.53E-01	3.92E-01	1.95E-01
80	1.54E-01	3.97E-01	1.97E-01
70	1.55E-01	4.03E-01	2.00E-01
60	1.58E-01	4.14E-01	2.05E-01
50	1.65E-01	4.37E-01	2.16E-01
40	1.81E-01	4.84E-01	2.38E-01
35	1.89E-01	5.14E-01	2.53E-01
30	1.99E-01	5.50E-01	2.69E-01
25	2.22E-01	6.11E-01	2.99E-01
20	2.78E-01	7.33E-01	3.62E-01
15	3.95E-01	9.91E-01	4.94E-01
12.5	4.46E-01	1.13E+00	5.63E-01
10	4.23E-01	1.13E+00	5.55E-01
9	3.83E-01	1.03E+00	5.07E-01
8	3.45E-01	9.18E-01	4.53E-01
7	3.02E-01	7.86E-01	3.90E-01
6	2.62E-01	6.72E-01	3.34E-01
5	2.23E-01	5.59E-01	2.79E-01
4	1.90E-01	4.68E-01	2.35E-01
3.5	1.77E-01	4.29E-01	2.16E-01
3	1.65E-01	3.94E-01	1.99E-01
2.5	1.43E-01	3.38E-01	1.71E-01
2	1.47E-01	3.46E-01	1.75E-01
1.5	1.29E-01	3.01E-01	1.52E-01
1.25	1.21E-01	2.84E-01	1.44E-01
1	1.07E-01	2.49E-01	1.26E-01
0.9	1.04E-01	2.45E-01	1.24E-01
0.8	9.98E-02	2.39E-01	1.21E-01
0.7	9.25E-02	2.28E-01	1.14E-01
0.6	8.43E-02	2.11E-01	1.05E-01
0.5	7.56E-02	1.92E-01	9.58E-02
0.4	6.04E-02	1.54E-01	7.66E-02
0.35	5.29E-02	1.35E-01	6.70E-02
0.3	4.53E-02	1.15E-01	5.75E-02
0.25	3.78E-02	9.62E-02	4.79E-02
0.2	3.02E-02	7.70E-02	3.83E-02
0.15	2.27E-02	5.77E-02	2.87E-02
0.125	1.89E-02	4.81E-02	2.39E-02
0.1	1.51E-02	3.85E-02	1.92E-02

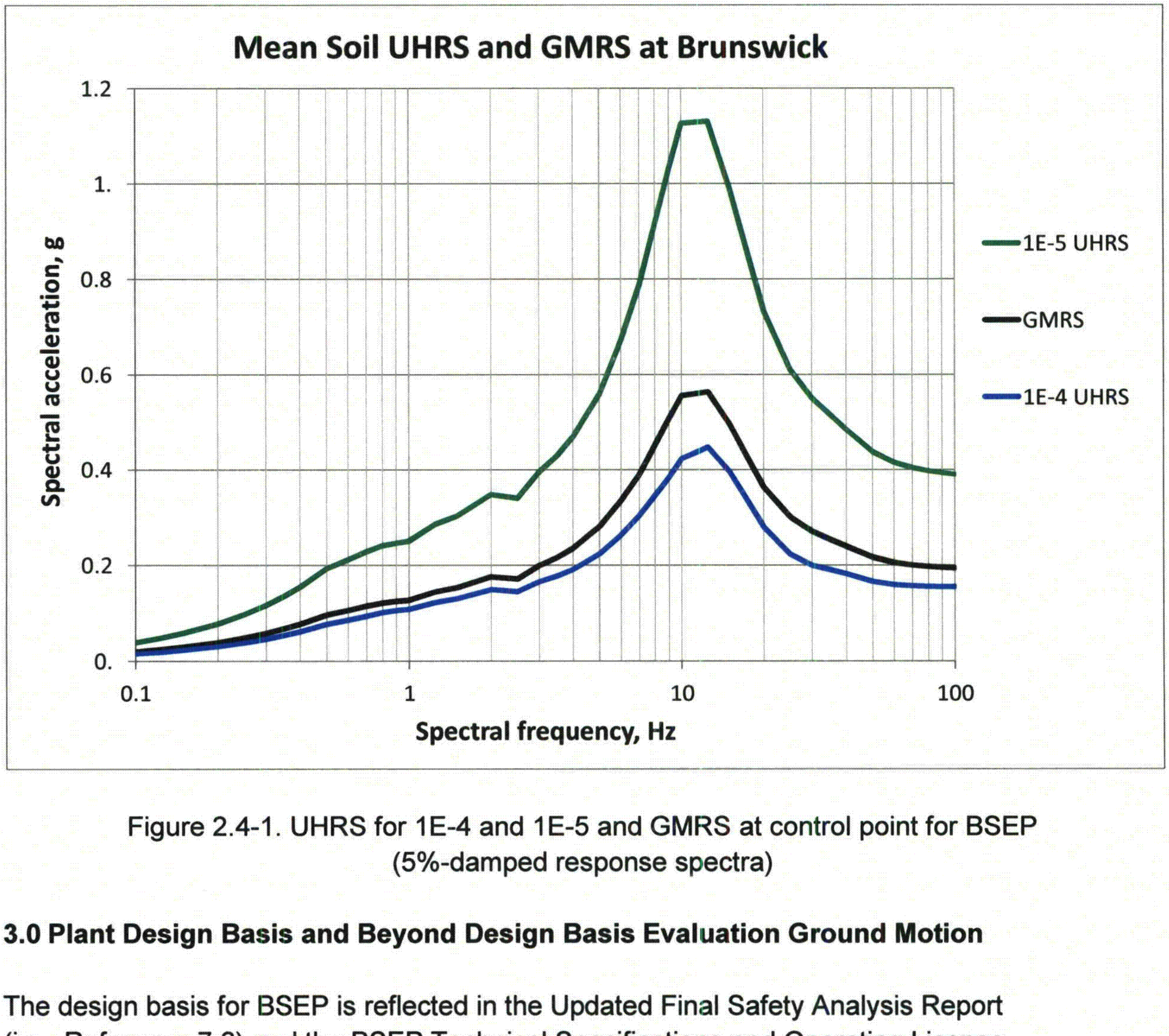


Figure 2.4-1. UHRS for 1E-4 and 1E-5 and GMRS at control point for BSEP (5%-damped response spectra)

3.0 Plant Design Basis and Beyond Design Basis Evaluation Ground Motion

The design basis for BSEP is reflected in the Updated Final Safety Analysis Report (i.e., Reference 7.8) and the BSEP Technical Specifications and Operating License.

An evaluation for beyond design basis (BDB) ground motions was performed in the IPEEE. The IPEEE plant level High Confidence of Low Probability of Failure (HCLPF) response spectrum (IHS) is included below for screening purposes.

3.1 SSE Description of Spectral Shape

For structures founded directly on dense sand, it was determined appropriate to use the Housner and El Centro response spectra with scaled amplitudes. Comparison of the two spectra proposed revealed that the response spectrum of El Centro will govern throughout the period range of interest. Thus, the envelope of the two recommended spectra is simply the smoothed 1940 North-South El Centro spectrum normalized by a factor of 0.08 g/0.33 g or 0.24 for OBE. The SSE has been taken to be a high intensity VII MM. The ground response spectra for the horizontal motion at the reactor foundation associated with the SSE was taken as

0.16 g /0.08 g or twice the ordinates of the OBE spectrum. The calculated spectral accelerations for the BSEP SSE are presented in Table 3.1-1. Figure 3.1-1 shows the SSE for BSEP at 5% Damping.

Table 3.1-1. SSE for BSEP at 5% Damping

Frequency (Hz)	Acceleration (g)
0.333	0.076
0.354	0.081
0.389	0.089
0.428	0.098
0.471	0.107
0.518	0.118
0.569	0.130
0.626	0.143
0.689	0.157
0.757	0.173
0.833	0.190
0.916	0.209
1.007	0.230
1.108	0.253
1.218	0.279
1.340	0.306
1.474	0.337
1.621	0.371
1.783	0.408
1.923	0.440
1.960	0.440
2.156	0.440
2.371	0.440
2.608	0.440
2.868	0.440
3.154	0.440
3.469	0.440
3.815	0.440
4.195	0.440
4.614	0.440
5.074	0.440
5.581	0.440
6.138	0.440
6.667	0.440
6.750	0.433
7.423	0.380
8.164	0.335
8.979	0.294
9.875	0.259

Table 3.1-1. (cont.)

Frequency (Hz)	Acceleration (g)
10.860	0.227
11.943	0.200
13.135	0.176
14.085	0.160
14.446	0.160
15.887	0.160
17.472	0.160
19.215	0.160
21.133	0.160
23.241	0.160
25.560	0.160
28.111	0.160
30.915	0.160
34.000	0.160

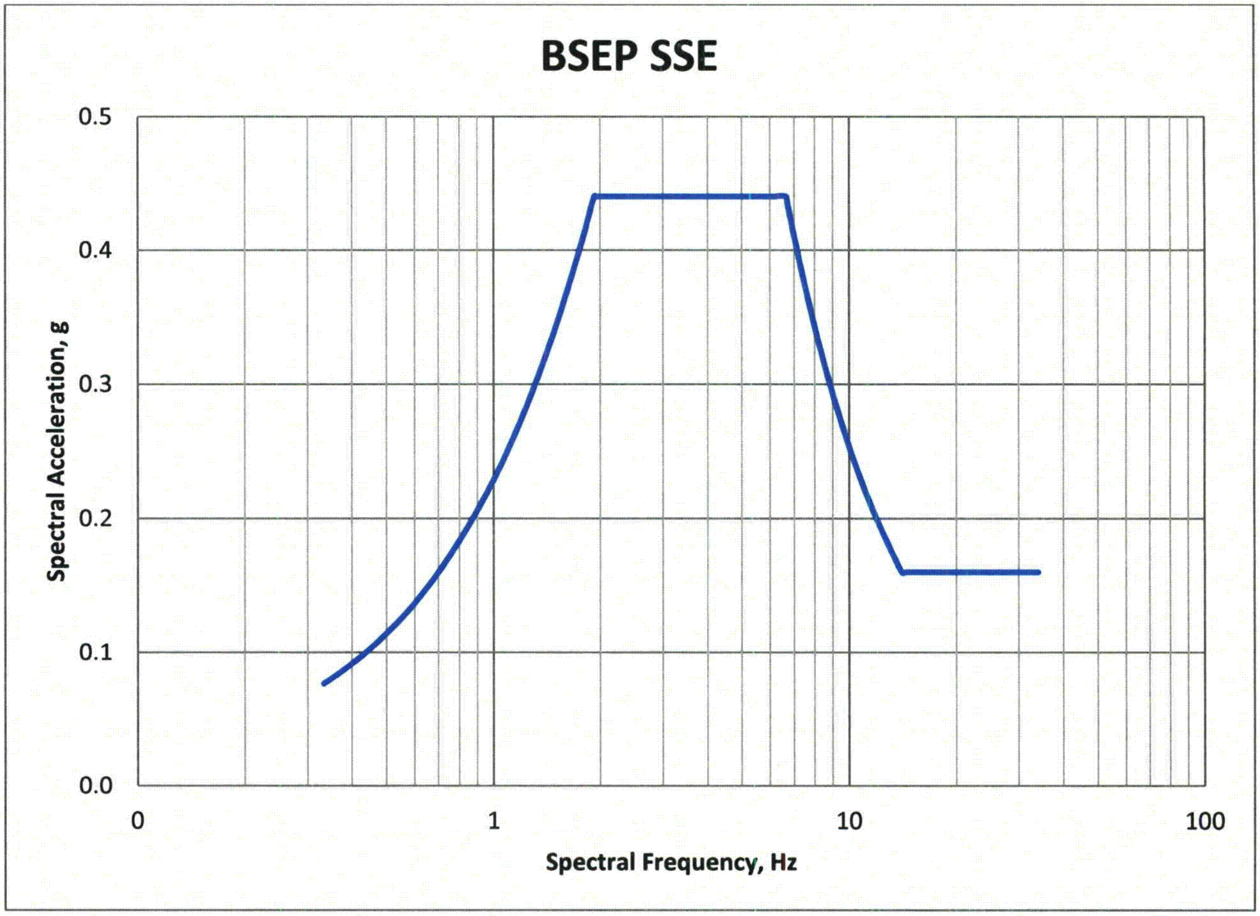


Figure 3.1-1. SSE for BSEP at 5% Damping

3.2 Control Point Elevation

As described in Section 2.3.2, the SSE control point is taken to be at the bottom of the Reactor Building basemat at Elevation -28.33 ft. The SSE control point selection complies with the guidance in Section 2.4.2 of the SPID.

3.3 IPEEE Description and Capacity Response Spectrum

BSEP performed the IPEEE as a focused scope plant (i.e., Reference 7.9). The IPEEE for BSEP followed the methodology presented in NUREG-1407, "*Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities*" (i.e., Reference 7.10). The BSEP IPEEE report concluded a HCLPF capacity for SSCs of at least 0.30 g, pending the outcome of the Unresolved Safety Issue (USI) A-46 outlier resolutions. The A-46 outliers have been resolved as documented in the CP&L transmittal to the NRC on September 11, 1998 (i.e., Reference 7.11). The NUREG/CR-0098 (i.e., Reference 7.12) median soil spectrum at 0.30 g PGA was defined as the Review Level Earthquake (RLE) for the BSEP site. The inflection points for the RLE curve are presented in Table 3.3-1.

Table 3.3-1. RLE Inflection Points

Frequency (Hz)	Spectral Acceleration (g)
0.1	0.015
0.25	0.098
1.64	0.635
8	0.635
33	0.300

The in-structure response spectra (ISRS) used for the BSEP IPEEE SMA were generated by scaling the ISRS utilized in the A-46 program. The seismic response generated for A-46 for the Reactor Building was produced using the Regulatory Guide (RG) 1.60 spectral shape anchored to 0.16 g PGA input motion at the surface of the soil, not at the reactor foundation. For consistency in screening with the GMRS, the control point for the IHS is needed at the same location as the GMRS and is derived below.

The free field time histories used for the A-46 program at the soil surface were deconvolved to the Reactor Building foundation using the SHAKE computer analyses. The 5% damped horizontal response spectra that results from the deconvolved time history is representative of the RG 1.60 spectral shape applied at the free field, deconvolved down to the Reactor Building foundation level. This spectrum is scaled to the IPEEE level using the same dominant mode scaling procedure used to scale the A-46 ISRS to the IPEEE ISRS for the Reactor Building.

The RLE defined at the soil surface and the resulting IHS (the deconvolved A-46 spectrum scaled up to IPEEE level for the Reactor Building) at the Elevation -28.33 ft control point are plotted against the GMRS in Figure 3.3-1.

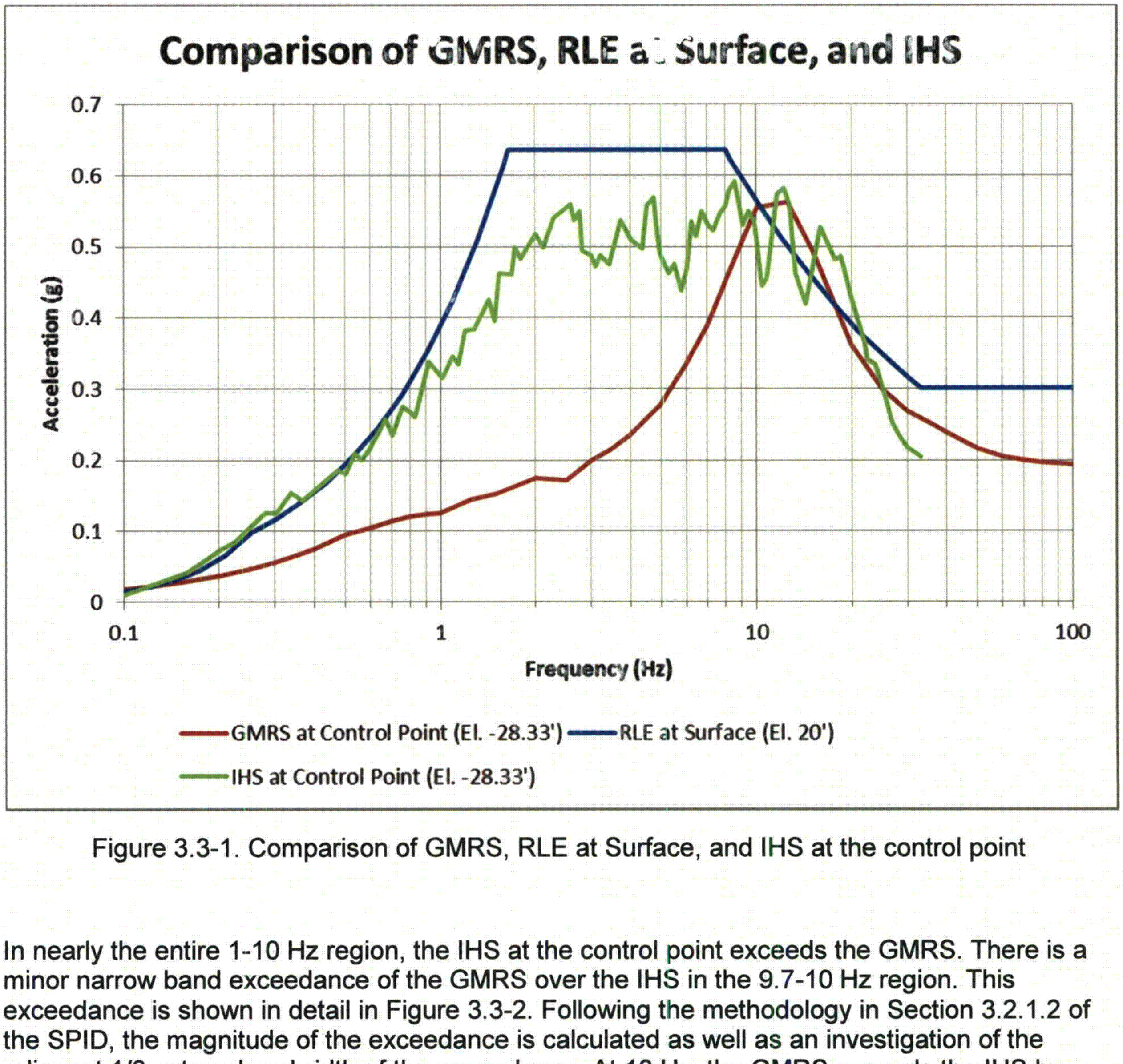


Figure 3.3-1. Comparison of GMRS, RLE at Surface, and IHS at the control point

In nearly the entire 1-10 Hz region, the IHS at the control point exceeds the GMRS. There is a minor narrow band exceedance of the GMRS over the IHS in the 9.7-10 Hz region. This exceedance is shown in detail in Figure 3.3-2. Following the methodology in Section 3.2.1.2 of the SPID, the magnitude of the exceedance is calculated as well as an investigation of the adjacent 1/3 octave bandwidth of the exceedance. At 10 Hz, the GMRS exceeds the IHS by approximately 9% which is within the 10% limit required by the SPID. The SPID also requires that the average ratio in the adjacent 1/3 octave bandwidth (1/6 on either side) is less than unity. Since the seismic risk evaluation screening in the SPID is limited to the 1-10 Hz region, only the 1/6 octave bandwidth $((10\ \text{Hz})/2^{(1/6)} = 8.91\ \text{Hz})$ below 10 Hz is evaluated. As shown in Figure 3.3-2, the area created between the IHS and the GMRS from 8.91 Hz to approximately 9.7 Hz is greater than the area created between the GMRS and the IHS from approximately 9.7 Hz to 10 Hz. Therefore, the average ratio of the GMRS to IHS is less than unity and this exceedance is considered acceptable.

The GMRS is greater than the IHS at frequencies above 10 Hz.

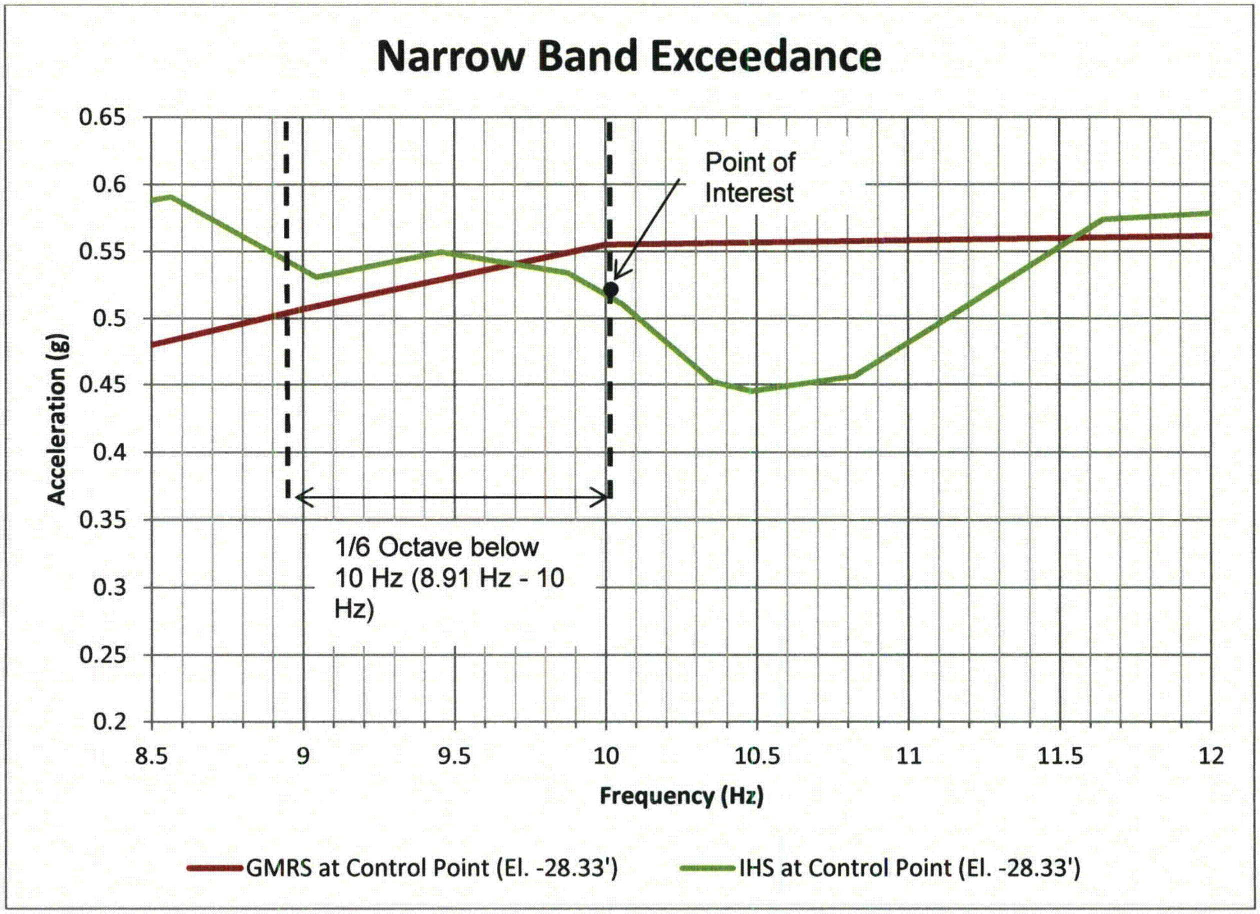


Figure 3.3-2. Narrow Band Exceedance

The IPEEE was reviewed for adequacy utilizing the guidance provided in Section 3.3 of the SPID. The IPEEE Adequacy Determination including the results of the full scope soils evaluation according to SPID Section 3.3.1 is included in Appendix B.

The results of the review have shown, in accordance with the criteria established in SPID Section 3.3, that the IPEEE is adequate to support screening of the updated seismic hazard for BSEP. The review also concluded that the risk insights obtained from the IPEEE are still valid under the current plant configuration.

The full scope detailed review of relay chatter required in SPID Section 3.3.1 has not been completed. As identified in the NEI letter to NRC dated October 3, 2013 (i.e., Reference 7.13), BSEP intends to complete the relay chatter review on the same schedule as the High Frequency Confirmation as proposed in the NEI letter to NRC dated April 9, 2013 (i.e., Reference 7.14) and accepted in NRC's response dated May 7, 2013 (i.e., Reference 7.15).

4.0 Screening Evaluation

In accordance with SPID, 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 IHS exceeds the GMRS. Based on this comparison, a risk evaluation will not be performed.

4.2 High Frequency Screening (> 10 Hz)

For a portion of the range above 10 Hz, the GMRS exceeds the IHS. Therefore, BSEP screens in for a High Frequency Confirmation.

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, BSEP screens in for a Spent Fuel Pool evaluation.

5.0 Interim Actions and Assessments

If the GMRS exceeds the design basis SSE, the NRC 50.54(f) letter requests: "interim evaluations and actions taken or planned to address the higher seismic hazard relative to the design basis, as appropriate, prior to completion of the risk assessment." Requested Information item number 5 of Enclosure 1 of the 50.54(f) letter also requests that estimates of plant seismic capacity developed from previous risk assessments and insights from NTTF Recommendation 2.3, walkdowns be provided. These evaluations and actions are discussed below.

Consistent with NRC letter dated February 20, 2014, (i.e., Reference 7.16) the seismic hazard reevaluations presented herein are distinct from the current design and licensing bases of BSEP. 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".

5.1 Expedited Seismic Evaluation Program

Based on the screening evaluation, the expedited seismic evaluation described in EPRI Report 3002000704 (i.e., Reference 7.3) was initiated at BSEP as proposed in a letter to NRC dated April 9, 2013 (i.e., Reference 7.14) and agreed to by NRC in a letter dated May 7, 2013 (i.e., Reference 7.15). Equipment selection follows Diverse and Flexible Coping Strategies as discussed in EPRI Report 3002000704. Walkdowns and HCLPF analyses have been performed and no enhancements have been identified.

5.2 Seismic Risk Estimates

NEI letter dated March 12, 2014, (i.e., Reference 7.17) 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."

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

5.3 Individual Plant Examination for External Events

The IPEEE investigations for BSEP followed the methodology for a focused scope Seismic Margins Assessment (SMA) presented in NUREG-1407. Methodologies from EPRI NP-6041-SL (i.e., Reference 7.18) were applied. Walkdown screening was performed using a 0.30 g NUREG/CR-0098 median soil spectrum as the RLE. The plant level IPEEE HCLPF was at least 0.30 g. The HCLPF was dependent on resolution of USI A-46 outlier conditions which have been completed. For IPEEE Adequacy Demonstration and full scope upgrade, refer to Appendix B and Section 3.3.

5.4 Walkdowns to Address NRC Fukushima NTTF Recommendation 2.3

Walkdowns have been completed for BSEP in accordance with the EPRI seismic walkdown guidance (i.e., Reference 7.19). Potentially adverse seismic conditions (PASC) found were entered into the corrective action program (CAP) and resolved. None of the PASC items challenged operability of the plant. There were no vulnerabilities identified under IPEEE, and identified enhancements were reviewed and found to be complete. BSEP confirmed through walkdowns that the existing monitoring and maintenance procedures keep the plant consistent with the design basis.

6.0 Conclusions

In accordance with the 50.54(f) request for information, a seismic hazard and screening evaluation was performed for BSEP. A GMRS was developed solely for the purpose of screening for additional evaluations in accordance with the SPID.

Based on the results of the screening evaluation, BSEP screens in for a Spent Fuel Pool evaluation and a High Frequency Confirmation. An IPEEE full scope relay chatter investigation is required to support this screening evaluation.

7.0 References

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7.2. Electric Power Research Institute (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," November 2012.

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7.17. Nuclear Energy Institute (NEI), A. Pietrangelo, Letter to E. Leeds of the USNRC, "Seismic Risk Evaluations for Plants in the Central and Eastern United States", March 12, 2014.

7.18. Electric Power Research Institute (EPRI), Report NP-6041-SL, "A Methodology for Assessment of Nuclear Power Plant Seismic Margin", Revision 1, 1991.

7.19. Electric Power Research Institute (EPRI), Final Report 1025286, "Seismic Walkdown Guidance: For Resolution of Fukushima Near-Term Task Force Recommendation 2.3: Seismic", June 2012.

APPENDIX A

Table A-1a. Mean and Fractile Seismic Hazard Curves for 100 Hz (PGA) at BSEP.

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.29E-02	1.69E-02	2.68E-02	3.33E-02	3.95E-02	4.31E-02
0.001	2.49E-02	1.13E-02	1.90E-02	2.46E-02	3.14E-02	3.57E-02
0.005	8.12E-03	3.68E-03	5.27E-03	7.55E-03	1.05E-02	1.57E-02
0.01	4.54E-03	1.84E-03	2.64E-03	4.13E-03	6.09E-03	9.37E-03
0.015	3.17E-03	1.07E-03	1.67E-03	2.84E-03	4.50E-03	6.73E-03
0.03	1.56E-03	3.14E-04	5.66E-04	1.27E-03	2.53E-03	3.90E-03
0.05	8.00E-04	9.51E-05	1.90E-04	5.35E-04	1.40E-03	2.46E-03
0.075	4.17E-04	3.05E-05	6.93E-05	2.22E-04	7.34E-04	1.51E-03
0.1	2.45E-04	1.25E-05	3.23E-05	1.10E-04	4.13E-04	9.79E-04
0.15	1.05E-04	3.23E-06	1.05E-05	4.07E-05	1.57E-04	4.37E-04
0.3	1.99E-05	2.13E-07	1.46E-06	7.45E-06	2.76E-05	7.13E-05
0.5	5.13E-06	2.13E-08	3.01E-07	1.98E-06	7.66E-06	1.79E-05
0.75	1.67E-06	3.47E-09	8.12E-08	6.45E-07	2.72E-06	6.26E-06
1	7.32E-07	9.11E-10	2.92E-08	2.68E-07	1.23E-06	2.92E-06
1.5	2.17E-07	1.72E-10	5.83E-09	6.93E-08	3.68E-07	9.11E-07
3	2.15E-08	8.12E-11	2.53E-10	4.13E-09	3.28E-08	9.37E-08
5	3.09E-09	5.05E-11	8.12E-11	3.84E-10	3.95E-09	1.34E-08
7.5	5.56E-10	4.01E-11	5.27E-11	8.85E-11	6.09E-10	2.35E-09
10	1.48E-10	4.01E-11	5.05E-11	8.12E-11	1.77E-10	6.54E-10

Table A-1b. Mean and Fractile Seismic Hazard Curves for 25 Hz at BSEP.

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.49E-02	2.10E-02	2.96E-02	3.52E-02	4.07E-02	4.43E-02
0.001	2.78E-02	1.51E-02	2.25E-02	2.80E-02	3.37E-02	3.84E-02
0.005	1.09E-02	5.27E-03	7.45E-03	1.02E-02	1.38E-02	2.01E-02
0.01	6.43E-03	2.92E-03	4.01E-03	5.91E-03	8.35E-03	1.27E-02
0.015	4.54E-03	1.84E-03	2.64E-03	4.13E-03	6.17E-03	8.98E-03
0.03	2.27E-03	6.09E-04	1.02E-03	1.98E-03	3.47E-03	4.98E-03
0.05	1.24E-03	2.07E-04	3.90E-04	9.79E-04	2.07E-03	3.19E-03
0.075	7.07E-04	7.66E-05	1.62E-04	4.77E-04	1.25E-03	2.13E-03
0.1	4.52E-04	3.73E-05	8.47E-05	2.68E-04	8.00E-04	1.51E-03
0.15	2.23E-04	1.29E-05	3.37E-05	1.13E-04	3.79E-04	8.23E-04
0.3	5.37E-05	1.82E-06	6.83E-06	2.49E-05	8.00E-05	1.98E-04
0.5	1.63E-05	3.33E-07	1.95E-06	8.23E-06	2.46E-05	5.50E-05
0.75	6.04E-06	7.13E-08	6.93E-07	3.33E-06	9.79E-06	1.92E-05
1	2.94E-06	2.19E-08	3.14E-07	1.69E-06	4.98E-06	9.65E-06
1.5	1.05E-06	4.07E-09	9.65E-08	6.17E-07	1.90E-06	3.57E-06
3	1.68E-07	2.57E-10	9.51E-09	8.47E-08	3.14E-07	6.26E-07
5	3.98E-08	8.12E-11	1.38E-09	1.53E-08	7.23E-08	1.60E-07
7.5	1.22E-08	8.12E-11	2.68E-10	3.23E-09	2.13E-08	5.35E-08
10	5.21E-09	7.13E-11	1.05E-10	9.79E-10	8.47E-09	2.39E-08

Table A-1c. Mean and Fractile Seismic Hazard Curves for 10 Hz at BSEP.

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.93E-02	3.01E-02	3.42E-02	3.95E-02	4.43E-02	4.77E-02
0.001	3.45E-02	2.39E-02	2.92E-02	3.47E-02	4.01E-02	4.31E-02
0.005	1.62E-02	8.85E-03	1.18E-02	1.57E-02	2.04E-02	2.46E-02
0.01	9.67E-03	4.98E-03	6.64E-03	9.24E-03	1.25E-02	1.60E-02
0.015	6.93E-03	3.37E-03	4.56E-03	6.64E-03	9.11E-03	1.18E-02
0.03	3.79E-03	1.57E-03	2.25E-03	3.57E-03	5.27E-03	6.83E-03
0.05	2.36E-03	7.89E-04	1.23E-03	2.16E-03	3.47E-03	4.63E-03
0.075	1.55E-03	4.13E-04	6.93E-04	1.36E-03	2.39E-03	3.33E-03
0.1	1.11E-03	2.49E-04	4.31E-04	9.24E-04	1.79E-03	2.60E-03
0.15	6.45E-04	1.10E-04	2.04E-04	4.90E-04	1.08E-03	1.72E-03
0.3	2.02E-04	2.07E-05	4.37E-05	1.23E-04	3.42E-04	6.64E-04
0.5	7.08E-05	4.77E-06	1.16E-05	3.79E-05	1.15E-04	2.49E-04
0.75	2.77E-05	1.27E-06	3.68E-06	1.36E-05	4.43E-05	9.79E-05
1	1.36E-05	4.63E-07	1.55E-06	6.45E-06	2.19E-05	4.77E-05
1.5	4.76E-06	9.65E-08	4.31E-07	2.16E-06	7.89E-06	1.69E-05
3	6.96E-07	4.63E-09	4.13E-08	2.80E-07	1.21E-06	2.72E-06
5	1.48E-07	4.70E-10	6.54E-09	5.35E-08	2.57E-07	6.09E-07
7.5	3.88E-08	1.08E-10	1.40E-09	1.25E-08	6.64E-08	1.62E-07
10	1.41E-08	8.12E-11	4.31E-10	4.13E-09	2.39E-08	6.00E-08

Table A-1d. Mean and Fractile Seismic Hazard Curves for 5 Hz at BSEP.

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.83E-02	2.84E-02	3.28E-02	3.84E-02	4.37E-02	4.70E-02
0.001	3.23E-02	2.13E-02	2.57E-02	3.23E-02	3.90E-02	4.25E-02
0.005	1.25E-02	6.17E-03	8.47E-03	1.23E-02	1.67E-02	1.92E-02
0.01	6.74E-03	3.23E-03	4.37E-03	6.54E-03	9.11E-03	1.08E-02
0.015	4.58E-03	2.04E-03	2.92E-03	4.43E-03	6.26E-03	7.55E-03
0.03	2.33E-03	7.89E-04	1.27E-03	2.19E-03	3.37E-03	4.31E-03
0.05	1.33E-03	3.23E-04	5.83E-04	1.20E-03	2.07E-03	2.84E-03
0.075	7.83E-04	1.46E-04	2.80E-04	6.45E-04	1.29E-03	1.90E-03
0.1	5.01E-04	7.66E-05	1.53E-04	3.79E-04	8.35E-04	1.36E-03
0.15	2.41E-04	2.84E-05	5.83E-05	1.57E-04	4.07E-04	7.45E-04
0.3	5.16E-05	3.68E-06	8.98E-06	2.68E-05	8.00E-05	1.84E-04
0.5	1.37E-05	6.17E-07	1.90E-06	6.73E-06	2.01E-05	4.77E-05
0.75	4.41E-06	1.23E-07	5.12E-07	2.16E-06	6.73E-06	1.46E-05
1	1.95E-06	3.42E-08	1.87E-07	9.24E-07	3.09E-06	6.54E-06
1.5	6.11E-07	4.83E-09	4.07E-08	2.64E-07	1.04E-06	2.22E-06
3	8.30E-08	1.74E-10	1.95E-09	2.49E-08	1.46E-07	3.47E-07
5	1.76E-08	8.12E-11	1.82E-10	3.57E-09	2.88E-08	7.89E-08
7.5	4.60E-09	5.05E-11	8.12E-11	6.83E-10	6.93E-09	2.16E-08
10	1.65E-09	4.07E-11	7.13E-11	2.16E-10	2.29E-09	7.77E-09

Table A-1e. Mean and Fractile Seismic Hazard Curves for 2.5 Hz at BSEP.

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.58E-02	2.57E-02	2.96E-02	3.57E-02	4.19E-02	4.56E-02
0.001	2.82E-02	1.74E-02	2.13E-02	2.80E-02	3.52E-02	3.90E-02
0.005	8.82E-03	4.31E-03	5.75E-03	8.47E-03	1.20E-02	1.44E-02
0.01	4.48E-03	1.95E-03	2.80E-03	4.31E-03	6.17E-03	7.55E-03
0.015	3.01E-03	1.13E-03	1.77E-03	2.88E-03	4.25E-03	5.27E-03
0.03	1.47E-03	3.42E-04	6.64E-04	1.34E-03	2.25E-03	3.05E-03
0.05	7.58E-04	1.18E-04	2.53E-04	6.17E-04	1.25E-03	1.87E-03
0.075	3.90E-04	4.43E-05	9.79E-05	2.76E-04	6.64E-04	1.13E-03
0.1	2.24E-04	2.04E-05	4.56E-05	1.36E-04	3.84E-04	7.34E-04
0.15	9.05E-05	6.00E-06	1.38E-05	4.37E-05	1.46E-04	3.37E-04
0.3	1.43E-05	5.05E-07	1.38E-06	4.98E-06	1.87E-05	5.50E-05
0.5	3.07E-06	5.75E-08	2.13E-07	9.65E-07	3.73E-06	1.04E-05
0.75	8.48E-07	8.12E-09	4.37E-08	2.64E-07	1.11E-06	2.80E-06
1	3.37E-07	1.79E-09	1.31E-08	9.93E-08	4.77E-07	1.20E-06
1.5	9.22E-08	2.29E-10	2.16E-09	2.35E-08	1.38E-07	3.68E-07
3	1.00E-08	7.13E-11	1.11E-10	1.44E-09	1.42E-08	4.63E-08
5	1.74E-09	4.01E-11	7.13E-11	1.79E-10	2.04E-09	8.23E-09
7.5	3.82E-10	4.01E-11	5.05E-11	8.12E-11	4.07E-10	1.77E-09
10	1.19E-10	4.01E-11	5.05E-11	8.12E-11	1.44E-10	5.75E-10

Table A-1f. Mean and Fractile Seismic Hazard Curves for 1 Hz at BSEP.

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	2.79E-02	1.49E-02	2.01E-02	2.84E-02	3.52E-02	3.95E-02
0.001	1.93E-02	8.72E-03	1.27E-02	1.92E-02	2.57E-02	3.01E-02
0.005	5.43E-03	2.16E-03	3.23E-03	5.20E-03	7.55E-03	9.51E-03
0.01	2.94E-03	9.37E-04	1.55E-03	2.76E-03	4.31E-03	5.50E-03
0.015	2.02E-03	4.98E-04	9.37E-04	1.87E-03	3.09E-03	4.07E-03
0.03	9.43E-04	1.31E-04	3.09E-04	7.89E-04	1.57E-03	2.25E-03
0.05	4.50E-04	3.90E-05	1.04E-04	3.28E-04	7.89E-04	1.27E-03
0.075	2.16E-04	1.31E-05	3.63E-05	1.34E-04	3.84E-04	7.03E-04
0.1	1.17E-04	5.66E-06	1.57E-05	6.36E-05	2.07E-04	4.13E-04
0.15	4.37E-05	1.57E-06	4.43E-06	1.90E-05	7.34E-05	1.69E-04
0.3	5.82E-06	1.31E-07	3.95E-07	1.82E-06	8.35E-06	2.39E-05
0.5	1.09E-06	1.55E-08	5.58E-08	2.96E-07	1.49E-06	4.31E-06
0.75	2.82E-07	2.35E-09	1.05E-08	6.93E-08	3.90E-07	1.16E-06
1	1.12E-07	5.91E-10	3.01E-09	2.46E-08	1.57E-07	4.83E-07
1.5	3.22E-08	1.13E-10	4.83E-10	5.27E-09	4.31E-08	1.51E-07
3	4.00E-09	5.05E-11	8.12E-11	3.37E-10	4.13E-09	1.90E-08
5	7.67E-10	4.01E-11	5.05E-11	8.23E-11	6.00E-10	3.33E-09
7.5	1.82E-10	4.01E-11	5.05E-11	8.12E-11	1.51E-10	7.23E-10
10	6.06E-11	4.01E-11	4.01E-11	8.12E-11	8.35E-11	2.57E-10

Table A-1g. Mean and Fractile Seismic Hazard Curves for 0.5 Hz at BSEP.

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	1.73E-02	8.98E-03	1.25E-02	1.72E-02	2.22E-02	2.60E-02
0.001	1.07E-02	5.12E-03	7.34E-03	1.04E-02	1.40E-02	1.74E-02
0.005	3.15E-03	1.04E-03	1.69E-03	2.96E-03	4.63E-03	5.91E-03
0.01	1.77E-03	3.63E-04	7.34E-04	1.60E-03	2.80E-03	3.79E-03
0.015	1.19E-03	1.69E-04	3.95E-04	1.01E-03	1.98E-03	2.84E-03
0.03	5.07E-04	3.42E-05	9.79E-05	3.47E-04	9.11E-04	1.53E-03
0.05	2.23E-04	8.35E-06	2.64E-05	1.16E-04	4.07E-04	8.00E-04
0.075	1.02E-04	2.46E-06	7.89E-06	4.01E-05	1.77E-04	4.13E-04
0.1	5.42E-05	9.51E-07	3.14E-06	1.69E-05	8.72E-05	2.35E-04
0.15	2.02E-05	2.35E-07	7.77E-07	4.50E-06	2.76E-05	9.11E-05
0.3	2.86E-06	1.57E-08	6.17E-08	3.79E-07	2.96E-06	1.21E-05
0.5	5.74E-07	1.64E-09	8.00E-09	6.00E-08	5.12E-07	2.32E-06
0.75	1.53E-07	2.64E-10	1.40E-09	1.34E-08	1.31E-07	6.64E-07
1	6.09E-08	9.93E-11	4.13E-10	4.50E-09	4.98E-08	2.84E-07
1.5	1.75E-08	7.13E-11	1.01E-10	9.51E-10	1.27E-08	8.47E-08
3	2.26E-09	4.01E-11	5.66E-11	9.79E-11	1.11E-09	9.79E-09
5	4.70E-10	4.01E-11	5.05E-11	8.12E-11	1.82E-10	1.69E-09
7.5	1.21E-10	4.01E-11	4.01E-11	8.12E-11	8.12E-11	4.01E-10
10	4.30E-11	4.01E-11	4.01E-11	7.13E-11	8.12E-11	1.57E-10

Table A-2. Amplification Functions for BSEP.

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-02	1.29E+00	1.39E-01	1.30E-02	1.11E+00	1.30E-01	1.90E-02	1.45E+00	3.23E-01	2.09E-02	1.09E+00	1.78E-01
4.95E-02	1.11E+00	1.63E-01	1.02E-01	7.46E-01	1.91E-01	9.99E-02	1.42E+00	3.47E-01	8.24E-02	1.07E+00	2.04E-01
9.64E-02	1.02E+00	1.62E-01	2.13E-01	6.61E-01	2.12E-01	1.85E-01	1.39E+00	3.50E-01	1.44E-01	1.07E+00	2.18E-01
1.94E-01	9.31E-01	1.57E-01	4.43E-01	5.89E-01	2.27E-01	3.56E-01	1.34E+00	3.62E-01	2.65E-01	1.06E+00	2.36E-01
2.92E-01	8.78E-01	1.55E-01	6.76E-01	5.49E-01	2.36E-01	5.23E-01	1.31E+00	3.70E-01	3.84E-01	1.05E+00	2.48E-01
3.91E-01	8.40E-01	1.53E-01	9.09E-01	5.21E-01	2.41E-01	6.90E-01	1.27E+00	3.75E-01	5.02E-01	1.04E+00	2.56E-01
4.93E-01	8.09E-01	1.51E-01	1.15E+00	5.00E-01	2.45E-01	8.61E-01	1.24E+00	3.80E-01	6.22E-01	1.03E+00	2.64E-01
7.41E-01	7.52E-01	1.47E-01	1.73E+00	5.00E-01	2.51E-01	1.27E+00	1.16E+00	3.81E-01	9.13E-01	1.02E+00	2.70E-01
1.01E+00	7.09E-01	1.44E-01	2.36E+00	5.00E-01	2.59E-01	1.72E+00	1.08E+00	3.77E-01	1.22E+00	1.00E+00	2.67E-01
1.28E+00	6.73E-01	1.42E-01	3.01E+00	5.00E-01	2.69E-01	2.17E+00	1.01E+00	3.74E-01	1.54E+00	9.88E-01	2.74E-01
1.55E+00	6.45E-01	1.42E-01	3.63E+00	5.00E-01	2.77E-01	2.61E+00	9.44E-01	3.68E-01	1.85E+00	9.79E-01	2.87E-01

2.5 Hz	Median AF	Sigma ln(AF)	1 Hz	Median AF	Sigma ln(AF)	0.5 Hz	Median AF	Sigma ln(AF)
2.18E-02	1.04E+00	1.33E-01	1.27E-02	1.54E+00	2.15E-01	8.25E-03	1.90E+00	1.88E-01
7.05E-02	1.01E+00	1.36E-01	3.43E-02	1.52E+00	2.05E-01	1.96E-02	1.87E+00	1.82E-01
1.18E-01	1.00E+00	1.37E-01	5.51E-02	1.51E+00	2.00E-01	3.02E-02	1.86E+00	1.81E-01
2.12E-01	9.89E-01	1.39E-01	9.63E-02	1.50E+00	1.93E-01	5.11E-02	1.86E+00	1.81E-01
3.04E-01	9.80E-01	1.42E-01	1.36E-01	1.49E+00	1.90E-01	7.10E-02	1.87E+00	1.81E-01
3.94E-01	9.71E-01	1.45E-01	1.75E-01	1.49E+00	1.89E-01	9.06E-02	1.87E+00	1.80E-01
4.86E-01	9.64E-01	1.50E-01	2.14E-01	1.49E+00	1.91E-01	1.10E-01	1.88E+00	1.80E-01
7.09E-01	9.52E-01	1.62E-01	3.10E-01	1.48E+00	1.95E-01	1.58E-01	1.88E+00	1.78E-01
9.47E-01	9.40E-01	1.72E-01	4.12E-01	1.48E+00	1.98E-01	2.09E-01	1.89E+00	1.82E-01
1.19E+00	9.34E-01	1.86E-01	5.18E-01	1.47E+00	2.00E-01	2.62E-01	1.89E+00	1.81E-01
1.43E+00	9.29E-01	1.91E-01	6.19E-01	1.47E+00	2.03E-01	3.12E-01	1.89E+00	1.83E-01

Table A2-b1. Median AFs and sigmas for Model 1, Profile 1, for 2 PGA levels.

M1P1K1	Rock PGA=0.194			M1P1K1	PGA=0.741		
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
100.0	0.167	0.862	0.154	100.0	0.430	0.580	0.131
87.1	0.168	0.843	0.155	87.1	0.430	0.563	0.131
75.9	0.168	0.809	0.155	75.9	0.431	0.532	0.131
66.1	0.169	0.746	0.156	66.1	0.432	0.479	0.132
57.5	0.171	0.644	0.157	57.5	0.434	0.399	0.132
50.1	0.173	0.544	0.159	50.1	0.437	0.329	0.133
43.7	0.178	0.471	0.165	43.7	0.440	0.280	0.135
38.0	0.185	0.447	0.181	38.0	0.446	0.262	0.138
33.1	0.193	0.440	0.192	33.1	0.457	0.258	0.145
28.8	0.200	0.455	0.191	28.8	0.469	0.268	0.150
25.1	0.211	0.475	0.187	25.1	0.484	0.279	0.151
21.9	0.229	0.542	0.182	21.9	0.506	0.311	0.150
19.1	0.263	0.631	0.198	19.1	0.550	0.348	0.165
16.6	0.318	0.794	0.224	16.6	0.622	0.416	0.187
14.5	0.398	1.037	0.317	14.5	0.730	0.517	0.256
12.6	0.457	1.225	0.305	12.6	0.881	0.648	0.332
11.0	0.492	1.351	0.298	11.0	1.015	0.773	0.343
9.5	0.470	1.351	0.311	9.5	1.106	0.890	0.317
8.3	0.409	1.275	0.322	8.3	1.088	0.958	0.310
7.2	0.355	1.181	0.344	7.2	0.980	0.929	0.297
6.3	0.313	1.106	0.316	6.3	0.894	0.908	0.282
5.5	0.284	1.051	0.257	5.5	0.809	0.867	0.256
4.8	0.269	1.017	0.215	4.8	0.779	0.859	0.264
4.2	0.257	1.004	0.216	4.2	0.759	0.869	0.245
3.6	0.239	0.958	0.159	3.6	0.735	0.870	0.225
3.2	0.228	0.969	0.178	3.2	0.686	0.866	0.216
2.8	0.220	0.985	0.148	2.8	0.663	0.886	0.184
2.4	0.210	1.022	0.134	2.4	0.615	0.896	0.153
2.1	0.218	1.166	0.129	2.1	0.627	1.008	0.127
1.8	0.205	1.223	0.144	1.8	0.613	1.108	0.112
1.6	0.196	1.353	0.200	1.6	0.585	1.226	0.158
1.4	0.199	1.590	0.181	1.4	0.609	1.489	0.142
1.2	0.176	1.595	0.205	1.2	0.588	1.642	0.160
1.0	0.141	1.419	0.154	1.0	0.489	1.525	0.162
0.91	0.125	1.378	0.132	0.91	0.419	1.443	0.116
0.79	0.125	1.522	0.203	0.79	0.403	1.546	0.172
0.69	0.129	1.770	0.227	0.69	0.408	1.775	0.209
0.60	0.127	2.002	0.178	0.60	0.402	2.019	0.181
0.52	0.119	2.204	0.142	0.52	0.379	2.256	0.157
0.46	0.107	2.371	0.151	0.46	0.347	2.487	0.169
0.10	0.003	1.342	0.053	0.10	0.008	1.335	0.053

Table A2-b2. Median AFs and sigmas for Model 2, Profile 1, for 2 PGA levels.

M2P1K1	PGA=0.194			M2P1K1	PGA=0.741		
Freq.(Hz)	Soil_SA	Med AF	sigma ln(AF)	Freq.(Hz)	Soil_SA	Med.AF	sigma ln(AF)
100.0	0.207	1.069	0.150	100.0	0.714	0.964	0.139
87.1	0.208	1.047	0.150	87.1	0.717	0.938	0.139
75.9	0.210	1.008	0.150	75.9	0.722	0.891	0.139
66.1	0.212	0.933	0.151	66.1	0.729	0.807	0.140
57.5	0.215	0.812	0.153	57.5	0.743	0.682	0.142
50.1	0.222	0.695	0.153	50.1	0.766	0.577	0.142
43.7	0.233	0.617	0.165	43.7	0.799	0.508	0.147
38.0	0.251	0.604	0.192	38.0	0.852	0.500	0.172
33.1	0.264	0.601	0.216	33.1	0.911	0.514	0.198
28.8	0.271	0.617	0.190	28.8	0.970	0.555	0.214
25.1	0.286	0.644	0.160	25.1	1.004	0.579	0.168
21.9	0.314	0.743	0.135	21.9	1.060	0.652	0.138
19.1	0.372	0.892	0.167	19.1	1.216	0.770	0.181
16.6	0.461	1.150	0.197	16.6	1.462	0.977	0.190
14.5	0.573	1.496	0.277	14.5	1.775	1.256	0.254
12.6	0.634	1.699	0.291	12.6	2.028	1.491	0.285
11.0	0.649	1.783	0.332	11.0	2.173	1.655	0.313
9.5	0.571	1.643	0.346	9.5	2.095	1.686	0.366
8.3	0.481	1.498	0.338	8.3	1.836	1.617	0.385
7.2	0.406	1.350	0.305	7.2	1.521	1.441	0.323
6.3	0.355	1.255	0.295	6.3	1.290	1.311	0.242
5.5	0.321	1.190	0.251	5.5	1.155	1.238	0.230
4.8	0.298	1.128	0.219	4.8	1.068	1.178	0.254
4.2	0.283	1.104	0.184	4.2	1.007	1.152	0.243
3.6	0.259	1.039	0.149	3.6	0.909	1.075	0.207
3.2	0.252	1.074	0.155	3.2	0.873	1.102	0.194
2.8	0.240	1.076	0.142	2.8	0.820	1.097	0.150
2.4	0.232	1.125	0.131	2.4	0.782	1.139	0.137
2.1	0.237	1.267	0.150	2.1	0.795	1.279	0.158
1.8	0.216	1.291	0.183	1.8	0.719	1.301	0.191
1.6	0.204	1.405	0.209	1.6	0.674	1.412	0.209
1.4	0.203	1.627	0.205	1.4	0.667	1.631	0.201
1.2	0.174	1.580	0.218	1.2	0.567	1.583	0.214
1.0	0.139	1.395	0.152	1.0	0.449	1.398	0.152
0.91	0.124	1.367	0.139	0.91	0.397	1.370	0.140
0.79	0.125	1.523	0.213	0.79	0.397	1.524	0.213
0.69	0.129	1.776	0.233	0.69	0.408	1.774	0.233
0.60	0.127	2.006	0.177	0.60	0.399	2.005	0.180
0.52	0.119	2.204	0.139	0.52	0.373	2.216	0.151
0.46	0.107	2.361	0.148	0.46	0.336	2.407	0.166
0.10	0.003	1.341	0.053	0.10	0.007	1.326	0.053

Tables A2-b1 and A2-b2 are tabular versions of the typical amplification factors provided in Figures 2.3.6-1 and 2.3.6-2. Values are provided for two input motion levels at approximately 10^{-4} and 10^{-5} mean annual frequency of exceedance.

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ACRONYMS

BSEP	Brunswick Steam Electric Plant
CB	Control Building
CDFM	Conservative Deterministic Failure Margin
CFR	Code of Federal Regulations
CP&L	Carolina Power and Light
DBE	Design Basis Earthquake
DGB	Diesel Generator Building
DW	Drywell
EOP	Emergency Operating Procedures
EPRI	Electric Power Research Institute
GERS	Generic Equipment Ruggedness Spectra
GIP	Generic Implementation Procedure
GL	Generic Letter
GMRS	Ground Motion Response Spectrum
HCLPF	High Confidence of Low Probability of Failure
HVAC	Heating, Ventilation, and Air-Conditioning
IHS	IPEEE HCLPF Spectrum
IPEEE	Individual Plant Examination of External Events
ISRS	In-Structure Response Spectrum
LOCA	Loss of Coolant Accident
MM	Modified Mercalli
NEI	Nuclear Energy Institute
NEP	Non-Exceedance Probability
NTTF	Near-Term Task Force
OBE	Operating Basis Earthquake
P&SC	Primary and Secondary Containment
PGA	Peak Ground Acceleration
RG	Regulatory Guide
RHR	Residual Heat Removal
RLE	Review Level Earthquake
RPV	Reactor Pressure Vessel
SDOF	Single Degree of Freedom

SER	Safety Evaluation Report
SEWS	Screening and Evaluation Worksheet
SMA	Seismic Margins Assessment
SME	Seismic Margin Earthquake
SPID	Screening, Prioritization, and Implementation Details
SPLD	Success Path Logic Diagram
SPRA	Seismic Probabilistic Risk Assessment
SQUG	Seismic Qualification Utilities Group
SRSS	Square Root of the Sum of the Squares
SRP	Standard Review Plan
SRT	Seismic Review Team
SSE	Safe Shutdown Earthquake
SSEL	Safe Shutdown Equipment List
SSI	Soil-Structure Interaction
SWEL	Seismic Walkdown Equipment List
SWIS	Service Water Intake Structure
UFSAR	Updated Final Safety Analysis Report
UPS	Uninterruptible Power Supply
USI	Unresolved Safety Issue
USNRC	United States Nuclear Regulatory Commission
VAC	Volt Alternating Current

EXECUTIVE SUMMARY

This report is an effort to demonstrate adequacy of the Individual Plant Examination of External Events (IPEEE) for use in screening seismic hazard results to determine the need for a seismic risk evaluation consistent with 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."

The results of the review show that the IPEEE is adequate for screening. The review also concludes that the risk insights obtained from the IPEEE are still valid under the current plant configuration.

A full-scope relay chatter investigation is required in the future to support this screening. A full-scope soil failure evaluation was performed as part of this adequacy investigation. Results from the soil failure investigation were acceptable for the Review Level Earthquake (RLE).

1.0 INTRODUCTION

As part of the lessons learned from the accident at the Fukushima Dai-ichi nuclear facility, the March 12, 2012 information request was issued pursuant to Title 10 of the Code of Federal Regulations (10 CFR), Section 50.54(f) (hereafter referred to as the 50.54(f) letter, Reference 6.1) by the United States Nuclear Regulatory Commission (USNRC) to nuclear power licensees. In response to Enclosure 1 of the 50.54(f) letter, the Electric Power Research Institute (EPRI) with significant interaction with the USNRC, the Nuclear Energy Institute (NEI), and other stakeholders produced EPRI Report No. 1025287, "Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic" (hereafter referred to as the SPID, Reference 6.2). The USNRC has endorsed the SPID to provide licensees with the guidance necessary to complete seismic reevaluations and report results in a manner consistent with the 50.54(f) letter (see Reference 6.3).

As discussed in the SPID, a screening process is necessary to determine which nuclear power plants are required to perform new seismic risk evaluations. The first screening option is to compare the newly developed horizontal ground motion response spectrum (GMRS) to the horizontal 5% damping plant safe shutdown earthquake (SSE). If the GMRS exceeds the SSE between 1 and 10 Hertz (Hz), a second screening option can be pursued. This screening compares the GMRS to the response spectrum corresponding to the HCLPF level documented in the plant's Individual Plant Examination of External Events (IPEEE). This spectrum is referred to as the IPEEE HCLPF spectrum (IHS). The IHS is permitted for screening purposes, provided the IPEEE meets the requirements of the *general considerations, prerequisites, and adequacy demonstration* listed in Section 3.3 of the SPID. As discussed in Reference 6.3, the USNRC will review the IPEEE adequacy demonstration in its "integrated totality" rather than by a pass or fail approach.

Figure 1.1 presents the comparison between the GMRS (Reference 6.19), the SSE (Section 3.7.1.1.2, Reference 6.8), the Review Level Earthquake (RLE) (Reference 6.5), and the IHS for the Brunswick Steam Electric Plant (BSEP). The GMRS exceeds the SSE but compares favorably with the IHS. Per Section 3.3 of the SPID, the following sections serve to address the general considerations, prerequisites, and adequacy demonstration for the BSEP IPEEE such that the BSEP IHS may be used for screening purposes.

The Seismic IPEEE for BSEP was completed by Carolina Power & Light Company and EQE International, Inc. in June of 1995. This report is provided in Appendix A of Reference 6.5. The Seismic IPEEE seismic margins assessment (SMA) was completed, following the guidance of NUREG-1407 (Reference 6.4) and EPRI NP-6041 (Reference 6.6), as a focused-scope plant with a RLE specified as the NUREG/CR-0098 (Reference 6.7) median soil spectrum anchored to 0.30g (see Reference 6.5, Section 2.2.1, and Section 4.1 of Appendix A). A review and summary of the BSEP Seismic IPEEE is provided herein. Section 2.0 describes the necessary work to enhance the BSEP IPEEE from focused-scope to full-scope such that the general considerations are met; Section 3.0 addresses the necessary prerequisites, and Section 4.0 describes the methodology, adherence to appropriate guidance, and adequacy of the criteria listed in Section 3.3.1 of the SPID. Unless otherwise stated, all summary information is referenced from the BSEP IPEEE (Reference 6.5).

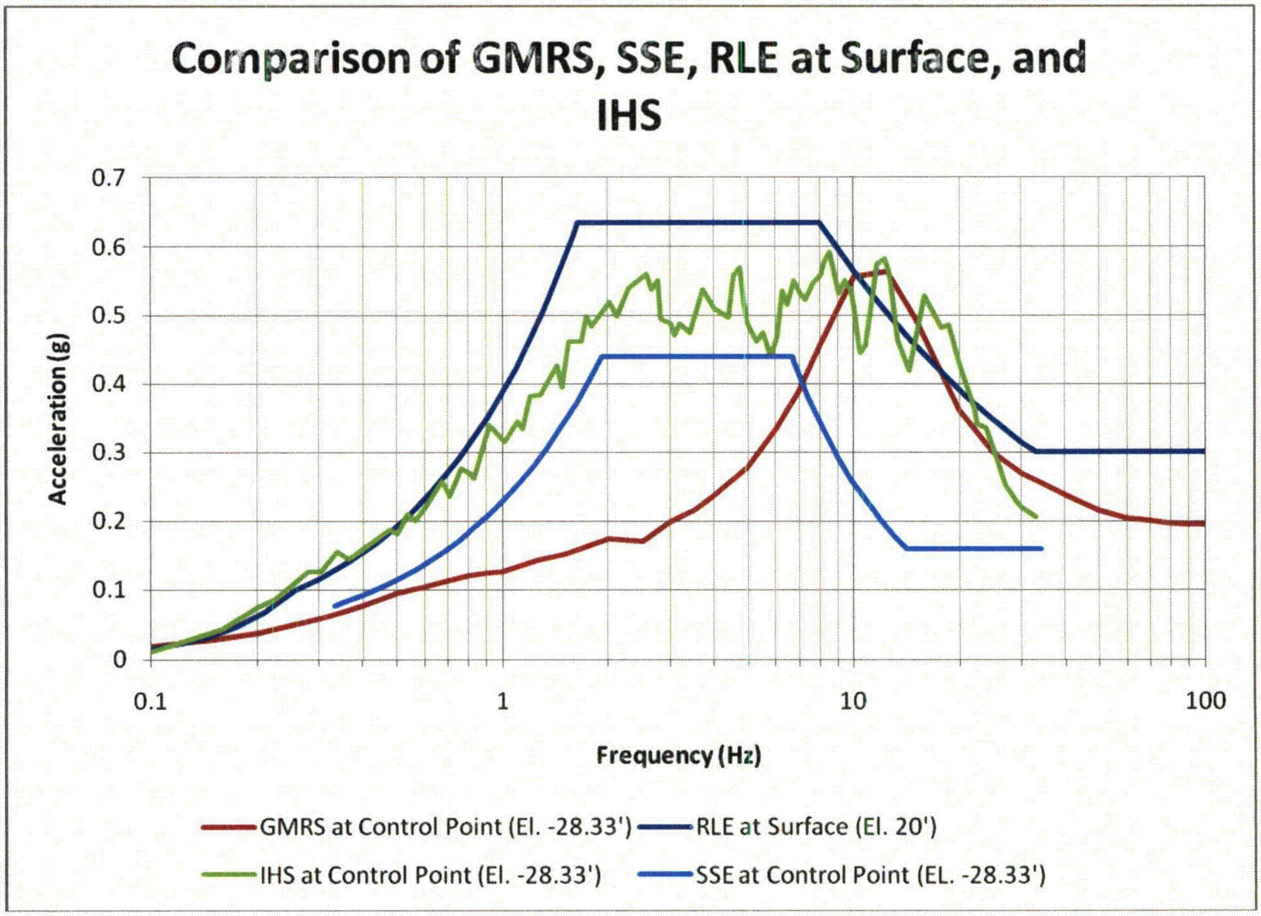

Figure 1.1 – BSEP GMRS, RLE, SSE, and IHS Accelerations vs Frequency

2.0 GENERAL CONSIDERATIONS

Section 3.3.1 of the SPID requires that focused-scope margin submittals be enhanced to bring the assessment in line with full-scope requirements, as described in USNRC NUREG-1407, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities" (Reference 6.4). These enhancements apply to BSEP. Enhancements necessary to upgrade the IPEEE from a focused-scope plant to a full-scope plant include (i) a full-scope detailed review of relay chatter for components such as electric relays and switches and (ii) a full evaluation of soil failures, such as liquefaction, slope stability, and settlement.

The soils and relay evaluations conducted for IPEEE (Section 5.6 and Section 7 of the BSEP Seismic IPEEE, Reference 6.5 Appendix A) are summarized below. Also, an overview of the full-scope soils evaluation and results is provided below.

2.1 Soils Evaluation

The BSEP site is underlain with loose layers of sands and silts (Pleistocene deposits) between existing grade at Elevation 24.0 ft and approximately Elevation -26.0 ft. A very dense sand (Miocene deposit) occurs between Elevation -26.0 ft and the Oligocene Sediments (Shear Wave Velocity = ~5500fps) at Elevation -52.0 ft. The Reactor Building foundations bear directly on the very dense sand strata. The remainder of the plant bears on a structural fill supported on this dense sand. The entire plant area, including a perimeter ring, was excavated to Elevation -25.0 ft and refilled with granular material compacted to relative densities consistent with bearing pressure requirements.

2.1.1 IPEEE Focused-Scope Summary

Soil failure was deemed not a significant issue based on a review of the UFSAR.

According to the BSEP Updated Final Safety Analysis Report (UFSAR) (Reference 6.8), Section 2.5.4.8, after analyzing the Pleistocene deposits against the conditions necessary for the soil to be susceptible to liquefaction, it was concluded that liquefaction of the Pleistocene deposits, because of the high percentage of fine-grained soils, will not occur at the site under dynamic loadings of the Design Basis Earthquake (DBE).

Buried piping and ductbanks are addressed by reference to design and analysis based on ASME publications by Goodley. This approach is augmented by engineering judgment and good practices, such as piping layout and using flexible building penetrations.

2.1.2 IPEEE Full-Scope Summary

The soils evaluation considered relevant structures that house or could affect equipment on the Safe Shutdown Equipment List (SSEL). These structures include the control building, diesel generator building and tank vault, reactor buildings, service water intake structures, intake canal, and the stack. Additional soil borings from recent site investigations were included with original construction records for screening. Analysis and screening for the full-scope investigation has been documented in Reference 6.36.

The failure mechanisms from EPRI NP-6041 (Reference 6.4) were considered. Liquefaction was screened out for the backfilled part of the site because adjusted

blowcount values are higher than the threshold. Liquefaction for the intake canal was screened from further review by consideration of consequences similar to Table 7-1A of Reference 6.4. An evaluation of the bearing capacity shows a factor of safety near 3 confirming no concerns for bearing capacity failure. Seismic induced settlement screens out due to the critical acceleration ratio required to induce seismic settlement being much larger than the acceleration ratio associated with the RLE. The sites topographic profile is relatively flat. The slight differences in site topography at the site in proximity to safety related structures are insufficient for any slope movement, therefore slope stability screens out at BSEP. Buried piping is placed in compacted backfill and geotechnical concerns for this fill material are screened from further review. The original design of buried piping and ductbanks were addressed in the BSEP IPEEE and was adequate for larger displacements associated with the RLE. Dynamic pressure on basement walls has been considered. The BSEP Class I structures were screened from further review during IPEEE based on Table 2-3 of EPRI NP-6041-SL. The original evaluation of dynamic pressure on basement walls was reviewed against margins analysis recommendations consistent with the IPEEE (Reference 6.8), and the basement walls are screened out from additional analysis. Conservative analysis of seismic sliding stability shows adequate margin.

2.2 Relay Evaluation

A focused-scope relay evaluation was performed for the BSEP IPEEE. However, further rigor is required for the relay evaluation to be considered adequate for a full-scope evaluation. As a focused-scope plant, Unresolved Safety Issue (USI) A-46 procedures were to be followed. If low seismic-ruggedness relays were discovered during the A-46 review, the relay review was expanded to include relays outside the scope of A-46, but within the scope of the IPEEE. For a full-scope evaluation, A-46 procedures should be followed and systems within the scope of the IPEEE (including those that are also within the scope of A-46) using appropriate margin (EPRI NP-6041) or A-46 procedures at the RLE. The full-scope detailed review of relay chatter required in SPID Section 3.3.1 has not been completed. As identified in the NEI letter to the USNRC dated October 3, 2013 (Reference 6.20), the relay chatter review is scheduled to be submitted concurrently with the High-Frequency Confirmation, following the schedule proposed in the NEI letter to the USNRC dated April 9, 2013 (Reference 6.22) and accepted in the USNRC's response dated May 7, 2013 (Reference 6.23).

Per the guidance in Reference 6.20, the full-scope relay review for BSEP will be performed after receipt of the high frequency confirmation study.

3.0 PREREQUISITES

Responses to each of the following *Prerequisites* listed in Section 3.3.1 of the SPID are provided such that the BSEP IHS may be used for comparison to the GMRS.

3.1 Prerequisite 1 – Confirmation of IPEEE Commitments

Section 3.3.1 of the SPID identifies Prerequisite 1 as the confirmation that commitments made under the IPEEE have been met. If the commitments were not met, licensees should address and close those commitments.

3.1.1 Prerequisite 1 Commitments

The Seismic Review Team (SRT) identified issues related to maintenance, housekeeping, and seismic interaction that required work orders to satisfy SRT field issues. Items were also noted as requiring repairs or modifications. These items were resolved as part of the A-46 program. See Section 3.2 of this report for resolution of A-46 items.

Numerous equipment items were selected for HCLPF evaluation after walkdowns were completed. These items were grouped into 8 HCLPF calculations based on similar characteristics. The purpose of these calculations was to demonstrate that each item had a seismic capacity greater than the RLE (0.3g). These groups are as follows:

1). Motor Control Centers

2). Main Steam Isolation Valves and Drywell (DW) Drain Valves

3). Core Spray Room and Residual Heat Removal (RHR) Room Coolers

4). Station Battery Racks

5). Control Room Cabinets

6). Diesel Generator Control Panels

7). RHR Heat Exchanger

8). 120/208 Volt Alternating Current (VAC) Main Uninterruptible Power Supply (UPS) Distribution Panels

Specific equipment identification numbers (organized by group), associated calculation number, and HCLPF capacity are shown in Table 3.1 (see Reference 6.5, Appendix A, Section 5.4.1, Section 6, and Table 6-1).

Table 3.1 Summary of Items Selected for HCLPF Evaluation

Group	Equipment No. (Tag No.)	Equipment Description	EQE Calculation Number (Reference 6.13)	HCLPF Capacity
1	1-1CA, B and 2-2CA, B	Control Building MCCs	52213-C-045	>0.3g
	1-1XA, B, 1XA, B-2	MCCs 1XA, 1XA-2, 1XB, 1XB-2	52213-C-045	>0.3g
	1-1XC, 1XD	MCCs 1XC, 1XD	52213-C-045	>0.3g
	1-1XDA, 1XDB	MCCs 1XDA, 1XDB	52213-C-045	>0.3g
	1-1XE, F, G, H, L, M	MCCs 1XE, 1XF, 1XG, 1XH, 1XL and 1XM	52213-C-045	>0.3g
	2-2XA, B, 2XA, B-2	MCCs 2XA, 2XA-2, 2XB, 2XB-s	52213-C-045	>0.3g
	2-2XC, 2XD	MCCs 2XC, 2XD	52213-C-045	>0.3g
	2-2XDA, 2XDB	MCCs 2XDA, 2XDB	52213-C-045	>0.3g
	2-2XE, F, G, H, L, M	MCCs 2XE, 2XF, 2XG, 2XH, 2XL, and 2XM	52213-C-045	>0.3g
	2-2A, 2B-250VDC	Switchboard 2A and 2B	52213-C-045	>0.3g
	2-DGA, B, C, D	Diesel Generator Building MCCs	52213-C-045	>0.3g
	1-1PA, PB & 2-2PA, PB	Service Water Intake MCCs	52213-C-045	>0.3g
2	1, 2-G16-F003, F004	DW Drain Valve (mini-MSIV)	52213-C-048	>0.3g
	1, 2-G16-F019, F020	DW Drain Valve(mini-MSIV)	52213-C-048	>0.3g
	1, 2-B21-F022A, B, C, D	Main Steam Line Inboard Isolation	52213-C-048	>0.3g
	1, 2-B21-F028A, B, C, D	Main Steam Line Outboard Isolation	52213-C-048	>0.3g
3	1-VA-1C, 1D-FCU-RB	Fan for CS Cooling Unit A and B	52213-C-054	>0.3g
	2-VA-2C, 2D-FCU-RB	Fan for CS Cooling Unit A and B	52213-C-054	>0.3g
	1-VA-1A, 1B-FCU-RB	Fan for RHR Cooling Unit A and B	52213-C-054	>0.3g
	2-VA-2A, 2B-FCU-RB	Fan for RHR Cooling Unit A and B	52213-C-054	>0.3g
	1, 2-VA-ZS-936A	Fan/Damper Limit Switches	52213-C-054	>0.3g
	1, 2-VA-ZS-936B	Fan/Damper Limit Switches	52213-C-054	>0.3g
4	1-1A-1, 2-125VDC-BAT	Battery 1A-1 and 1A-2	52213-C-034	>0.3g
	1-1B-1, 2-125VDC-BAT	Battery 1B-1 and 1B-2	52213-C-034	>0.3g
	2-2A-1, 2-125VDC-BAT	Battery 2A-1 and 2A-2	52213-C-034	>0.3g
	2-2B-1, 2-125VDC-BAT	Battery 2B-1 and 2B-2	52213-C-034	>0.3g

Table 3.1 (continued) Summary of Items Selected for HCLPF Evaluation

Group	Equipment No. (Tag No.)	Equipment Description	EQE Calculation Number (Reference 6.13)	HCLPF Capacity
5	1,2-CAC-TY-4426-1	Supp Pool Temp Monitor Microprocessors	55213-C-047	>0.3g
	1,2-CAC-TY-4426-2	Supp Pool Temp Monitor Microprocessors	55213-C-047	>0.3g
	1,2-H12-P601	Engineering Safeguards Vertical Boards	55213-C-047	>0.3g
	1,2-H12-P612	Feedwater and Reactor Recirc Instrument Panels	55213-C-047	>0.3g
	1,2-XU-02	Main Control Room RTG Boards	55213-C-047	>0.3g
	1,2-H12-P614	NSSS Temp Rec and Leak Detect Vertical Board S- IPEEE	55213-C-047	>0.3g
	1,2-H12-P613	Process Instrument Cabinets	55213-C-047	>0.3g
	1,2-H12-P603	Reactor Control Panels	55213-C-047	>0.3g
	1,2-XU-03	RX, Cont & Turb Bldg HVAC & Turb Aux Cntl Pnls	55213-C-047	>0.3g
	1,2-H12-P628	Auto Depressurization System Relay Vertical Boards	55213-C-047	>0.3g
	1,2-H12-P624	Benchboard Auxiliary Relay Cabinets	55213-C-047	>0.3g
	1,2-XU-09	BOP Process Instrument Power Supply Cabinets	55213-C-047	>0.3g
	1,2-XU-51	BOP RTG Board	55213-C-047	>0.3g
	1,2-H12-P626	Core Spray A Relay Vertical Boards	55213-C-047	>0.3g
	1,2-H12-P627	Core Spray B Relay Vertical Boards	55213-C-047	>0.3g
	1-XU-39	Div-I Term Cab for EB & ED Systems	55213-C-047	>0.3g
	2-XU-41	Div-I Term Cab for EB & ED Systems	55213-C-047	>0.3g
	1-XU-40	Div-II Term Cab for RTGB XU-2	55213-C-047	>0.3g
	2-XU-42	Div-II Term Cab for RTGB XU-2	55213-C-047	>0.3g
	1-XU-07	ESS Logic Cabinet – DG1	55213-C-047	>0.3g
	1-XU-24	ESS Logic Cabinet - DG2	55213-C-047	>0.3g
	2-XU-29	ESS Logic Cabinet - DG3	55213-C-047	>0.3g
	2-XU-30	ESS Logic Cabinet - DG4	55213-C-047	>0.3g
	1,2-XU-73	Fluid Flow Det Cabinets for SRV Position Ind	55213-C-047	>0.3g
	1,2-H12-P620	HPCI Vertical Relay Panels	55213-C-047	>0.3g
	1,2-B21-PNL-QV9	Main Steam Leak Detection Cabinets	55213-C-047	>0.3g
	1,2-H12-P622	NSSS Inboard Valve Relay Boards	55213-C-047	>0.3g

Table 3.1 (continued) Summary of Items Selected for HCLPF Evaluation

Group	Equipment No. (Tag No.)	Equipment Description	EQE Calculation Number (Reference 6.13)	HCLPF Capacity
5 (cont'd)	1,2-H12-P623	NSSS Outboard Valve Relay Boards	55213-C-047	>0.3g
	1,2-XU-75	Post Accident Misc Instrument Cabinets	55213-C-047	>0.3g
	1,2-XU-79	Post Accident Misc Instrument Cabinets	55213-C-047	>0.3g
	1,2-H12-P608	Power Range Neutron Monitoring Panels	55213-C-047	>0.3g
	1,2-H12-P606	Radiation Monitoring Cabinets	55213-C-047	>0.3g
	1,2-H12-P630	Reactor Annunciator Cabinets	55213-C-047	>0.3g
	1,2-H12-P617	RHR A Relay Vertical Boards	55213-C-047	>0.3g
	1,2-H12-P618	RHR B Relay Vertical Boards	55213-C-047	>0.3g
	1,2-XU-50	RIP Terminal Cabinets	55213-C-047	>0.3g
	1,2-XU-58	RIP Terminal Cabinets Div. I - IPEEE	55213-C-047	>0.3g
	1,2-XU-57	RIP Terminal Cabinets Div. II – IPEEE	55213-C-047	>0.3g
	1,2-H12-P616	Rod Manual Control Panels	55213-C-047	>0.3g
	1,2-H12-P615	Rod Position System Information Cabinets	55213-C-047	>0.3g
	1,2-H12-P610	RPS Test and Monitor Panels	55213-C-047	>0.3g
	1,2-XU-65	RPS Trip Calibration Cabinets, Channel A1	55213-C-047	>0.3g
	1,2-XU-66	RPS Trip Calibration Cabinets, Channel A2	55213-C-047	>0.3g
	1,2-XU-67	RPS Trip Calibration Cabinets, Channel B1	55213-C-047	>0.3g
	1,2-XU-68	RPS Trip Calibration Cabinets, Channel B2	55213-C-047	>0.3g
	1,2-H12-P609	RPS Trip System A and B Main Control Room Panels	55213-C-047	>0.3g
	1,2-H12-P611	RPS Trip System B Main Control Room Panels	55213-C-047	>0.3g
	1,2-XU-27	RX, DG & CB HVAC Div. I Terminal Cabinets	55213-C-047	>0.3g
	1,2-XU-28	RX, DG & CB HVAC Div. II Terminal Cabinets	55213-C-047	>0.3g
	1,2-XU-13	Terminal Cabinets for Systems SW, EB, RCC, & BAT	55213-C-047	>0.3g
	1,2-XU-25	Terminal Cabinets for Systems SW, EB, RCC, & BAT	55213-C-047	>0.3g
	1,2-XU-53	Terminating Cabinets Div. I – IPEEE	55213-C-047	>0.3g

Table 3.1 (continued) Summary of Items Selected for HCLPF Evaluation

Group	Equipment No. (Tag No.)	Equipment Description	EQE Calculation Number (Reference 6.13)	HCLPF Capacity
5 (cont'd)	1,2-XU-56	Terminating Cabinets Div. II – IPEEE	55213-C-047	>0.3g
	1,2-XU-63	Trip Calibration Cabinets – ECCS Div. I	55213-C-047	>0.3g
	1,2-XU-64	Trip Calibration Cabinets – ECCS Div. I	55213-C-047	>0.3g
	1,2-XU-76	TSC/EOF Computer Isolator Cabinets	55213-C-047	>0.3g
	1,2-XU-77	TSC/EOF Computer Isolator Cabinets	55213-C-047	>0.3g
6	2-DGX-ENG-CTRL-PNL	DG1, 2, 3 and 4 Engine Control Panel	52213-C-050	>0.3g
	2-DGX-EXCIT-PNL	DG1, 2, 3 and 4 Excitation Panel	52213-C-050	>0.3g
	2-DGX-GEN-CTRL-PNL	DG1, 2, 3 and 4 Generator Control Panel	52213-C-050	>0.3g
7	1-E11-B001A	RHR Heat Exchanger 1A	52213-C-053	>0.3g
	2-E11-B001A	RHR Heat Exchanger 2A	52213-C-053	>0.3g
	2-E11-B001B	RHR Heat Exchanger 2B	52213-C-053	>0.3g
8	1-1A-UPS and 2-2A-UPS	120/208 VAC Main UPS DP	52213-C-049	>0.3g

3.1.2 Prerequisite 1 Conclusions

All equipment items selected for evaluation were shown to have HCLPF capacities greater than the RLE; therefore, no further action was required in this regard. All A-46 outlier issues have been resolved as well (see Section 3.2), meaning all IPEEE commitments have been met.

3.2 Prerequisite 2 – Confirmation of IPEEE Modifications

Section 3.3.1 of the SPID identifies Prerequisite 2 as the confirmation of whether all of the modifications and other changes credited in the IPEEE analysis are in place. Section 1.3.5.1 of the IPEEE states that there were no significant seismic issues identified which require resolution or reporting in the IPEEE submittal. Section 11 of Appendix A of the IPEEE states that the SRT took note of items that required repair or modification; however, these items were to be resolved as part of the A-46 program.

In March of 1997, the USNRC requested more information from Carolina Power and Light (CP&L) to support their review of the plant-specific summary report of the A-46 program for BSEP. Items of significance included whether the letter, not simply the intent, of certain GIP caveats was followed; confirmation that all anchorage, load path, and interaction issues were resolved for cabinets and panels; a recommendation to minimize the number of essential relays; what corrective actions had been taken to address a corrosion problem in the mechanical Heating, Ventilation, and Air-Conditioning (HVAC) room; and how the In-Structure Response Spectra were used. In June, 1997, CP&L provided their response (Reference 6.12).

A letter dated September 11, 1998 from CP&L (Reference 6.24) gave notice to the USNRC that CP&L had completed final outlier resolution for both BSEP Unit 1 and Unit 2. The Unit 1 outlier resolutions were documented in CP&L calculation number 1SEIS-0028 (Reference 6.25). Unit 2 outlier resolutions were documented in CP&L calculation number 2SEIS-0028 (Reference 6.26). These calculations were reviewed to confirm that outlier resolutions do not change the basis for seismic margin conclusions included in IPEEE analyses.

In a letter from the USNRC dated August 5th, 1999, the USNRC stated that the corrective actions and physical modifications for A-46 outliers were satisfactorily completed and sufficient basis provided to close the A-46 review at BSEP (Reference 6.9). It is therefore concluded that all modifications and requested changes credited in the IPEEE analysis are in place.

3.3 Prerequisite 3 – Confirmation of Justification of Identified NUREG-1407 Deficiencies

Section 3.3.1 of the SPID identifies Prerequisite 3 as the confirmation that any identified deficiencies or weaknesses to NUREG-1407 in the plant-specific USNRC Safety Evaluation Report (SER) are properly justified to ensure that the IPEEE conclusions remain valid.

In the SER dated November 18th, 1998 (Reference 6.10), the USNRC concluded that the IPEEE for BSEP was complete with regard to the information requested by Supplement 4 to Generic Letter (GL) 88-20 (Reference 6.11) and associated guidance in

NUREG-1407 (Reference 6.4). It is therefore concluded that Prerequisite 3 of the SPID has been satisfied.

3.4 Prerequisite 4 – Confirmation of Major Plant Modifications since IPEEE

Section 3.3.1 of the SPID identifies Prerequisite 4 as the confirmation that major plant modifications that have been implemented since the completion of the IPEEE evaluation have not degraded or impacted the conclusions reached in the IPEEE.

As part of the industry response to Near-Term Task Force (NTTF) Recommendation 2.3: Seismic, EPRI produced EPRI 1025286, "Seismic Walkdown Guidance: For Resolution of Fukushima Near-Term Task Force Recommendation 2.3: Seismic" (Reference 6.14). One of the purposes of this response was to perform walkdowns to identify and address degraded, nonconforming, or unanalyzed conditions through the corrective action program. Section 3 of Reference 6.14 requires that representative items that are major new and replacement equipment (since the completion of IPEEE) as well as equipment enhanced due to the vulnerabilities identified during the IPEEE program be included on the Seismic Walkdown Equipment List (SWEL). The subsequent seismic walkdowns were to focus on adverse seismic conditions, including, anchorage, spatial interactions, and other adverse seismic conditions.

In response to NTTF Recommendation 2.3, BSEP followed the guidance of Reference 6.14 in producing their response. This evaluation is documented in BSEP EC-87913 and EC-87912 (Reference 6.18 and Reference 6.17, for Unit 1 and Unit 2, respectively). As part of this effort, major modifications completed since the completion of IPEEE were reviewed, and a representative sample of new and replacement equipment was included in the BSEP SWEL. These items were subsequently walked down and evaluated. For BSEP Unit 1, 13 major modifications were identified and 11 were included on the SWEL. For Unit 2, 19 major modifications were identified and 12 of these were included on the SWEL. These are listed in Attachment Z10 of EC 87913 and 87912, respectively (References 6.18 and 6.17). Most of these modifications consisted of replacing worn valves, gauges and other worn components. Larger modifications included a permanent change to the Chlorine Detection System for the Control Building HVAC system, the replacement of Control Room condensing units, and a rerouting of ductwork for the Residual Heat Removal Cooler. There were no potential adverse seismic conditions noted for any of the modified/new equipment. Therefore, it is determined that the major plant modifications completed since IPEEE have not degraded/impacted the conclusions reached in the IPEEE report.

4.0 ADEQUACY DEMONSTRATION

The following sections describe the methodology used and adherence to applicable guidance associated with the BSEP IPEEE evaluation. More specifically, adherence to the requirements set forth in NUREG-1407 (Reference 6.4) and other applicable guidance is presented for each of the criteria listed in Section 3.3.1 of the SPID, "Adequacy Demonstration". A statement as to whether the methodology and results are adequate for screening purposes is also provided.

NUREG-1407 defines the EPRI SMA methodology (Reference 6.6), with some enhancements, as an acceptable method for addressing the IPEEE objectives. The BSEP SMA followed the aforementioned guidance, as discussed in the following sections.

4.1 Structural Models and Response Analysis

4.1.1 Structural Models and Response Analysis Applicable Guidance

NUREG-1407 (Reference 6.4) does not require any additional enhancements over and above the guidance in EPRI NP-6041 regarding structural models and response analysis. Therefore, the adherence of the BSEP IPEEE to applicable guidance is based on a comparison to the guidance in EPRI NP-6041.

Section 4 of EPRI NP-6041 recommends that existing structural models to be used in the SMA be reviewed for adequacy. Inclusion of torsional effects (if applicable), appropriate mass and stiffness distribution, modeling of floor and roof diaphragms, out-of-plane floor flexibility, and significance of nonlinear response are all recommended for review.

With regard to response analysis, it is recommended that the effects of soil-structure interaction (SSI) be accounted for in major structures at sites with soil shear wave velocity at the foundation/soil interface of 3,500 ft/sec or lower. Table 4-1 of EPRI NP-6041 contains recommended damping values for structures. The recommended damping value for a reinforced concrete structure beyond or just below yield is 10%. Similarly, Table 4-3 of EPRI NP-6041 contains recommended damping values for components and subsystems. The guidance also recommends that the structural seismic responses be combined considering three-dimensional effects accounted for by the Square Root of the Sum of the Squares (SRSS) or the 100, 40, 40 method.

4.1.2 Structural Models and Response Analysis Methodology

The BSEP Seismic IPEEE report contains a brief description of the models and analysis methodology used. The UFSAR, other licensing documents, and several EQE calculations provide further details for these items.

There are four Class I structures that are part of the BSEP Seismic IPEEE. These are the Primary and Secondary Containment (P&SC), Service Water Intake Structure (SWIS), Control Building (CB), and Diesel Generator Building (DGB). For resolution of USI A-46, the ISRS specified for these buildings correspond to two types of ground motion. For the DGB and CB, the input corresponds to the design basis earthquake (DBE), specified in the plant UFSAR and having a peak horizontal ground acceleration (PGA) of 0.16g. The ground response spectra for vertical motion associated with the DBE is defined as two-thirds of the horizontal motions. For the SWIS and the P&SC, new A-46 in-structure spectra were developed with input ground motion specified as the

Regulatory Guide (RG) 1.60 design response spectra, having a horizontal PGA of 0.16g (plant DBE) (Reference 6.27, Section 2).

The ISRS for use in the IPEEE were obtained by scaling the conservative design response spectra specified for A-46. As such, the models and response analysis for two structures are based on the UFSAR and for the other two structures, they are based on the new spectra developed for A-46.

Primary and Secondary Containment
The P&SC is made up of three units: The reactor building (secondary containment), the Drywell (primary containment), and the Reactor Pressure Vessel (RPV) System. All of these units are supported and hence coupled upon a massive, rigid foundation mat. The foundation mat is rectangular, approximately 190 feet (X-direction) x 154 feet (Y-direction) in plan. The reactor building is square in plan (142 feet x 142 feet) for most of its height. The drywell and the RPV system are approximately axisymmetric about a vertical axis (Reference 6.8, Section 3.7.2.1.3.1). This structure is founded on the natural dense sand layer (Lower Yorktown Formation).

The structural model for the P&SC used for the analyses was based on the original dynamic building model documented in the UFSAR (Reference 6.8).

The Drywell, the Sacrificial Shield, and the RPV are interconnected by seismic restraints, represented by coupling springs as truss elements (Appendix A, Reference 6.27).

Conservative, design response spectra were generated for the P&SC from three-dimensional SSI analyses using time histories whose response spectra match the RG 1.60 design response spectra (Reference 6.27, Section 3.2).

Best-estimated properties for the final model were obtained from the existing lumped mass model (Reference 6.8) and the structural drawings. The eigensolution recovered 30 modes, capturing approximately 80% of the total lateral mass of the structure. However, when only the dynamic lateral mass of the structure is considered, i.e., the masses associated with the fixed nodes (foundation mass) are subtracted from the total, 97% of the dynamic mass is captured by the first 30 modes (Reference 6.27, Appendix A).

The high-strain profiles and the structural model were combined to build three soil-structure interaction (SSI) models (best estimate, lower bound, and upper bound). In these models, the structure was considered embedded below EL +19' and foundation impedances were obtained with the computer code SUPELM (Reference 6.27, Appendix A).

A 7% damping value was assumed for the structure. The seismic input was located at the surface (EL +19') and spatial variation of the motion with depth was included in the analyses. Three-dimensional SSI analyses were performed with the EQE proprietary computer program SSIN for each soil profile. For each of the analyses, it was considered that the three components of the seismic input were acting simultaneously (Reference 6.27, Appendix A).

For each SSI analysis, acceleration time histories were calculated at every mass point for the North-South, East-West, and vertical directions. From these acceleration time histories, ISRS were calculated for 3% and 5% spectral damping. The corresponding

spectra for each soil case were then enveloped, and the enveloped spectra broadened by ±15%. The SSI analyses and the processing of the response spectra were done in compliance with SRP (Reference 6.33) recommendations and USNRC guidelines (Reference 6.27, Appendix A).

Service Water Intake Structure (Reference 6.27, Appendix B)
The SWIS is a rectangular structure with dimensions of 71'-11" in the East-West direction, 104' in the North-South direction, and is about 58'-4" high. It is founded mainly at EL -17'-4" and is embedded up to EL +19'-6". This structure is founded on Class 1 backfill. The exterior North, South, and West walls are in contact with the foundation soil. The East face is not in contact with the soil. The dynamic behavior of the structure itself was controlled by its shear walls, and given the size and amount of them, the SWIS was considered to be a rigid system.

A three-dimensional, lumped mass model of the SWIS was developed (stick model). Equivalent beams represent the ensemble of structural elements between floors, and lumped masses represent the masses of the floors and portions of walls, equipment, and water close to the floors. The equivalent beams are located along the center of rigidity of the section between floors and the lumped masses are located at their center of masses. In this way, the three-dimensional behavior of the structure is captured. The values of the main frequencies of the structure confirm that it is very rigid in comparison to the dominant frequency of the upper soil layer (about 4 Hz). This implies that the global dynamic behavior of the soil-structure system will be controlled by the soft foundation soil and that the structure will behave basically as a rigid "box" on a soft foundation soil.

The horizontal and vertical ground motions defined in RG 1.60 were used as the surface seismic input for the SSI analysis. These input spectra were anchored to the plant SSE, 0.16g. Two artificial acceleration time histories were developed to envelop the horizontal RG 1.60 target, and one artificial acceleration time history was developed to envelop the vertical RG 1.60 target.

To cover the uncertainty in the soil properties, three low strain soil profiles were developed: a best estimate, lower bound, and upper bound case. To perform the SSI analyses, due to the nonlinear behavior of the soil, it was necessary to develop soil properties compatible with the level of strain induced by the seismic waves (high strain properties). Dynamic wave analyses were performed for the three low strain soil profiles with the computer code SHAKE. The seismic input for these analyses was one of the horizontal artificial time histories described above.

The high strain soil profiles and the structural model were combined to build three SSI models (best estimate, lower bound, and upper bound). In these models, the structure was considered embedded below EL + 19' and the North, South, and West sides bonded to the soil. The East side was considered completely unbonded to the soil. A 7% damping was assumed for the structure. The seismic input was located at the surface (EL +19') and spatial variation of the motion with depth was included in the analyses.

Three-dimensional SSI analyses were performed with the computer program SASSI for each soil profile. For each of the analyses, it was considered that the three components of the seismic input were acting simultaneously. For each SSI analysis, acceleration time histories were calculated at every mass point for the North-South, East-West, and vertical directions. From these acceleration time histories, ISRS were calculated for several damping values. The corresponding spectra for each soil case were then

enveloped, and the envelope spectra broadened by ± 15%. The SSI analyses and processing of the response spectra were done in compliance with the SRP (Reference 6.33) recommendations and USNRC guidelines.

Control Building (References 6.8 and 6.28)
The foundation of the Control Building is 236'-8" long by 69' wide and was considered to be surficial. The control building was simulated by a lumped-mass model consisting of three masses and connected by massless members. Horizontal movement at the base was assumed restrained, so only the rotary moment of inertia was considered at EL 21.0' of the building. Soil-structure interaction was idealized in terms of a rotational spring (Reference 6.8, Section 3.7.2.2.1).

With the exception of the base mat at EL 23', the floor response spectra for the Control Building was derived using the time history method of analysis (Reference 6.8, Section 3.7.2.2.3.5). These response spectra were enveloped and broadened up to ±10%.

The Review Level Earthquake floor response spectra for the CB were obtained by scaling the CB spectra for the design basis earthquake. This scaling was done using the dominant mode scaling procedure as presented in Reference 6.6, using the equivalent frequencies and damping ratios of the complete soil-structure system (Reference 6.28, also see Section 4.2 of this report).

Diesel Generator Building (References 6.8 and 6.29)
The DGB has a rectangular foundation with length of 180' and a width of 70'. The foundation is embedded in backfill from EL +19.5' to EL -1.5'. The building and diesel generator pedestals were constructed on a common reinforced concrete mat supported on structural fill.

The DBE floor response spectra for the DGB are documented in Reference 6.35.

Similar to the CB, the DGB RLE in-structure floor response spectra were obtained by scaling the original design SSE spectra using the dominant mode scaling procedure from Reference 6.6. The impedance functions were obtained for only one soil condition, the best estimate soil, since the scaling factors for all three soil cases considered were fairly similar and the seismic SSI response was controlled by the best estimate at the predominant frequency of the system (Reference 6.29).

To obtain the dominant frequencies and damping of the soil-structure system, an equivalent SDOF model was defined. The effect of SSI in the seismic response was modeled by translational and rotational springs and dashpots added to the foundation (Reference 6.29).

4.1.3 Structural Models and Response Analysis Conclusion

Based on the methodology presented above, it is concluded that the structural modeling and response analysis was in accordance with the current analysis practice at the time and that the original analysis models used to generate the existing in-structure response spectra (as well as the newly-generated spectra) are considered to be adequate and to meet the recommendations of EPRI NP-6041 (Reference 6.6).

While an exhaustive model review was not documented in the BSEP IPEEE, the structural models and response analysis were reviewed and determined to be adequate. Therefore, the structural modeling and response analysis used in the IPEEE evaluation

is considered acceptable for the screening purposes defined in the SPID (Reference 6.2).

4.2 In-Structure Demands

4.2.1 In-Structure Demands Applicable Guidance

Aside from specifying the seismic margin earthquake (SME) for BSEP as the NUREG/CR-0098 median rock or soil spectrum anchored to 0.3g, NUREG-1407 (Reference 6.4) does not require any additional enhancements over and above the guidance in EPRI NP-6041 regarding in-structure demands. Therefore, the adherence of the BSEP IPEEE to applicable guidance is based on a comparison to the guidance in EPRI NP-6041.

Section 4 of EPRI NP-6041 defines one acceptable method for scaling in-structure response spectra (ISRS) as a direct scaling and frequency shifting of the SSE-based ISRS. This method is considered acceptable for rock sites (assuming the original structural models are acceptable) provided the overall shapes of the SSE and SME ground response spectra are similar. It is recommended that the ratio of peak floor accelerations be obtained from the ratio of the spectral accelerations at the dominant response frequency. For soil sites where there are major changes in composite modal damping ratios, or increases in the geometric damping, or for soil or rock sites where the shape of the SME ground response spectra are significantly different from the SSE response spectra, it is recommended that the in-structure response spectra be developed for the SME by conducting new analyses (Reference 6.6, page 4-18).

4.2.2 In-Structure Demands Methodology

For methodology related to analysis methods and broadening of the A-46 spectra, see Section 4.1 of this report. In-structure floor response spectra corresponding to the Review Level Earthquake (RLE) are required for the Seismic Margins Assessment (SMA). For BSEP Units 1 and 2, the RLE is defined as an earthquake having a response spectrum that matches the median CR-0098 spectral shape for soil anchored to a zero-period acceleration (ZPA) of 0.30g.

The ISRS for the four Class I buildings that make up BSEP were obtained from the A-46 spectra, using scaling procedures which followed the recommendations given in EPRI NP-6041 (Reference 6.6). When appropriate, frequency shifting of the spectra, consistent with changes in frequencies of the complete soil-structure system, was considered in the scaling methodology, along with amplification of the spectral ordinates. An analogous procedure was used to scale the vertical ISRS (Reference 6.5, Appendix A, Section 4.1).

The dominant mode scaling procedure from Reference 6.6 was used, since the input motion spectra for the A-46 and SMA earthquakes have similar shapes over the relevant range of frequencies. It was also expected that the SSI be similar for both cases (Reference 6.30). The procedure uses two scaling factors, one for the frequency shift, and one for the spectral amplitude change, to predict the seismic response of a given system when the input motion is changed (Reference 6.5, Appendix A, Section 4.2). The factor for the spectral frequency shift is controlled by changes in the SSI. The factor for the spectral amplitude can be defined as the ratio between the spectral ordinates of the

A-46 and the SMA acceleration input spectra at the predominant frequency and damping ratios of the combined SSI system.

To obtain the predominant frequencies and damping of the soil-structure system, this system was represented by an equivalent Single Degree of Freedom (SDOF) model. The dynamic behavior of the superstructure is modeled using lumped mass, m, at an equivalent height, h, with spring and dashpot constants, k and c, respectively. The equivalent height of the lumped mass is defined such that it produces the same rocking effect at the foundation mode as the fixed-base model. The response of the superstructure is dominated by the fundamental mode characterized by these parameters. This concept is the basis of the dominant mode scaling procedure (Reference 6.5, Appendix A, Section 4.3).

The effect of soil-structure interaction on the seismic response is modeled with translational and rotational springs and dashpots at the foundation. The values of these spring and dashpot constants are obtained from the impedances of the soil-foundation system. Impedances for the four Class I buildings that make up the BSEP site were calculated for both the design basis and the SMA review level earthquakes. A 7% structural damping value was considered for the generation of the SMA spectra (Reference 6.5, Appendix A, Section 4.3).

The vertical input ground motion specified for the seismic IPEEE is defined as two-thirds of the horizontal motion (Reference 6.7). Since the vertical A-46 ISRS is also defined as two-thirds of the horizontal spectra, the scale factors used to obtain the vertical SMA ISRS are the same as for the horizontal case. This method was used to generate the vertical SMA ISRS for the Control Building and the Diesel Generator Building (Reference 6.5, Appendix A, Section 4.4).

However, for the Reactor and Containment and Service Water Intake Structure (SWIS), the vertical A-46 ISRS were available from the SSI analyses, therefore, these generated spectra were scaled directly to obtain the vertical SMA spectra (Reference 6.5, Appendix A, Section 4.4).

References 6.28, 6.29, 6.30, 6.31, and 6.32 provide the calculations and results of the scaling procedure for the four Class I structures within BSEP.

4.2.3 In-Structure Demands Conclusion

The ISRS for the BSEP SMA are in compliance with EPRI NP-6041 and NUREG-1407, and are considered to be adequate for screening purposes.

4.3 Selection of Safe Shutdown Equipment List (SSEL)

The safe shutdown equipment list (SSEL) identifies equipment necessary to maintain operability of those frontline systems required to safely shut down the plant and maintain it in hot or cold shutdown for 72 hours following an RLE event. The relevant plant functions are:

- Reactivity control
- Reactor coolant system inventory control
- Reactor coolant system pressure control
- Decay heat removal

Essential equipment, and those structures and subsystems that either house this equipment, or whose failure could potentially contribute sequentially to its failure, were required to be assessed for the IPEEE program. An initial SSEL, listing equipment along candidate 'success paths', and the series of interrelated equipment and components dependent on each other in order to maintain functionality during a safe shutdown scenario, is identified prior to the initiation of plant walkdowns.

4.3.1 SSEL Applicable Guidance

Section 3.2 of NUREG-1407 (Reference 6.4) states that the methodology documented in EPRI NP-6041 (Reference 6.6) for the selection of safe shutdown equipment meets the objectives set forth by the IPEEE program for a full or focused-scope site; however, for IPEEE purposes, it is desirable that, to the maximum extent possible, the alternative path involve operational sequences, systems, piping runs, and components different from those used in the preferred path. The procedure used in the trial application of the EPRI methodology (EPRI NP-6359, Reference 6.34) provides an acceptable approach for use in selecting success paths (preferred and alternative). NUREG-1407 also recommends that the number of success paths be narrowed to two and the narrowing documented in detail.

The USNRC, in Generic Letter No. 88-20, Supplement 4 (Reference 6.11), indicated that the EPRI methodology is acceptable with the following additional conditions:

1) Non-seismic failures and human actions should be considered in accordance with guidance provided in NUREG-1407.
2) Containment isolation and mitigation systems should be examined as discussed in NUREG-1407. The focus is to identify vulnerabilities that involve early failure of containment functions.

4.3.2 SSEL Methodology

The BSEP seismic IPEEE was completed in accordance with the requirements of EPRI-6041, NUREG-1407, and Generic Letter 88-20, Supplement 4.

A preliminary walkthrough was performed to search for potential low-seismic-capacity components. Reference 6.6 was used in choosing the items and identifying boundary conditions and assumptions (Reference 6.5, Appendix A, Section 3).

Success path logic diagrams (SPLD) were constructed based on an understanding of available plant equipment function as well as the plant's normal and emergency operating procedures. The SPLDs were reviewed and agreed upon by Brunswick operations personnel. They were used as a basis for the identification of the equipment to be included on the SSEL. Equipment selected for inclusion on the SSEL also followed the requirements of the Seismic Qualification Utilities Group (SQUG) Generic Implementation Procedure (GIP, Reference 6.15). Guidance from Reference 6.6 was also used in preparing the format for the list of components.

The assessment of the equipment necessary to maintain the identified functions subsequent to the RLE was made under a set of boundary conditions. Offsite power was assumed to be lost, however, the potential for adverse effects should power not be lost, or if it should be restored, was also considered. The success paths had to be capable of maintaining the plant in either hot or cold shutdown for a period of 72 hours. The success path development addressed seismically-induced transient events or a seismically-induced one-inch Loss of Coolant Accident (LOCA). Non-seismic component or system unavailabilities were not addressed for multiple or redundant trained systems, but were required to be considered for single train systems.

The complete SSEL for BSEP Units 1 and 2 is contained in Appendix C of Appendix A of Reference 6.5. Appendices A and B of Appendix C of Appendix A of Reference 6.5 provide a discussion of the frontline and support systems considered for the safe shutdown paths selected, including a brief discussion of system function, design, and dependency.

The Operations Department review of the SSEL was performed by an USNRC-licensed senior reactor operator. A desktop review was performed to confirm that the safe shutdown options selected for the SSEL were compatible with approved normal procedures, the Emergency Operation Procedures (EOPs), and associated operator training.

The Operations review was thorough, in that, the necessary components for each system were verified to be included on the SSEL. Additionally, instrumentation needed to monitor plant operation (e.g., reactor water level, pressure, power and primary containment parameters) was verified. The reviewer concluded that the SSEL was adequate to place the plant in a safe cold shutdown condition following the prescribed seismic event with some exceptions. A list of changes made as a result of the review is included in Section 3 of Appendix C of Appendix A of Reference 6.5.

The acceptance of the revised SSEL by Operations is documented by memorandum from Mr. Jeffrey H. Bond to Mr. T.R. Jones, et al, dated April 4, 1995. A copy of this memorandum is located in Appendix G of Appendix C of Appendix A of Reference 6.5.

4.3.3 SSEL Conclusion

In light of the acceptance by Operations and considering that the SSEL process was conducted per the guidance from EPRI NP-6041, NUREG-1407 and GL 88-20, Supplement 4, the SSEL for BSEP is adequate for screening purposes.

4.4 Screening of Components

4.4.1 Screening Applicable Guidance

NUREG-1407 (Section 3.2.4.4 of Reference 6.4) allows the use of the screening guidance given in the GIP (Reference 6.15). The guidance also requires the following:

(i) The review is conducted at the appropriate RLE.

(ii) Caveats included in margins reports are observed.

(iii) Limitations on the use of the generic equipment ruggedness spectrum (GERS) are observed.

(iv) Spatial interaction evaluation, such as assessing the effects of flooding, as noted in EPRI NP-6041, is retained.

EPRI NP-6041 provides screening tables to support the seismic capacity screening of SSEL items. Tables 2-3 and 2-4 (Reference 6.6) provide a generic, conservative estimate for the ground motion below which, in general, it is not necessary to perform a seismic margin review for a particular item because that item has, in general, demonstrated a HCLPF capacity above the screening ground motion level. Each table contains a number of caveats that must be met, and the tables should only be used in conjunction with a plant walkdown of equipment by a qualified SRT. It is also noted that the screening tables are primarily intended for items mounted fairly low (less than 40 feet above grade) in stiff nuclear power plant type structures. It is recommended that care be exercised when using the guidance for components mounted significantly more than about 40 feet above grade. The basis for the aforementioned screening tables is provided in Appendix A of EPRI NP-6041 (Reference 6.6).

4.4.2 Screening Methodology

Screening is further discussed in Appendix A, Section 5 of the IPEEE report and is summarized here.

The BSEP seismic IPEEE was completed following the EPRI seismic margins methodology recommended by NUREG-1407 (Reference 6.4) for a focused-scope plant (Reference 6.5, Section 5.3).

Civil structures, equipment, and subsystems were screened following the methodology provided in Reference 6.6 for focused and full-scope plants. Screening criteria are provided in Tables 2-3 and 2-4 of Reference 6.6 for civil structures and equipment and subsystems, respectively. The criteria corresponding to 5%-damped peak spectral acceleration less than 0.8g were used for BSEP, based on the RLE. The guidelines are supplemented by Appendix A of the EPRI seismic margins methodology. Walkdown data sheets provided by Reference 6.6 were used during the SRT walkdowns (Reference 6.5, Section 5.3 of Appendix A).

Interaction reviews were performed to identify falling, impact, spray, and flood issues that could affect success path items. No spray or flood issues were noted during the SRT walkdown. Interaction, housekeeping, and maintenance issues were addressed as part of the A-46 outlier resolution. Items which were not screened out were evaluated with margin calculations (See Section 3.1.1).

Table 5-1 in Appendix A of the BSEP IPEEE lists civil structures, following the format of Reference 6.6, Table 2-3 along with screening results for BSEP. All BSEP Class I structures are screened from further review based on Reference 6.6, Table 2-3 and Section 3.8 of the UFSAR (Reference 6.5, Appendix A, Section 5.5). Table 5-1 is reproduced here (Table 4.1) for convenience and includes updated resolutions of certain items.

Appendix B of the BSEP Seismic IPEEE report provides screening results of equipment and subsystems, as well as items requiring HCLPF analysis or A-46 outlier resolution.

Table 4.1 Summary of Civil Structures Seismic Margin Evaluation

TYPE OF STRUCTURE	DISPOSITION*
Concrete containment	Screened based on EPRI NP-6041, Table 2-3.
Containment Internal Structure	Screened based on EPRI NP-6041, Table 2-3. The structure was designed for greater than 0.1g.
Shear walls, footing, and containment shield walls	Screened based on EPRI NP-6041, Table 2-3. The walls were designed for greater than 0.1g.
Diaphragms	Screened based on EPRI NP-6041, Table 2-3. Diaphragms were designed for greater than 0.1g.
Category I concrete frame structures	Screened based on EPRI NP-6041, Table 2-3. Concrete frame structures were designed for greater than 0.1g. * See Section 5.5 for a summary of the evaluation.
Masonry walls	CP&L will review masonry walls based on past upgrade programs. *Section 5.9.1 states that masonry walls for BSEP are acceptable for the RLE.
Control room ceilings	Screened pending resolution of hardware anomalies identified by the SRT. (See Section 3.2 of this report for resolution of this issue.)
Impact between structures	Screened based on EPRI NP-6041, Table 2-3.
Category II structures with safety-related equipment or with potential to fail Category I structures	Screened pending SSEL refinement to remove all items that are not located within Seismic Category I structures. *See *Composite Safe Shutdown Equipment List* (Appendix C) of Appendix C.
Dams, levees, dikes	Not required, based on proposed Supplement 5 to Generic Letter 88-20.
Soil failure modes	Not required, based on proposed Supplement 5 to Generic Letter 88-20.

* Refer to Appendix A of Reference 6.5 for referenced sections (unless otherwise noted).

Reference to "Category" in this table is intended to be a generic reference to functional requirements. BSEP specific seismic classifications for structures, components and systems are Class I and Class II.

4.4.3 Screening Conclusions

The screening methodology implemented for the BSEP IPEEE was in compliance with the applicable guidance, listed in Section 4.4.1. Therefore, it can be concluded that the screening of BSEP components is adequate for IPEEE screening purposes.

4.5 Walkdowns

4.5.1 Walkdown Applicable Guidance

Section 3.2.4.1 of NUREG-1407 (Reference 6.4) specifies that the methodology documented in EPRI NP-6041 (Reference 6.6) should be used to perform the IPEEE walkdown evaluations for a full or focused-scope plant. The main objective of the plant walkdowns is to find as-designed, as-built, and as-operated seismic weaknesses in the plant SSEL components.

Section 2 of EPRI NP-6041 lists eight (8) critical steps in conducting an SMA. The following four (4) steps (3 through 6 of Section 2, Reference 6.6) are associated with the plant walkdown evaluations.

1). Preparatory Work Prior to Walkdowns (3)

The first stage, or Step 1, of the walkdowns, consists of gathering and reviewing information about the plant design and operation.

2). Systems and Elements Selection ("Success Paths") Walkdown (4)

The second step, the systems and elements selection walkdown, is performed upon completion of a preliminary SSEL. EPRI NP-6041 (Reference 6.6) specifies that success paths should be identified for major plant equipment based on their relative seismic ruggedness. Alternate and preferred success paths should also be identified as a result of the SSEL walkdown. If weak links are observed that are not economically feasible to fix, then a success path that relies on the weak link component is to be avoided. Additionally, EPRI NP-6041 specifies that the most common failure mode for equipment is anchorage failures, which should be a major point of focus during the plant walkdown evaluations.

3). Seismic Capability Walkdown (5)

Step 3 is performed after the selected success paths have been identified in Step 2 and involves the evaluation of all fluid, electrical power and instrumentation systems for potential weak links. The potential for seismic spatial systems interactions (SI) is also determined in Step 3.

4). Subsequent Walkdowns (6)

Step 4 is optional and only necessary for gathering additional data that was not obtained in the preceding steps.

After the walkdown steps have been completed, the systems and components identified in the screening as requiring further assessment can be defined. Additional assessment and information related to the screening process is further discussed in Section 4.4 of this report.

4.5.2 Walkdown Methodology

A preliminary walkthrough was performed to search for potential low-seismic-capacity components. Reference 6.6 was used in choosing the items and identifying boundary conditions and assumptions (Reference 6.5, Appendix A, Section 3).

The seismic capability walkdowns concentrated on the strength and load path of the equipment, as well as function and integrity. The review of equipment anchorage was a prime objective for the walkdown teams. The anchorage evaluation addressed both physical attributes of the anchorage installation and the capacity relative to other success path items, as well as the postulated demand at the RLE.

Interaction reviews were performed to identify falling, impact, spray, and flood issues that could affect success path items. No spray or flood issues were noted during the SRT walkdowns.

The SRT was assembled following the guidance of EPRI NP-6041. Each walkdown team included a minimum of two SRT members who had completed the Seismic Qualification Utility Group (SQUG) Walkdown Screening and Seismic Evaluation training course, as well as EPRI's add-on training for IPEEE. Joint walkdown teams generally consisted of at least one EQE engineer and at least one CP&L engineer. Component screening and HCLPF analysis candidate selection was performed jointly between CP&L and EQE (Reference 6.5, Section 6.1.1).

The SRT had liberal access to plant design drawings, analyses and test reports to use in conjunction with the screening criteria. A considerable amount of information was reviewed and summarized in the Screening and Evaluation Worksheets (SEWS) during a pre-screening. Pre-screening was enhanced by the use of the software program EHOST. EHOST is a database program which has been adapted specifically for use in performing Unresolved Safety Issue (USI) A-46 and IPEEE evaluations. The program is set up so that the data is incorporated into SEWS forms which are consistent with those recommended in EPRI NP-6041. In this manner the walkdown teams, using portable computers with the companion program EWALK, were then able to work more efficiently by having access to SEWS that had already been partially completed.

For a complete description of the walkdown plan and procedure, see Reference 6.16.

Results of the walkdowns can be found in Section 3.1.3 of Reference 6.5 as well as Section 5 of Appendix A of Reference 6.5.

4.5.3 Walkdown Conclusion

The seismic capability walkdowns were conducted and documented in accordance with EPRI NP-6041 and NUREG-1407. The walkdown methodology used is adequate for screening purposes.

4.6 Fragility Evaluations

4.6.1 Fragility Evaluations Applicable Guidance

Aside from specifying the seismic margin earthquake (SME) for BSEP as the NUREG/CR-0098 median rock or soil spectrum anchored to 0.3g, NUREG-1407 (Reference 6.4) does not require any additional enhancements over and above the guidance in EPRI NP-6041 (Reference 6.6) regarding fragility evaluations. Both the fragility analysis and conservative deterministic failure margin (CDFM) methods for computing HCLPFs are acceptable. NUREG-1407 (Reference 6.4) suggests that, for full-scope plants, HCLPFs for unscreened structures and components should be calculated as needed to accurately characterize plant HCLPFs and vulnerabilities and rank them. Therefore, the adherence of the BSEP IPEEE to applicable guidance is based on a comparison to the guidance in EPRI NP-6041.

EPRI NP-6041 adopts the CDFM approach as an acceptable method to compute the HCLPF values of structures and components. As listed in Section 2 of EPRI NP-6041 (Pages 2-45 and 2-47, Reference 6.6), the approach is intended to meet the following criteria:

1). For the specific SME, the elastic computed response (SME demand) of structures and components mounted thereon should be defined at the 84% non-exceedance probability (NEP).

2). Capacities for most components should be defined at about the 98% exceedance probability so that even if the SME demand slightly exceeds this CDFM capacity by more than a permissible conservatively specified inelastic energy absorption capability, there will result a very low probability of failure. However, for the CDFM of very brittle failure modes (weld failure, relay chatter, etc.) which have no inelastic energy absorption capability, so that this capability cannot be conservatively underestimated, the conservatism at which the capacity is defined should be increased to about the 99% exceedance probability.

3). Inelastic distortion associated with a Demand/Capacity ratio greater than unity is permissible. The permissible level of inelastic distortion should be specified at about the 5% failure probability level. The inelastic energy absorption capability, F_{μ}, should be slightly conservatively estimated at about the 84% NEP for this permissible level of inelastic distortion.

4). The seismic demand to capacity ratio must be less than or equal to the inelastic energy absorption factor, F_{μ}.

The guidance also notes that alternative criteria are acceptable so long as the aforementioned goals are approximately achieved.

4.6.2 Fragility Evaluations Methodology

Numerous equipment items were selected for HCLPF evaluation after walkdowns were completed. The items were grouped into 8 HCLPF calculations based on similar characteristics. These groups are as follows:

1) Motor Control Centers

2) Main Steam Isolation Valves and DW Drain Valves
3) Core Spray Room and RHR Room Coolers
4) Station Battery Racks
5) Control Room Cabinets
6) Diesel Generator Control Panels
7) RHR Heat Exchanger
8) 120/208 VAC Main UPS Distribution Panels

Specific equipment identification numbers, organized by group, associated calculation number, and HCLPF capacity are shown in Table 3.1.

The HCLPF calculations were performed by following the guidelines presented in EPRI NP-6041 and the GIP (References 6.6 and 6.15). The Conservative Deterministic Failure Margin (CDFM) approach was used to obtain the SME capacity of the critical anchorage configuration.

Because there were so many components evaluated via HCLPF, a bounding calculation for each type/group was performed considering the critical anchorage capacity based on the results of USI A-46 anchorage evaluations. The complete HCLPF capacity calculations are provided in Reference 6.13. See Table 3.1 in this report for specific calculation numbers associated with each group of equipment.

All components for which a HCLPF evaluation was performed were found to have a capacity greater than 0.3g.

4.6.3 Fragility Evaluations Conclusion

Based upon this review of the applicable guidance, it is determined that the BSEP IPEEE HCLPF evaluations followed the appropriate guidance and methodology of EPRI NP-6041 and met the intent of NUREG-1407. Therefore, the BSEP IPEEE HCLPF evaluations are considered to be acceptable for screening purposes.

4.7 Systems Modeling

4.7.1 Systems Modeling Applicable Guidance

Section 3.2.1 of NUREG-1407 (Reference 6.4) states that each licensee should examine its plant critically to ensure that the generic insights used in the development of margin methodology, as it relates to the process of identifying critical functions, systems and success path logic, is applicable. The EPRI NP-6041 methodology (Reference 6.6), which is based on a systems success path approach, is referenced as an accepted margins methodology. The approach defines and evaluates the capacity of those components required to bring the plant to a stable condition for at least 72 hours. The preferred success path, as well as alternative success paths, are defined in the form of success path logic diagrams (SPLDs). Section 3.2.5.1 of NUREG-1407 also recommends that the required 2 or 3 success paths be narrowed from a fuller set and that the alternative paths involve, to the maximum extent possible, operational sequences, systems, piping runs, and components that differ from those on the primary path.

EPRI NP-6041 describes the guidelines and procedures for the identification of essential systems. It states that identification of the preferred success path and an alternate success path should be based on operational and systems considerations. It also emphasizes that human involvement in a success path, such as operational procedures and the minimum necessary instrumentation and controls required by plant operators to use in the event of a safe shutdown state, should be considered.

Success paths are chosen based on a screening criterion applied to nonseismic failures and needed human actions. It is important that the failure modes and human actions are clearly identified and have low enough probabilities to not affect the seismic margins evaluation. Redundancies along a given success path should be specifically analyzed and documented when they exist. In a complementary sense, where a single component is truly "alone" in performing a vital function along a success path, this should be highlighted, too. This information will serve to indicate the extent to which a single failure would or would not invalidate the plant's ability to respond safely to a given earthquake level (Reference 6.4, Section 3.2.5.8).

Section 6.3.3.3 of NUREG-1407 states that licensees should coordinate information collected for the then on-going USI A-46 effort and IPEEE seismic review and walkdowns in order to avoid unnecessary duplication. USI A-46 depends on the requirements set forth by SQUG in the GIP (Reference 6.15) to identify safe shutdown equipment along system paths. However, there may be overlaps or differences in the equipment scope for USI A-46 and the seismic IPEEE. For equipment that is within the scope of USI A-46 or the seismic IPEEE only, it is clear that either GIP or IPEEE guidelines, respectively, should apply. For the overlapping equipment, the efficient approach is to use the GIP for both walkdowns; however, the IPEEE should use the review level earthquake. Caveats and interaction provisions of EPRI NP-6041 should be observed and documented.

The systems essential to perform the safety functions necessary to establish and maintain a long-term safe shutdown condition are namely the following:

1). Reactivity control

2). Reactor coolant system inventory control

3). Reactor coolant system pressure control

4). Decay heat removal

4.7.2 Systems Modeling Methodology

Section 3.1.2 of the IPEEE report states that SPLDs were constructed based on an understanding of available plant equipment function as well as the plant's normal and emergency operating procedures. The SPLDs were used as a basis for the identification of equipment to be included on the SSEL. Equipment selected for inclusion on the SSEL was evaluated in a manner similar to that described in the SQUG GIP. Guidance from EPRI NP-6041 (Reference 6.6) was also used in preparing the format for the list of components.

Development of the SPLDs involved the assessment of equipment necessary to maintain function in either a hot or cold shutdown for a period of 72 hours while offsite power is assumed to be lost. In addition to identifying the components of a system to be

included in the SPLDs, the structures containing those components were reviewed. For more detail of the success path logic used, see Appendix C of Appendix A of Reference 6.5.

The SPLDs identified the systems required for success. Two (primary and alternative) or more SPLDs were identified for each of the four major system functions:

1). Reactivity control

2). Reactor coolant system inventory control

3). Reactor coolant system pressure control

4). Decay heat removal

The primary and alternate success paths were identified based on operational and systems considerations and a preliminary walkthrough was conducted to identify potentially low-seismic capacity components.

Non-seismic failures and human actions were considered in accordance with guidance provided in NUREG-1407.

See Section 4.3.2 for more information about the development of the SPLDs and SSEL.

4.7.3 Systems Modeling Conclusion

The finalized SPLDs were reviewed and agreed upon by the BSEP operations personnel. It can be concluded that BSEP did adhere to the requirements set forth in NUREG-1407 and EPRI NP-6041 as evidenced by the information presented in this document and the assent given by plant personnel related to the SPLDs. The overall conclusion of the peer review, the plant staff, and the information presented in this document, is that the SPLDs met the objectives set forth by the IPEEE program. Therefore, the systems modeling conducted for the BSEP Seismic IPEEE is considered acceptable for the screening purposes as defined in the SPID (Reference 6.2).

4.8 Containment Performance

4.8.1 Containment Performance Applicable Guidance

NUREG-1407 requires that a containment performance evaluation be included in the IPEEE submittal (Section 3.2.6, Reference 6.4). The primary purpose of the evaluation is to identify vulnerabilities that involve the early failure of containment functions such as the containment integrity and isolation, preventions of bypass functions, and other various specific systems depending on a containment design (e.g. igniters, suppression pools, ice baskets). The guidance also includes the following recommendations.

1). Generally, containment penetrations are seismically rugged, and rigorous fragility analysis is only needed at RLEs greater than 0.3g. A walkdown to evaluate unusual conditions is recommended for all review levels.

2). An evaluation of the backup air system of the equipment hatch and personnel lock that employ inflatable seals should be performed at all review levels.

3). Penetrations that require cooling should be considered for loss of cooling consequences.

4). Valves involved in the containment isolation system should be walked down to ensure high capacities and that no special interaction issues are present.

5). Actuation and control systems should be included in the evaluation. For valves reliant on backup air systems, the air systems should be examined.

6). Components of the heat removal/pressures suppression system that are not known to have high capacities should be examined through walkdowns. Support systems and other system interaction effects (e.g., relay chatter) should be examined as applicable.

4.8.2 Containment Performance Methodology

Section 9 of the BSEP Seismic IPEEE report (Appendix A, Reference 6.5), presents the methodology, evaluation, and results of the BSEP containment performance assessment.

With regard to containment systems, the major concern was determined to be relay chatter. The BSEP IPEEE relay evaluation is discussed in Section 7 of Appendix A of Reference 6.5. Approximately 95% of the BSEP IPEEE and A-46 relays were either screened by capacity/demand or system consequence screening. The unscreened relays were addressed as A-46 outliers and resolved (Reference 6.24). The full-scope relay evaluation will be conducted separately, as noted in Section 2.1.1 of this document.

Another concern is the post-accident operation of penetration cooling systems. BSEP makes combined use of insulation and penetration cooling for hot piping penetrations. The penetration cooling subsystem is non-safety-related. The portion of the piping inside primary containment has been designed to Class IB (piping class) standards in order to minimize possible damage to Class I equipment inside the drywell from pipe break and flooding. Analysis shows that under a condition of total loss of coolant, and under the most adverse conditions, the concrete temperature adjacent to any penetration does not exceed 350°F. This analysis is based upon heat conduction and does not take into account dissipation into surrounding structures or atmosphere. Penetration coolers were added as a result of good engineering practice and design; however, as seen from the above, they are not considered necessary to safe operation of the plant or to maintain containment integrity.

NUREG 1407 suggests that hatches which employ inflated seals are a potential concern. However, BSEP hatches do not use inflated seals.

Therefore, the only containment evaluations determined to be necessary were the relay evaluations and walkdowns. As previously mentioned, relays were evaluated and 95% were either screened by capacity/demand or system consequence screening. The unscreened relays were addressed as A-46 outliers and resolved (Reference 6.24). The full-scope relay evaluation will be conducted at a later date. The containment walkdown was completed by the SRT and focused on inspecting and evaluating unusual conditions (e.g. spatial interactions, unique penetrations, piping hard spots, items/components bridging the seismic gap between the containment liner and interior structure, etc.). Containment penetrations were reviewed on an area basis to identify anomalies that

might affect containment performance. Concerns such as falling and differential building displacement were considered. Also reviewed were displacement concerns between the containment shell and internal structure. Containment isolation valves were also reviewed on a walk-by basis based on the caveats listed on the valve SEWS (Reference 6.5, Section 3.1.3.2).

No unusual conditions or configurations were identified. Again, the main objective of the containment analysis is to identify vulnerabilities that involve early failure of containment functions. The SRT reviews and walkdowns performed on the containment did not reveal any significant vulnerabilities. Therefore, the HCLPF for the containment is greater than 0.3g, based on SRT reviews, walkdowns, and Appendix A of NP-6041 (Reference 6.6)

4.8.3 Containment Performance Conclusion

Based upon this review of the applicable guidance, it is determined that the BSEP IPEEE containment performance evaluation addressed all the specified issues and met the intent of Section 3.2.6 of NUREG-1407. Therefore, the containment performance evaluation completed in IPEEE is considered acceptable for the screening purposes defined in the SPID (Reference 6.2).

4.9 Peer Review

4.9.1 Peer Review Applicable Guidance

Section 7 of NUREG-1407 requires that a peer review be conducted by qualified individuals not associated with the initial evaluation in order to ensure the accuracy of the IPEEE submittal and validate the IPEEE processes and results. The guidance recommends that the seismic peer review team have combined experience in the areas of systems engineering, seismic capacity engineering, and seismic probabilistic risk assessments (SPRAs) or seismic margins methodologies. The peer review portion of the submittal is to contain at least a description of the review performed, the results of the review team's evaluation, and a list of the review team members.

4.9.2 Peer Review Methodology

Section 10 of Appendix A of Reference 6.5 summarizes the peer review of the BSEP Seismic IPEEE effort. The peer review for the BSEP Seismic IPEEE was conducted by Mr. Charbel M. Abou-Jaoude and Mr. Steve Reichle of Vectra Technologies, Inc. during May and June of 1995.

Mr. Abou-Jaoude's technical experience at the time of the BSEP IPEEE was in structural mechanics and seismic design. He was also well versed in the SQUG GIP, completed SQUG/EPRI sponsored A-46 and Seismic IPEEE training courses, and participated as an SRT member in several A-46/IPEEE walkdowns.

At the time of the BSEP IPEEE, Mr. Reichle was serving as the Systems Project Engineer for the USNRC's Unresolved Safety Issue (USI) A-46 projects for multiple utilities. His role included identification of safe shutdown paths and the development of a success path component list for each unit. Resumes for each peer reviewer were documented in Appendix A of Appendix A of Reference 6.5.

The detailed comments and recommendations from the Vectra BSEP Peer Review were documented in a letter to CP&L dated June 23rd, 1995 (Reference 6.21). A two day plant visit of all accessible areas of both units, excluding drywell and high radiation areas or dress-out areas, was conducted. Screening and Evaluation Worksheets (SEWS) for each of the equipment classes and data packages were sampled subsequent to the walkdowns to compare field notes with the SRT-recorded observations and conclusions; a brief review of a number of back-up evaluations and anchorage analyses was performed at the CP&L offices. The methodology utilized to select and document the safe shutdown paths and equipment was also reviewed. The peer reviewers stated that the vast majority of conditions that were noted during the plant visit had been previously identified by the SRT. Additional observations from the peer review primarily dealt with equipment in the A-46 scope. Completion of the A-46 effort and resolution of all pending outliers would ensure that the plant HCLPF would be in excess of the 0.3g review level. See Section 3.2 of this report for confirmation of A-46 completion.

The IPEEE program for the two BSEP units was found to have been conducted in a very thorough and competent manner. The peer reviewers found that the effort was performed in accordance with the guidance of EPRI NP-6041 (Reference 6.6) and met the stated objectives of NUREG-1407 (Reference 6.4). The results and findings from the program appeared to be reasonable and are consistent with expectations for a plant of this vintage. The plant structures and piping were found to be rugged, owing to the original design and upgrades that were performed in response to various IE Bulletins or self-initiated reassessment studies. A number of equipment and general housekeeping upgrades were also noted during the walkthrough which have resulted in improved seismic ruggedness (Section 10, Appendix A, Reference 6.5).

4.9.3 Peer Review Conclusion

Based on the review of the applicable guidance, it is determined that the BSEP IPEEE peer review and documentation meets the intent of the NUREG-1407 requirements. A thorough peer review was conducted by individuals with seismic capacity and systems engineering experience that were not associated with the original evaluation. Therefore, the peer review completed in the BSEP IPEEE evaluation is considered acceptable for the screening purposes defined in the SPID (Reference 6.2).

5.0 CONCLUSION

The BSEP IPEEE was a focused-scope margin submittal and requires the performance of a detailed review of relay chatter and full evaluation of soil failures in order to be considered a full-scope assessment. The full scope soils evaluation has been completed in Reference 6.36 and a general overview has been provided in Section 2.1. A relay evaluation consistent with a full-scope IPEEE, as described in NUREG-1407, will be performed on the schedule provided for High-Frequency Confirmation in the NEI letter to the USNRC dated October 3, 2013 (Reference 6.20).

This report presents the key elements of the methodology and analysis used in BSEP IPEEE evaluation and the adherence of the BSEP IPEEE to the guidance set forth by NUREG-1407 and other applicable guidance. Based on the IPEEE Adequacy review, performed consistent with the guidance contained in the SPID and documented herein, the BSEP IPEEE results are considered adequate for screening and the risk insights gained from the IPEEE remain valid under the current plant configuration.

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