Dominion Nuclear Connecticut, Inc.
5000 Dominion Boulevard, Glen Allen, VA 23060
Web Address: www.dom.com

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DOMINION NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNITS 2 AND 3
RESPONSE TO MARCH 12, 2012 INFORMATION REQUEST
SEISMIC HAZARD AND SCREENING REPORT (CEUS SITES) FOR
RECOMMENDATION 2.1

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
2. NEI letter to NRC, Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations, dated April 9, 2013
3. NRC Letter, Electric Power Research Institute Final Draft Report 3002000704, "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
4. EPRI Report 1025287, Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic
5. NRC Letter, Endorsement of EPRI Final Draft Report 1025287, "Seismic Evaluation Guidance," dated February 15, 2013

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

In Reference 2, the Nuclear Energy Institute (NEI) requested NRC agreement to delay submittal of the final CEUS Seismic Hazard and Screening Reports so that an update to the Electric Power Research Institute (EPRI) ground motion attenuation model could be completed and used to develop that information. NEI proposed that descriptions of subsurface materials and properties and base case velocity profiles be submitted to the NRC by September 12, 2013, with the remaining seismic hazard and screening information submitted by March 31, 2014. NRC agreed with that proposed path forward in Reference 3.

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NRR

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

The attached Seismic Hazard and Screening Report for Millstone Power Station Units 2 and 3 provides the information described in Section 4 of Reference 4 in accordance with the schedule identified in Reference 2.

If you have any questions regarding this information, please contact Wanda Craft at (804) 273-4687.

Sincerely,

David A. Heacock
President and Chief Nuclear Officer
Dominion Nuclear Connecticut, Inc.

VICKI L. HULL
Notary Public
Commonwealth of Virginia
140542
My Commission Expires May 31, 2014

COMMONWEALTH OF VIRGINIA)
)
COUNTY OF HENRICO)

The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by David A. Heacock, who is President and Chief Nuclear Officer of Dominion Nuclear Connecticut, Inc. He has affirmed before me that he is duly authorized to execute and file the foregoing document in behalf of that company, and that the statements in the document are true to the best of his knowledge and belief.

Acknowledged before me this 31st day of March, 2014.

My Commission Expires: May 31, 2014

Vicki L. Hull
Notary Public

Commitments made in this letter: No new regulatory commitments

Attachment: Seismic Hazard and Screening Report

cc: U.S. Nuclear Regulatory Commission
Region I
2100 Renaissance Blvd
Suite 100
King of Prussia, PA 19406-2713

Mohan C. Thadani
Project Manager
U.S. Nuclear Regulatory Commission
One White Flint North, Mail Stop 08 B 1
11555 Rockville Pike
Rockville, MD 20852-2738

NRC Senior Resident Inspector
Millstone Power Station

50.54f_Seismic.Resource@nrc.gov

ATTACHMENT

SEISMIC HAZARD AND SCREENING REPORT

MILLSTONE POWER STATION UNITS 2 AND 3
DOMINION NUCLEAR CONNECTICUT, INC.

EXECUTIVE SUMMARY

Following the accident at the Fukushima Daiichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the 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. Subsequently, the NRC issued a 10 CFR 50.54(f) letter (Reference 7.1) that requests information to assure that selected recommendations from the NTTF are addressed by U.S. nuclear power plants. Recommendation 2.1: Seismic involves reevaluation of the seismic hazard at plant sites consistent with present-day NRC requirements. The 10 CFR 50.54(f) letter requests licensees to re-evaluate the seismic hazard for applicable reactor units. Depending on the comparison of the re-evaluated seismic hazard and the current design basis, a risk assessment may be required. Based upon the results of risk evaluations, where performed, the 10 CFR 50.54(f) letter indicates that NRC staff will determine whether additional regulatory actions are necessary.

This report provides the information requested in items (1) through (7) of the Enclosure 1 section titled "Requested Information" of the 50.54(f) letter for Millstone Power Station Unit 2 (MPS2) and Unit 3 (MPS3). In providing this information, Dominion Nuclear Connecticut, Inc. (Dominion) followed the guidance provided in Electric Power Research Institute (EPRI) Report 1025287, *Seismic Evaluation Guidance: Screening, Prioritization, and Implementation Details (SPID) for Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic* (Reference 7.2).

In response to the 50.54(f) letter, and following the guidance provided in EPRI Report 1025287 (SPID), a seismic hazard reevaluation was performed. For screening purposes, a Ground Motion Response Spectrum (GMRS) was developed. The GMRS was compared to the MPS2 and MPS3 Individual Plant Examination of External Events (IPEEE) High Confidence of a Low Probability of Failure (HCLPF) spectra (IHS) for screening. For both MPS2 and MPS3, the corresponding IHS exceeds the GMRS in the 1 to 10 Hz frequency range. Evaluation of the IPEEE programs for MPS2 and MPS3 shows that both meet the adequacy criteria for screening, in accordance with the guidance in the EPRI SPID. In addition, a soil failure analysis was completed, and a relay chatter review will be performed, for both MPS2 and MPS3 to meet full-scope IPEEE requirements. The relay chatter review will be completed consistent with the schedule provided in NEI letter dated October 3, 2013 (Reference 7.25).

Therefore, both MPS2 and MPS3 screen out from further risk assessments in accordance with the guidance in EPRI Report 1025287 (SPID). Based on the screening, a high-frequency confirmation and a Spent Fuel Pool evaluation are required.

EPRI Report 3002000704, *Augmented Approach, Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic* (Reference 7.10), has been developed as the process for evaluating selected critical plant equipment. In accordance with this guidance, MPS2 and MPS3 screen in for performance of the Expedited Seismic Evaluation Process (ESEP).

Seismic core damage frequency (CDF) calculations have been performed by EPRI for plants in

the Central and Eastern United States (CEUS) using the plant capacities from the IPEEE program and the recently updated seismic hazard curves. The results of these calculations for MPS2 and MPS3 support the conclusion of the NRC GI-199 Safety/Risk Assessment (Reference 7.31) that "Overall seismic core damage risk estimates are consistent with the Commission's Safety Goal Policy Statement..." and "...the current seismic design of operating reactors provides a safety margin to withstand potential earthquakes exceeding the original design basis" as indicated in NEI letter to NRC dated March 12, 2014 (Reference 7.30).

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1.0 INTRODUCTION

Following the accident at the Fukushima Daiichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the NRC 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 10 CFR 50.54(f) letter (Reference 7.1) that requests information to assure that these recommendations are addressed by all U.S. nuclear power plants. The 50.54(f) letter requests that licensees and holders of construction permits under 10 CFR Part 50 reevaluate the seismic hazards at their sites against present-day NRC requirements. The comparison between the reevaluated seismic hazard and the current design basis will result in either no further risk evaluation or the performance of a seismic risk assessment. Risk assessment approaches acceptable to the NRC staff include a seismic probabilistic risk assessment (SPRA) or a seismic margin assessment (SMA). Based upon this information, 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 10 CFR 50.54(f) letter pertaining to NTTF Recommendation 2.1 for Millstone Power Station Unit 2 (MPS2) and Unit 3 (MPS3), located in Waterford, Connecticut. In providing this information, Dominion Nuclear Connecticut, Inc. (Dominion) followed the guidance provided in 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* (Reference 7.2). EPRI Report 3002000704, *Augmented Approach, Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic* (Reference 7.10), was developed as the process for evaluating selected critical plant equipment as an interim action to address the GMRS.

In response to the 10 CFR 50.54(f) letter and following the guidance provided in Reference 7.2, a seismic hazard reevaluation was performed. For screening purposes, a Ground Motion Response Spectrum (GMRS) was developed.

2.0 SEISMIC HAZARD REEVALUATION

The Millstone Power Station (MPS) site is located at the southern tip of Millstone Point in Waterford, Connecticut, on Long Island Sound and Niantic Bay. MPS is on a low-lying peninsula within the Seaboard Lowland section of the New England physiographic province, a geologically complex region characterized by metamorphosed and folded rocks of Ordovician-Silurian age. The Millstone site is underlain by the Ordovician Monson Gneiss of pre-Silurian age and the Westerly Granite of Pennsylvanian or younger age. Detailed studies carried out during the siting investigation for MPS show that there are no capable faults within the vicinity of the site. The principal plant structures are founded on competent bedrock, at elevations ranging from about 15 ft above to 40 ft below mean sea level. Monson Gneiss is thinly layered with light feldspathic and dark biotitic and hornblendic layers. The foliation is well defined and exhibits a consistent northwest trend.

The site region is characterized by earthquakes of low to moderate intensity. During the past 300 years, only 13 earthquakes greater than or equal to Intensity V Modified Mercalli (MM) have been reported within 50 miles of the site. The site lies in the Southeastern New England-Maritime Tectonic Province. The largest earthquake in this province was an Intensity VI (MM) event which occurred in 1904 east of Eastport, Maine. Two moderate size earthquakes have occurred in the Moodus, Connecticut area, located in the adjacent New England Province, in 1568 (Intensity VII (MM)) and 1791 (Intensity VI-VII (MM)). The maximum earthquake potential at the site was assumed to be due to an earthquake of Intensity VII (MM) occurring close to the site. This corresponds to a peak ground acceleration of 0.10g (Section 2.5.2 of Reference 7.19).

For MPS2, the Design Basis Earthquake (DBE) (referred to as safe-shutdown earthquake (SSE) in this report) is defined as the maximum credible earthquake at the plant site that can reasonably be predicted from geologic and seismic evidence and is chosen to have a peak horizontal ground acceleration of 0.17g and a vertical acceleration of 0.11g.

For MPS3, a SSE of 0.17g in the horizontal direction and 2/3 of this value in the vertical direction, input at the bedrock surface, has been used as the design basis for seismic loading.

2.1 REGIONAL AND LOCAL GEOLOGY

The MPS site is within the Seaboard Lowland section of the New England physiographic province, a geologically complex region characterized by metamorphosed and folded rocks of Ordovician-Silurian age. The site is underlain by the Ordovician Monson Gneiss of pre-Silurian age and the Westerly Granite of Pennsylvanian or younger age. The Monson Gneiss is part of a series of lower Paleozoic metavolcanic and metasedimentary rocks and granitic gneisses that underlie most of eastern Connecticut. The Monson Gneiss at the site area is light gray and medium-grained. The Westerly Granite at the site is a dike or molten rock intrusion described as fine-grained, gray (surficially altered to pink) rock. The Monson Gneiss is underlain by Cambrian age rock or alternatively, by pre-Silurian Brimfield Schist (Reference 7.13).

The Millstone area was covered with glacial ice until approximately 15,000 years ago. These glaciers deposited drift materials including glacial till, moraine deposits, and stream deposits and, as they receded, outwash deposits. This includes a layer of very dense basal till and overlying ablation till blanketing the MPS site. Both the basal and overlying ablation tills are relatively impermeable. The thickness of the till varies between MPS2 and MPS3. At MPS2, the till is present from grade at El. 14 ft down to bedrock at El. -2 ft, which corresponds to a thickness of 16 ft. At MPS3, the till is present from grade at El. 24 ft down to bedrock at El. 15 ft (location of Refueling Water Storage Tank foundation), which corresponds to a thickness of 9 ft. Around the foundations, the till materials have generally been removed and replaced with structural fill.

Beneath the till, the dominant bedrock at the site is the Monson Gneiss which is approximately 3,700 ft thick (Reference 7.13, Table 2.5.1-3) underlain by Cambrian age rock. MPS3 FSAR reports the Monson Gneiss is 3,700 ft thick. However, this applies to Eastern Connecticut and Western Rhode Island. Although the site is within this area, the noted thickness is not specific to the site. At the MPS site, the Monson Gneiss is thinly layered with light feldspathic and dark biotitic and hornblendic layers. The foliation is well defined and exhibits a consistent northwest trend. The other rock at the site is a dike comprised of Westerly Granite injected as a molten intrusion into the Monson Gneiss. Its mechanical properties are expected to be similar to the Monson Gneiss. For the soil/rock column, the properties of the more prevalent Monson Gneiss were used.

An alternate interpretation of the subsurface geology is based on geologic quadrangle mapping at a scale of 1:2400 (Reference 7.13). This U.S. Geological Survey (USGS) map includes four interpretive cross sections based on surface mapping and a regional interpretation of the metamorphic sequence and thicknesses of rock units. Cross Section B-B' is located approximately 0.5 miles northwest of the site. This cross section indicates that the Monson Gneiss is underlain by the Brimfield Schist at a depth of approximately 2,000 ft. The Brimfield Schist is described in Reference 7.13 as a gray to dark-gray sillimanite- and garnet-bearing schist and gneiss. This mineralogy is often indicative of high-grade metamorphism that occurred under high temperatures and pressures. A note in Reference 7.13 indicates that this rock unit might have been subjected to another subsequent episode of less intense metamorphism. In general, fractures observed in this part of New England are often parallel to topography and are sheeting joints that formed as erosion removed overlying material and the rock mass adjusted to a lower vertical confining stress. High angle fractures appear to be parallel to the metamorphic fabric while other high angle fractures may have formed in response to tectonic stresses. Despite fracture origin or orientation, it is likely that any fractures that occur in this unit at the ground surface are healed (closed) at a depth of 2,000 ft and that this is a very hard rock.

There are some uncertainties associated with these alternate interpretations. The geology in some parts of Connecticut and New England has been remapped and reinterpreted using modern age-dating methods. In these areas, the new maps are different from the older interpretations. The quadrangle adjacent to that mapped by Reference 7.13 has been remapped and shows a more complex interpretation. It is conceivable that any modern remapping of the Niantic quadrangle might result in an alternate interpretation of the subsurface geology in the site vicinity.

2.2 PROBABILISTIC SEISMIC HAZARD ANALYSIS

The information provided in Section 2.2.1 was developed for EPRI by Lettis Consultants International (LCI), as part of an industry-wide effort (References 7.15 and 7.16). EPRI/LCI also provided the baseline hard rock probabilistic seismic hazard analysis (PSHA) calculation and deaggregation data for the Millstone site (Reference 7.33). Using the hard rock hazard and de-aggregation data, Bechtel Power Corporation performed the site response analyses and developed the control point hazard curves and response spectra for MPS (Reference 7.17), as described in Sections 2.3 and 2.4.

2.2.1 PROBABILISTIC SEISMIC HAZARD ANALYSIS RESULTS

In accordance with the 10 CFR 50.54(f) letter and following the guidance in the SPID, a PSHA was completed and reported in LCI Project 1041 Report (Reference 7.15) using the recently developed NUREG-2115, "Central and Eastern United States Seismic Source Characterization for Nuclear Facilities," (CEUS-SSC) (Reference 7.11) together with the updated EPRI Report 3002000717, "EPRI (2004, 2006) Ground-Motion Model (GMM) Review Project," (Reference 7.12). For the PSHA, a lower-bound moment magnitude of 5.0 was used, as specified in the 10 CFR 50.54(f) letter.

For the PSHA, the CEUS-SSC background seismic sources out to a distance of 400 miles (640 km) around Millstone were included. This distance exceeds the 200 mile (320 km) recommendation contained in NRC Regulatory Guide (RG) 1.208 "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion," (Reference 7.23) and was chosen for completeness. Background sources included in this site analysis are the following:

1. Atlantic Highly Extended Crust (AHEX)
2. Extended Continental Crust—Atlantic Margin (ECC_AM)
3. Great Meteor Hotspot (GMH)
4. Mesozoic and younger extended prior – narrow (MESE-N)

5. Mesozoic and younger extended prior – wide (MESE-W)
6. Midcontinent-Craton alternative A (MIDC_A)
7. Midcontinent-Craton alternative B (MIDC_B)
8. Midcontinent-Craton alternative C (MIDC_C)
9. Midcontinent-Craton alternative D (MIDC_D)
10. Northern Appalachians (NAP)
11. Non-Mesozoic and younger extended prior – narrow (NMESE-N)
12. Non-Mesozoic and younger extended prior – wide (NMESE-W)
13. Paleozoic Extended Crust narrow (PEZ_N)
14. Paleozoic Extended Crust wide (PEZ_W)
15. St. Lawrence Rift, including the Ottawa and Saguenay grabens (SLR)
16. Study region (STUDY_R)

Large magnitude CEUS-SSC modeled sources Repeated Large Magnitude Earthquake (RLME), within 620 miles (1,000 km) of the site were included in the analysis. These sources are:

- Charlevoix

For each of the above background and RLME sources, the mid-continent version of the updated CEUS EPRI GMM (Reference 7.12) was used.

2.2.2 BASE ROCK SEISMIC HAZARD CURVES

Consistent with the industry report template, base rock seismic hazard curves are not provided. Seismic hazard curves are provided in Section 2.3.7 at the control point elevation.

2.3 SITE RESPONSE EVALUATION

Following the guidance contained in Seismic Enclosure 1 of the 50.54(f) letter and in the SPID, for nuclear power plant sites that are not sited on hard rock (shear wave velocity ≥ 9200 ft/sec [SPID]), a site response analysis was performed for Millstone Units 2 and 3.

2.3.1 DESCRIPTION OF SUBSURFACE MATERIAL

Very dense basal till overlies the bedrock at the MPS site, and consists of a widely-graded mixture of cobble and boulder-size rock, gravel-size material, sand and some silt binder. Between the till and final grade is a thin layer of ablation till, a medium dense silty sand with typically 20 to 40 percent passing the No. 200 sieve. Around the foundations, the till materials have generally been removed and replaced with structural fill.

The GMRS was calculated as a geologic outcrop on the top of the Monson Gneiss using a truncated rock column as opposed to outcrop motion using the full height soil column. Since the gneiss is a strong rock with linear stress-strain behavior, the presence of the till or structural fill will not influence the material properties below the GMRS elevations. Therefore, in calculation of the GMRS, the thin layer of till (and structural fill) at the top of the site profile was not included for analysis. These soils are thus not included further in this report.

Table 2.3.1-1 provides a brief description of the subsurface material in terms of the geologic units and layer thicknesses. This table includes best estimate values of shear wave velocity (V_S), compressive wave velocity (V_P), unit weight and Poisson's ratio.

As described in Section 2.1, there are two alternatives deep rock profiles. Table 2.3.1-1 presents the profile where the hard Brimfield Gneiss occurs at and below about 2,000 ft depth. The alternative profile is the Monson Gneiss extending to around 3,700 ft depth and being underlain by Cambrian rock. This is discussed further in terms of base case profiles in Section 2.3.2.

MPS3 FSAR reports the Monson Gneiss has a unit weight of 165 pounds per cubic foot (pcf) and a Poisson's ratio of 0.33. These values are adopted for the underlying Cambrian rock or pre-Silurian Brimfield Schist.

For MPS2, a groundwater level of El. +10 ft (i.e., 4 ft below final grade) is selected for use.

For MPS3, a groundwater level of El. +20 ft (i.e., 4 ft below final grade) is selected for use.

Table 2.3.1-1 Geologic profile and estimated layer thicknesses for MPS

Depth Range (ft)	Soil/Rock Description	Density (pcf)	V_S (ft/sec)	V_P (ft/sec)	Poisson's Ratio
0	SSE control point[(1)]	---	---	---	---
0 – 115	Ordivician Monson Gneiss	165	6500	12,900	0.33
115 – 515	Ordivician Monson Gneiss	165	6600	13,100	0.33
515 – 915	Ordivician Monson Gneiss	165	6800	13,500	0.33
915 – 1315	Ordivician Monson Gneiss	165	7000	13,900	0.33
1315 – 1715	Ordivician Monson Gneiss	165	7200	14,290	0.33
1715 – 2000	Ordivician Monson Gneiss	165	7400	14,690	0.33
2000+[(2)]	Pre-Siluriann Brimfield Schist	165	>9200	>18,260	0.33

Note:

(1) As described in Section 3.2, the Control Point is defined as the foundation bearing elevation of the highest rock-supported, safety-related structure. The tabulated profile is for MPS3 where the Control Point is at El. +15 ft. For MPS2, the Control Point is at El. -2 ft.

(2) The layer depth variation in considered as described in Section 2.3.2

2.3.2 DEVELOPMENT OF BASE CASE PROFILES AND NONLINEAR MATERIAL PROPERTIES

The site profile consists of Monson Gneiss, underlain by Cambrian or pre-Silurian age rock or the Brimfield Schist. The V_S of the Monson Gneiss was measured using seismic cross-hole tests from El. +10 ft to El. -50 ft beneath MPS3. Additionally, down-hole tests measured V_S from El. +5 ft to El. -99 ft (approximate to El. -100 ft).

The V_S average values in the Monson Gneiss were consistently at 6,500 ft/sec for both cross-hole and down-hole tests. MPS3 FSAR notes some slight scattering, and assigns a variation of ± 300 ft/sec. This variation is small (COV = 5%) and suggests that either very few tests were taken or else the material is very uniform. In the approximately 100 ft depth of the gneiss sampled, the average unconfined compression strength of 9 cores tested was 10,000 psi (range of 4,000 psi to 14,000 psi) with an average unit weight of 165 pcf. This range in strength suggests that the rock strength (and hence V_S) is not uniform.

There are no V_S data below about El. -100 ft. SPID Appendix B indicates that for Cenozoic or Paleozoic sedimentary rocks, a constant V_S gradient of 0.5 m/sec/m (0.5 ft/sec/ft) should be used. The Monson Gneiss is Paleozoic, but is metasedimentary rather than sedimentary. Nevertheless, it is reasonable to use this constant V_S gradient. This is equivalent to 200 ft/sec increase over 400 ft depth. Assuming this increase starts at 6,500 ft/sec at El. -100 ft, V_S at the base of the Monson Gneiss at about El. -3700 ft will be 8,300 ft/sec. The same gradient is adopted for the V_S

increase of the Cambrian rock below the Monson Gneiss.

As noted in Section 2.1, the other profile considered has approximately 2,000 ft of Monson Gneiss underlain by the Brimfield Schist. The Brimfield Schist is a very hard material and can be expected to have a Vs value of, or greater than, 9,200 ft/sec. Based on the pedigree of Reference 7.13 and on engineering judgment, this profile is given a higher weight (see below).

Due to the limited amount of data constraining the site characteristics, the methodology outlined in SPID was used to develop three profiles to include both the epistemic and aleatory uncertainties in subsequent site response analyses. As described in SPID guidance Appendix B, the lower range (LR), base case (BC), and upper range (UR) profiles correspond to the 10th, 50th, and 90th percentiles, respectively. The SPID recommends the use of 0.3, 0.4, and 0.3 weight factors for the LR, BC, and UR, respectively, which is an accurate three-point approximation of the normal distribution. While it is conceivable that hard rock extends to, or close to, the ground surface, this appears to be contradicted by the limited, available data discussed previously, and this profile was given a lower weight. Thus, for the current analysis, the adjusted weight factors of 0.3, 0.5, and 0.2 were used for the LR, BC, and UR, respectively.

SPID Appendix B recommends for sites with very limited V_S data the uncertainty in V_S be modeled using a log-normal distribution with a logarithmic standard deviation ($\sigma_{\mu ln}$) of 0.35. The 10th-percentile velocity profile is computed by multiplying the BC velocity profile by exp (-1.28 · 0.35), which corresponds to 0.64. Similarly, the 90th-percentile profile is computed by multiplying the BC velocity profile by exp (1.28 · 0.35) or 1.57. Using these relationships, the increase in the V_S gradient is approximately 0.32 ft/sec/ft for the 10th percentile and about 0.78 ft/sec/ft for the 90th percentile.

To accommodate a range of potential depths to hard rock, two alternative profiles were included in the analysis. The first profile (assigned a weight of 0.3) considered the depth to hard rock given the V_S gradient discussed above for the LR and BC profiles. This is a deep profile where the hard rock is reached within the Cambrian formation. During the site response analyses, these profiles were truncated at the last exceedance of 9,200 ft/sec. The second profile, based on the regional geology described in Section 2.3.1, was assigned a weight of 0.7. This profile assumed a best estimate depth to hard rock of 2000 ft, i.e. where the Brimfield Schist is encountered. At 2000 ft depth the V_S of the LR and BC profiles changed to 9200 ft/sec. The UR profile has more than 9,200 ft/sec velocity at the top of the profile and was separately included in the analysis. Thus a total of 5 base-case profiles were considered in the GMRS calculation: LR-Deep, LR-2000, BC-Deep, BC-2000, and UR.

The five profiles selected for use are presented in Table 2.3.2-1. During the site response analyses, these profiles were truncated at the last exceedance of 9,200 ft/sec. The five profiles are plotted in Figure 2.3.2-1.

Table 2.3.2-1 Geologic profile and estimated layer thicknesses for MPS

Material[1]	Elevation (ft)	Thickness (ft)	V_S (ft/sec)					σ_{lnVs} [6]
			$V_{BC\text{-}Deep}$	$V_{BC\text{-}2000}$	$V_{LR\text{-}Deep}$	$V_{LR\text{-}2000}$	V_{UR}[3]	
Monson	+15 to -100[2]	115[2]	6500	6500	4150	4150	10200	0.25
Monson	-100 to -500	400	6600	6600	4210	4210	10360	0.15
Monson	-500 to -900	400	6800	6800	4340	4340	10670	0.15
Monson	-900 to -1300	400	7000	7000	4470	4470	10980	0.15
Monson	-1300 to -1700	400	7200	7200	4600	4600	11300	0.15
Monson	-1700 to -2100	400	7400	>9200[5]	4730	>9200[5]	11610	0.15
Monson	-2100 to -2500	400	7600		4850		11920	0.15
Monson	-2500 to -2900	400	7800		4980		12240	0.15
Monson	-2900 to -3300	400	8000		5110		12550	0.15
Monson	-3300 to -3700	400	8200		5240		12870	0.15
Cambrian	-3700 t0 -4100	400	8400		5370		13180	0.15
Cambrian	-4100 to -4500	400	8600		5490		13490	0.15
Cambrian	-4500 to -4900	400	8800		5620		13810	0.15
Cambrian	-4900 to -5300	400	9000		5750		14120	0.15
Cambrian	-5300 to -5500	200	9150		5850		14360	0.15
Cambrian	Below -5500	-	>9200		(4)		-	0.15

Notes:

(1) Monson refers to the Monson Gneiss and includes the Westerly Granite, where present.

(2) Values are for MPS3. For MPS2, elevation range is -2 ft to -100 ft, and thickness is 98 ft.

(3) Since for the UR profile $V_S \geq$ 9,200 ft/sec, site response analysis is not required. Amplification factor of unity is used for this case.

(4) For V_{LR}, values continue to increase at the same gradient of 0.32 ft/sec per ft until V_{LR} = 9,200 ft/sec, at approximately El. -16,000 ft.

(5) V_S of more than 9200 ft/sec below depth of 2000 ft (Elevation -1985).

(6) σ_{lnVs} is discussed in Section 2.3.3

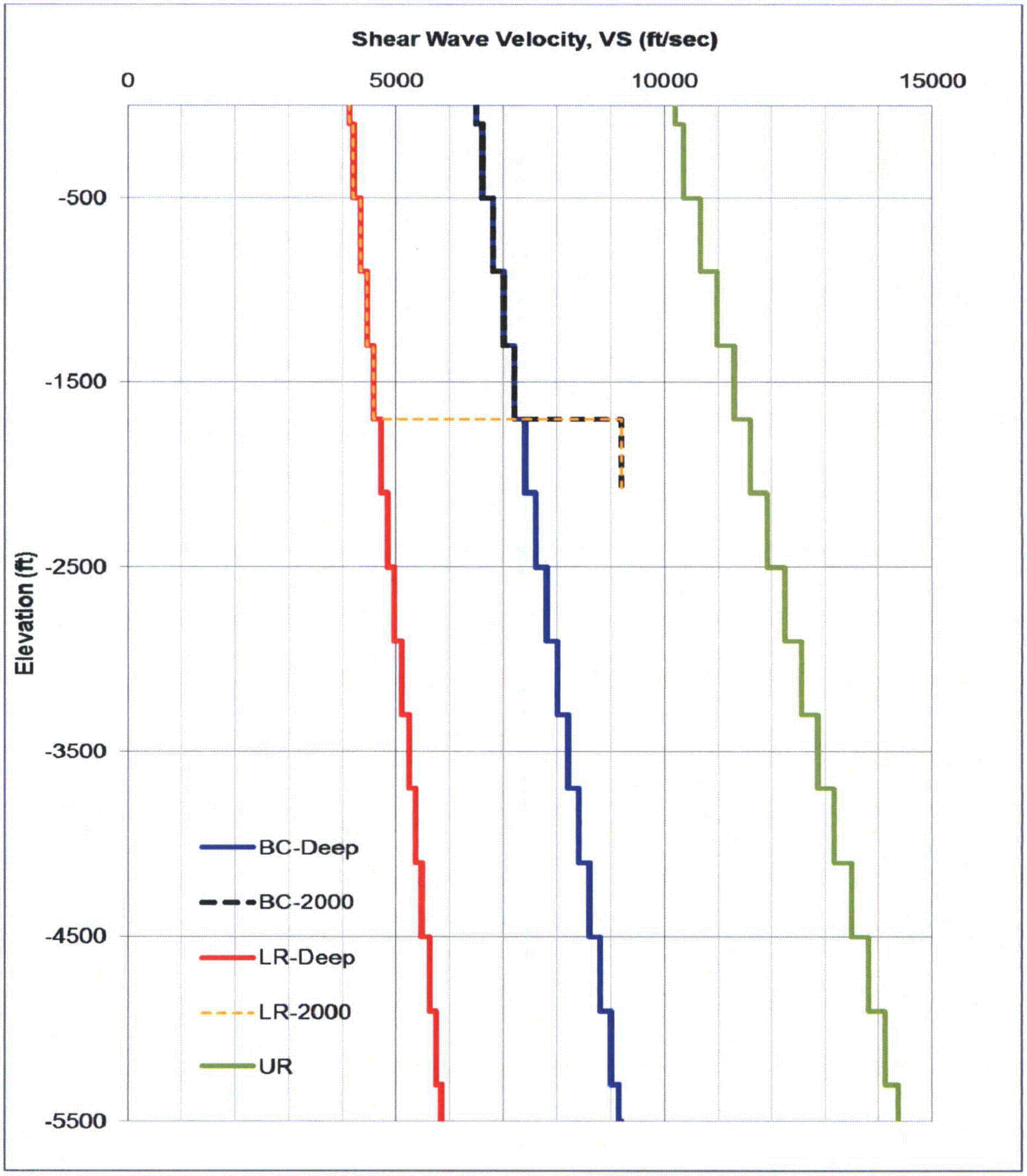

Figure 2.3.2-1. Shear wave velocity profiles used in site response calculations for MPS

Note: During the site response analyses; these profiles were truncated at the last exceedance of 9,200 ft/sec.

2.3.2.1 SHEAR MODULUS AND DAMPING CURVES

The shear modulus (G) and damping ratio (D) values of the Monson Gneiss are considered to be independent of shear strain. The damping values used in the site response analysis were established as described in Section 2.3.2.2 given the specified site attenuation (κ_0).

2.3.2.2 KAPPA

Kappa was considered for four base-case profiles: LR-Deep, LR-2000, BC-Deep, and BC-2000. For the LR-Deep and BC-Deep profiles, the base case value for the total site attenuation (κ_0) for each profile was calculated using Equation 1 following the recommendation of Section B-5.1.3.1 of SPID, where V_{S100} refers to the average shear-wave velocity of the upper 100 ft of the profile. A logarithmic standard deviation (log-SD) of 0.4 was used for κ_0 as recommended by the same reference, and LR and UR values for κ_0 were also established for each one of the LR-Deep and BC-Deep shear wave velocity profiles considered as presented in Table 2.3.2-2 (a). Considering kappa of 0.006 sec from the underlying reference rock, the remaining kappa for each profile was calculated as shown in Table 2.3.2-2 (b). The damping ratio for each profile was determined such that it yielded the required profile kappa considering the scattering as well as intrinsic hysteretic damping.

$$\log(\kappa_0) = 2.2189 - 1.0930 \times \log(V_{S100}) \qquad \text{Equation (1)}$$

Since the LR-2000 and BC-2000 cases have a thickness of less than 3000 ft for the firm rock layers, the kappa for these profiles were estimated using Q_S of 40 and an additional kappa of 0.006 sec for the underlying rock. The Q_S of 40 resulted in a damping ratio (D) of 1.25% for the profiles. From this damping the κ_0 of 0.0176 sec and 0.0135 sec for the LR-2000 and BC-2000 cases were respectively calculated.

The UR velocity case exceeds the 9200 ft/sec threshold and was included in the GMRS calculation with a mean site amplification of 1.0 and a Log-SD of zero. Therefore, no kappa considerations are necessary for this profile.

Table 2.3.2-2. Kappa Values Used for Site Response Analyses

(a) Total kappa (κ_0) including reference rock

		Kappa		
		LR	BC	UR
VS	LR-Deep	0.0110	0.0184	0.0307
	BC-Deep	0.0067	0.0113	0.0188
	UR	N/A	N/A	N/A

(b) Profile kappa excluding reference rock

		Kappa		
		LR	BC	UR
VS	LR-Deep	0.0050	0.0124	0.0247
	BC-Deep	0.0007	0.0053	0.0128
	UR	N/A	N/A	N/A

The considered soil profile cases are presented as branches of the decision tree shown in Figure 2.3.2-2. As shown in this figure, three velocity cases (LR, BC, and UR) were considered as well as two depth scenarios for the LR and BC velocity profiles using either the V_S gradient recommended in SPID or a 2000 ft deep profile. Where applicable, each branch was split to accommodate the epistemic uncertainty associated with the local site attenuation parameter as discussed in Section 2.3.2.2. Each branch was assigned a weight factor which indicates its relative likelihood compared to its parallel cases at the split point. The weight factors associated with the velocity profiles and depth to rock were assigned based on the available geotechnical data as discussed in Section 2.3.1. The weight factors associated with the local site attenuation parameter (κ_0) follow the recommendations of SPID guidance. The final weight factors were obtained by horizontally multiplying the weight factors corresponding to each branch and sum up to unity.

Note that the UR velocity case exceeds the 9200 ft/sec threshold and was included in the analysis with a mean site amplification of 1.0 and a Log-SD of zero.

VS		Depth to Rock		Kappa		Final Weight Factor	Case
LR	0.3	SPID Gradient	0.3	LR	0.3	0.027	LR-Deep-LR
				BC	0.4	0.036	LR-Deep-BC
				UR	0.3	0.027	LR-Deep-UR
		2000 ft	0.7	Q = 40 (D = 1.25%, SPID)		0.21	LR-2000
BC	0.5	SPID Gradient	0.3	LR	0.3	0.045	BC-Deep-LR
				BC	0.4	0.06	BC-Deep-BC
				UR	0.3	0.045	BC-Deep-UR
		2000 ft	0.7	Q = 40 (D = 1.25%, SPID)		0.35	BC-2000
UR	0.2	Vs>9200 fps				0.2	UR
					Σ =	1.00	

Figure 2.3.2-2 Decision tree and associated weight factors for soil profile uncertainty considerations

2.3.3 RANDOMIZATION OF BASE CASE PROFILES

The soil profile simulation was performed to generate sets of site-specific simulated (randomized) soil profiles to represent the dynamic properties of the soil columns while considering the uncertainty associated with each of these properties. The outputs are intended for use in site response analysis using random vibration theory (RVT).

Sets (in this case 8 sets: LR-Deep-LR, LR-Deep-BC, LR-Deep-UR, LR-2000, BC-Deep-LR, BC-Deep-BC, BC-Deep-UR, and BC-2000) of simulated (randomized) profiles (in this case 60 profiles) were provided using the following inputs based on available field data:

- Estimates of soil and rock stratum thicknesses and their range of variation
- Estimates of mean and standard deviation of V_S for each soil or rock stratum
- Cross correlations between adjacent layers are also assigned for each soil or rock property to prevent unreasonable variations between them

The thicknesses of the soil and rock strata were modeled using a beta distribution (with $\pm 2\sigma$ bounds) and appropriate mean and standard deviations. The beta distribution was selected because its probability density function is bell shaped, similar to the normal distribution, and it provides the ability to specify bounds of the distribution in either a symmetric or skewed manner.

The epistemic uncertainty for the site was considered in selection of the base profiles as described in Section 2.3.2. Aleatory uncertainty in the shear-wave velocity was modeled using a log-normal distribution with the $\sigma_{\ln Vs}$ value of 0.25 for the top 115 ft of the profile and 0.15 below that consistent with the recommendations of SPID. The values of the median shear-wave velocities and $\sigma_{\ln Vs}$ used for profile simulation are presented in Table 2.3.2-1.

The site response associated with the soil profiles corresponding to the MPS2 and MPS3 are very similar and only the MPS3 profile was used in the site amplification calculations.

For each base profile, a set of 60 simulated profiles was generated which represents the simulated free field subsurface conditions. The simulation included aleatory variation of the shear-wave velocity, stratum thicknesses (± 20%), and damping ratios (aleatory variation using Log-SD of 0.3) for linear material.

A limit of $\pm 2\sigma$ about the median value for shear wave velocity and damping ratio in each stratum was assumed. These limits were placed to prevent unrealistic variation of the parameters. In the case that a variation exceeded the limit, a new random variable was computed.

The Reference 7.22 correlation model was used to obtain the between-stratum correlation as a function of the stratum interface depth and the average thickness of the two correlated strata. The model uses coefficients based on the USGS site classification A, which is based on the average Vs of the top 100 feet (30 meters) of soil (V_{s30}).

2.3.4 INPUT SPECTRA

Consistent with the guidance in Appendix B of the SPID, input Fourier amplitude spectra and associated acceleration response spectra were defined for a single representative earthquake magnitude using two different assumptions regarding the shape of the seismic source spectrum (single-corner and double-corner). A range of 11 different input amplitudes (peak ground accelerations (PGA) ranging from 0.01 to 1.5 g) were used in the site response analyses. These specific loading levels are identified later in the report as 'G001, G005, G010, G020, G030, G040, G050, G075, G100, G125, and G150' based on the suite of 11 specific input PGA levels. The characteristics of the seismic source and upper crustal attenuation properties assumed for the analysis of the Millstone 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. The input spectra for the single-corner and double-corner seismic source spectra are shown in Figures 2.3.4-1a and 2.3.4-1b. These spectra are defined at a suite of 38 spectral frequencies between 0.1 – 100 Hz.

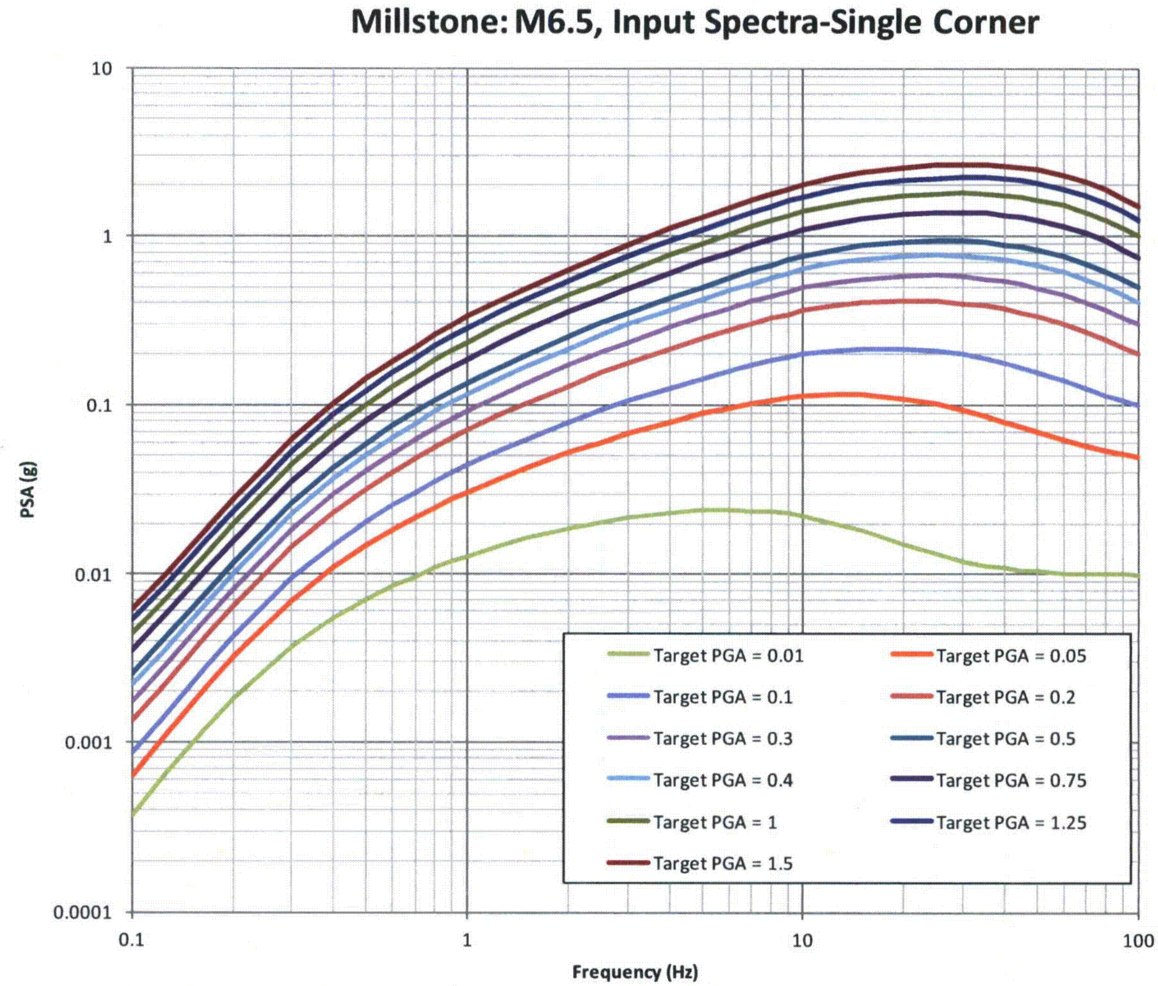

Figure 2.3.4-1a. Input spectra based on the single-corner seismic source model for the suite of 11 PGA levels for a spectral damping of 5%.

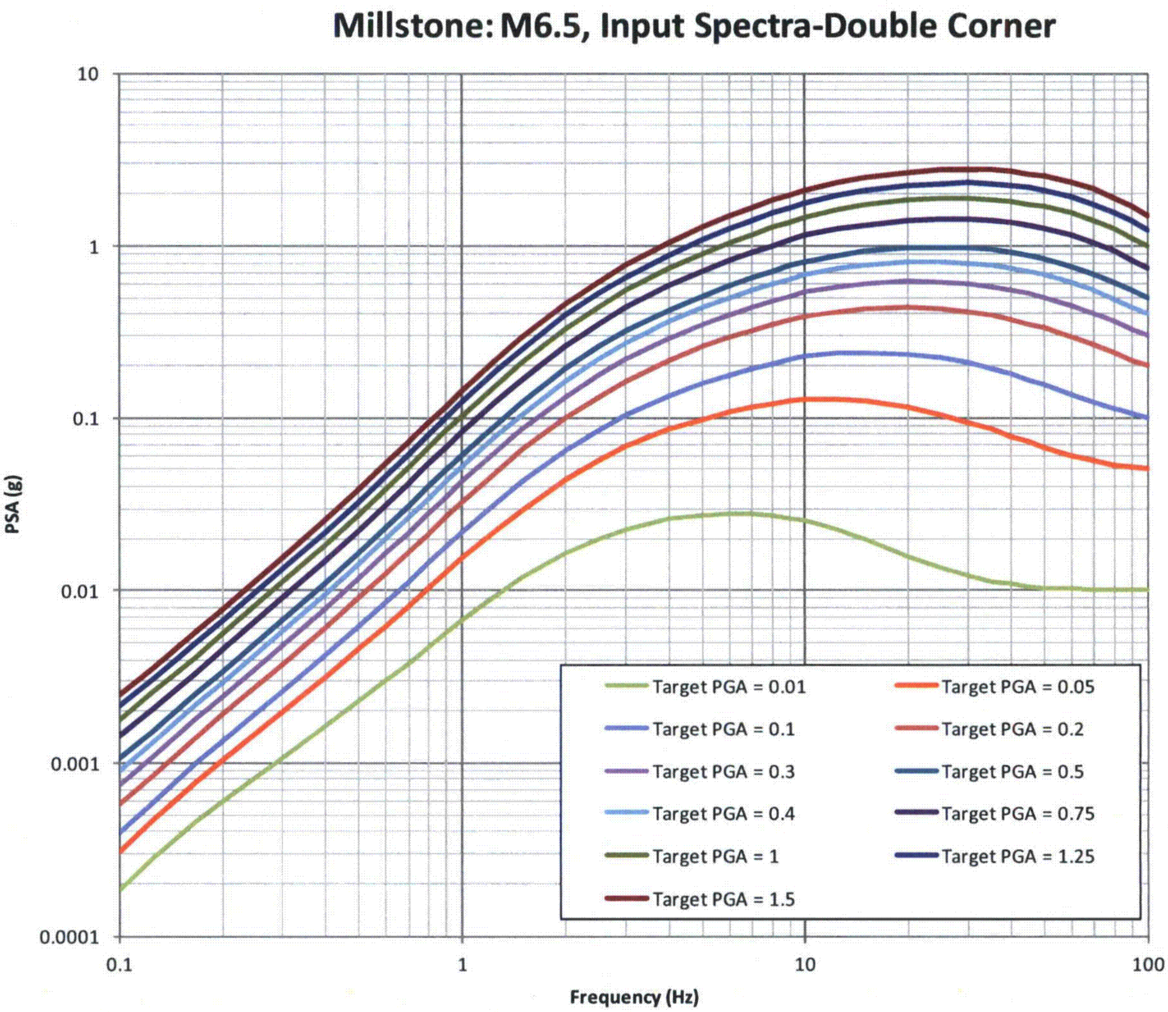

Figure 2.3.4-1b. Input spectra based on the double-corner seismic source model for the suite of 11 PGA levels for a spectral damping of 5%.

2.3.5 METHODOLOGY

Site response analyses were carried out to evaluate the amplification factors corresponding to the 8 sets of the 60 simulated (randomized) profiles for each of the input hard-rock spectra. Random vibration theory (RVT) was employed consistent with existing NRC requirements and the SPID. Moreover, the guidance contained in Appendix B of the SPID on incorporating the applicable uncertainties in the site response model and source spectra was followed.

For each combination of the base profiles and its corresponding 60 randomized profiles, described in Section 2.3.3, and input motions, described in Section 2.3.4, the site amplification was computed as the ratio between 5% damped geologic outcrop pseudo acceleration response spectrum at the control point and bedrock. The analysis was carried out at 301 frequency points ranging from 0.1 to 100 Hz and equally spaced in logarithmic space. The median (computed as the logarithmic mean) and the log-SD of the site amplification at each frequency were then computed.

The probabilistic seismic hazard curves were defined at the following 38 frequencies (in units of Hz):

100 90 80 70 60 50 45 40 35 30 25 20 15 12.5 10 9 8 7 6 5 4 3 2.5 2 1.5 1.25 1 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.167 0.125 0.1

For each of the 38 frequencies that do not line up with 301 calculated frequencies, the site amplification was computed using linear interpolation in log-log space from the 301 site amplification values.

2.3.6 AMPLIFICATION FUNCTIONS

For each base profile and for each seismological model, the median amplification (exponential of the log-mean amplification factors for 5% damped pseudo spectral acceleration (PSA)) and log-SD were calculated at the 38 frequencies of interest for each of the 11 different input amplitudes. The input PSA values for the single-corner seismological model are presented in Table 2.3.6-1. As an example, the single-corner median amplification factors and log-SD for the BC-2000 profile (base case velocity and 2000 ft mean depth to hard rock) are provided in Tables 2.3.6-2 and 2.3.6-3, respectively. The same information is shown in Figures 2.3.6-1 and 2.3.6-2.

Similar results for the single-corner seismological model and BC-Deep-BC profile (base case velocity with deep hard rock and base case kappa) are presented in Table 2.3.6-4 and Table 2.3.6-5 as well as Figure 2.3.6-3 and Figure 2.3.6-4.

For each seismological model, the weighted average median amplification and total log-SD were obtained by combining the results of each base profile using their associated weight factors. The median amplification factors and log-SD at the 38 frequencies of interest for the single-corner seismological model are presented in Table 2.3.6-6 and Table 2.3.6-7 as well as Figure 2.3.6-5 and Figure 2.3.6-6.

Similar results for the double-corner seismological model are presented in Table 2.3.6-8 through Table 2.3.6-10 and Figure 2.3.6-7 and Figure 2.3.6-8.

Generally, the computed amplification is insensitive to loading level due to the high-shear wave velocities in the profile and its linear nature. The exceptions are the high frequency results corresponding to the low amplitude input rock motions (target PGA = 0.01g in Figure 2.3.4-1a and Figure 2.3.4-1b) which are different due to significantly different shapes of these input response spectra compared to those of the higher input levels.

Table 2.3.6-1. Input 5% damped PSA values in g at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g using the single-corner seismological model.

Freq. [Hz]	Loading Level										
	G001	G005	G010	G020	G030	G040	G050	G075	G100	G125	G150
0.1	0.000368	0.000630	0.000858	0.00134	0.00174	0.00217	0.00253	0.00349	0.00439	0.00531	0.00622
0.125	0.000639	0.00108	0.00144	0.00221	0.00285	0.00352	0.00410	0.00562	0.00704	0.00851	0.00995
0.167	0.00124	0.00215	0.00283	0.00429	0.00549	0.00675	0.00783	0.0107	0.0133	0.0160	0.0187
0.2	0.00181	0.0032	0.00423	0.00640	0.00818	0.0100	0.0116	0.0158	0.0197	0.0237	0.0276
0.3	0.00366	0.00694	0.00935	0.0143	0.0183	0.0225	0.0261	0.0354	0.0441	0.0531	0.06192
0.4	0.00544	0.0109	0.0149	0.0230	0.0296	0.0365	0.0424	0.0577	0.0720	0.0867	0.101
0.5	0.00704	0.0146	0.0203	0.0316	0.0409	0.05051	0.0588	0.0804	0.100	0.121	0.141
0.6	0.00846	0.0182	0.0255	0.0401	0.0519	0.0643	0.0749	0.103	0.128	0.155	0.181
0.7	0.00973	0.0215	0.0305	0.0482	0.0626	0.0777	0.0906	0.124	0.156	0.188	0.220
0.8	0.0109	0.0247	0.0353	0.0559	0.0729	0.0905	0.106	0.145	0.182	0.220	0.258
0.9	0.0119	0.0277	0.0398	0.0634	0.0827	0.103	0.120	0.166	0.208	0.252	0.294
1	0.0128	0.0305	0.0441	0.0705	0.0922	0.115	0.134	0.185	0.233	0.282	0.330
1.25	0.0148	0.0367	0.0539	0.0869	0.114	0.143	0.167	0.231	0.291	0.352	0.413
1.5	0.0163	0.0423	0.0628	0.102	0.134	0.168	0.197	0.274	0.345	0.418	0.490
2	0.0187	0.0521	0.0788	0.129	0.171	0.215	0.253	0.352	0.445	0.540	0.634
2.5	0.0205	0.0604	0.0927	0.154	0.204	0.257	0.303	0.424	0.535	0.651	0.765
3	0.0217	0.0676	0.105	0.176	0.235	0.297	0.350	0.490	0.620	0.754	0.887
4	0.0232	0.0795	0.127	0.215	0.288	0.365	0.432	0.608	0.771	0.940	1.106
5	0.0238	0.0886	0.144	0.247	0.333	0.424	0.503	0.710	0.902	1.101	1.298
6	0.0240	0.0960	0.159	0.276	0.374	0.477	0.567	0.802	1.021	1.248	1.472
7	0.0238	0.102	0.172	0.301	0.410	0.525	0.624	0.886	1.130	1.383	1.632
8	0.0234	0.107	0.183	0.323	0.442	0.567	0.676	0.962	1.229	1.505	1.778
9	0.0228	0.111	0.193	0.344	0.471	0.606	0.724	1.033	1.320	1.619	1.914
10	0.0222	0.114	0.201	0.360	0.496	0.640	0.765	1.094	1.400	1.719	2.032
12.5	0.0200	0.116	0.211	0.385	0.535	0.693	0.831	1.195	1.534	1.887	2.235
15	0.0180	0.115	0.215	0.400	0.558	0.727	0.874	1.263	1.627	2.004	2.377
20	0.0150	0.109	0.215	0.411	0.581	0.764	0.923	1.346	1.741	2.152	2.559
25	0.0132	0.101	0.208	0.408	0.584	0.774	0.939	1.379	1.792	2.222	2.647
30	0.0120	0.0934	0.198	0.398	0.575	0.767	0.935	1.382	1.803	2.242	2.675
35	0.0114	0.0860	0.188	0.384	0.559	0.750	0.917	1.365	1.786	2.225	2.661
40	0.0111	0.0795	0.177	0.367	0.539	0.726	0.891	1.333	1.751	2.187	2.618
45	0.0109	0.0738	0.166	0.349	0.516	0.699	0.860	1.294	1.703	2.132	2.555
50	0.0107	0.0691	0.156	0.332	0.493	0.670	0.827	1.249	1.647	2.065	2.479
60	0.0106	0.0618	0.139	0.298	0.446	0.610	0.755	1.148	1.521	1.913	2.301
70	0.01049	0.0571	0.125	0.268	0.402	0.550	0.683	1.043	1.386	1.745	2.103
80	0.0105	0.0541	0.114	0.241	0.361	0.494	0.614	0.937	1.246	1.571	1.893
90	0.0104	0.0522	0.106	0.219	0.326	0.444	0.550	0.837	1.111	1.399	1.685
100	0.0104	0.0510	0.101	0.203	0.297	0.402	0.495	0.748	0.989	1.242	1.493

Table 2.3.6-2. Median amplification factors (for 5% damped PSA) developed for the BC-2000 profile (base case velocity with 2000 ft mean depth to hard rock), at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g using the single-corner seismological model.

Freq.	Loading Level										
[Hz]	G001	G005	G010	G020	G030	G040	G050	G075	G100	G125	G150
0.1	1.042	1.044	1.046	1.047	1.047	1.047	1.047	1.047	1.047	1.046	1.046
0.125	1.042	1.049	1.051	1.051	1.051	1.050	1.050	1.049	1.049	1.048	1.048
0.167	1.049	1.054	1.055	1.055	1.055	1.055	1.055	1.055	1.055	1.055	1.055
0.2	1.056	1.060	1.060	1.061	1.061	1.061	1.061	1.061	1.060	1.060	1.060
0.3	1.087	1.088	1.088	1.088	1.087	1.087	1.087	1.087	1.086	1.086	1.086
0.4	1.128	1.127	1.126	1.125	1.124	1.124	1.124	1.123	1.123	1.123	1.123
0.5	1.174	1.172	1.170	1.169	1.168	1.167	1.167	1.166	1.166	1.165	1.165
0.6	1.221	1.217	1.214	1.212	1.211	1.210	1.210	1.209	1.208	1.208	1.208
0.7	1.259	1.253	1.250	1.247	1.246	1.245	1.245	1.244	1.243	1.242	1.242
0.8	1.280	1.272	1.269	1.266	1.264	1.263	1.263	1.262	1.261	1.260	1.260
0.9	1.278	1.270	1.266	1.264	1.262	1.261	1.260	1.259	1.258	1.258	1.258
1	1.258	1.249	1.246	1.243	1.242	1.241	1.240	1.239	1.238	1.237	1.237
1.25	1.166	1.158	1.155	1.153	1.152	1.151	1.151	1.150	1.149	1.149	1.148
1.5	1.090	1.084	1.081	1.080	1.079	1.078	1.078	1.077	1.077	1.076	1.076
2	1.099	1.095	1.092	1.091	1.090	1.089	1.089	1.088	1.088	1.087	1.087
2.5	1.175	1.168	1.165	1.163	1.162	1.161	1.160	1.159	1.159	1.158	1.158
3	1.109	1.101	1.098	1.095	1.094	1.093	1.093	1.092	1.092	1.091	1.091
4	1.110	1.103	1.100	1.097	1.096	1.095	1.095	1.094	1.094	1.093	1.093
5	1.059	1.047	1.044	1.042	1.041	1.040	1.039	1.038	1.038	1.038	1.037
6	1.037	1.024	1.021	1.018	1.017	1.017	1.016	1.015	1.015	1.014	1.014
7	1.038	1.025	1.022	1.019	1.018	1.017	1.017	1.016	1.015	1.015	1.015
8	1.046	1.031	1.027	1.024	1.023	1.022	1.022	1.021	1.020	1.020	1.019
9	1.028	1.008	1.003	1.000	0.999	0.998	0.997	0.996	0.995	0.995	0.995
10	1.001	0.974	0.969	0.966	0.964	0.963	0.963	0.961	0.961	0.960	0.960
12.5	0.961	0.912	0.905	0.901	0.899	0.898	0.897	0.896	0.895	0.895	0.894
15	0.941	0.863	0.852	0.847	0.845	0.843	0.843	0.841	0.840	0.840	0.839
20	0.936	0.781	0.761	0.752	0.749	0.747	0.745	0.743	0.742	0.741	0.741
25	0.964	0.743	0.712	0.699	0.694	0.691	0.689	0.686	0.684	0.683	0.683
30	0.995	0.728	0.683	0.664	0.657	0.653	0.650	0.646	0.644	0.643	0.642
35	1.014	0.718	0.655	0.628	0.618	0.612	0.609	0.603	0.600	0.598	0.597
40	1.025	0.717	0.634	0.597	0.584	0.575	0.571	0.563	0.559	0.556	0.555
45	1.032	0.725	0.625	0.577	0.560	0.549	0.542	0.533	0.527	0.524	0.522
50	1.036	0.741	0.626	0.569	0.547	0.533	0.525	0.513	0.507	0.502	0.499
60	1.040	0.781	0.646	0.571	0.541	0.523	0.512	0.494	0.485	0.479	0.474
70	1.042	0.820	0.682	0.596	0.560	0.537	0.523	0.501	0.489	0.481	0.475
80	1.042	0.849	0.724	0.634	0.594	0.568	0.552	0.526	0.512	0.502	0.496
90	1.041	0.868	0.761	0.678	0.638	0.611	0.594	0.566	0.551	0.540	0.533
100	1.044	0.883	0.792	0.721	0.685	0.660	0.645	0.618	0.603	0.592	0.585

Table 2.3.6-3. Log-SD of the amplification factors (for 5% damped PSA) developed for the BC-2000 profile (base case velocity with 2000 ft mean depth to hard rock), at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g using the single-corner seismological model.

Freq.	Loading Level										
[Hz]	G001	G005	G010	G020	G030	G040	G050	G075	G100	G125	G150
0.1	0.0122	0.0133	0.0137	0.0139	0.0140	0.0141	0.0141	0.0141	0.0141	0.0141	0.0141
0.125	0.0125	0.0142	0.0148	0.0150	0.0150	0.0149	0.0149	0.0149	0.0148	0.0148	0.0148
0.167	0.0144	0.0155	0.0160	0.0163	0.0164	0.0165	0.0166	0.0167	0.0167	0.0168	0.0168
0.2	0.0166	0.0173	0.0177	0.0179	0.0180	0.0181	0.0181	0.0182	0.0182	0.0183	0.0183
0.3	0.0264	0.0261	0.0260	0.0260	0.0260	0.0260	0.0260	0.0259	0.0259	0.0259	0.0259
0.4	0.0390	0.0380	0.0376	0.0374	0.0373	0.0372	0.0371	0.0370	0.0370	0.0369	0.0369
0.5	0.0524	0.0508	0.0502	0.0498	0.0496	0.0495	0.0494	0.0492	0.0491	0.0491	0.0490
0.6	0.0637	0.0616	0.0608	0.0603	0.0600	0.0598	0.0597	0.0595	0.0594	0.0593	0.0592
0.7	0.0693	0.0670	0.0661	0.0655	0.0652	0.0650	0.0648	0.0646	0.0645	0.0644	0.0643
0.8	0.0678	0.0656	0.0647	0.0641	0.0639	0.0637	0.0635	0.0633	0.0632	0.0631	0.0631
0.9	0.0619	0.0603	0.0596	0.0592	0.0590	0.0588	0.0588	0.0586	0.0585	0.0584	0.0584
1	0.0580	0.0572	0.0569	0.0567	0.0566	0.0565	0.0564	0.0564	0.0563	0.0563	0.0563
1.25	0.0707	0.0715	0.0717	0.0717	0.0717	0.0718	0.0718	0.0718	0.0718	0.0718	0.0718
1.5	0.0855	0.0865	0.0866	0.0867	0.0867	0.0867	0.0867	0.0867	0.0867	0.0867	0.0867
2	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.109	0.109	0.109
2.5	0.116	0.117	0.117	0.117	0.116	0.116	0.116	0.116	0.116	0.116	0.116
3	0.120	0.122	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123
4	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103
5	0.0968	0.102	0.103	0.103	0.103	0.104	0.104	0.104	0.104	0.104	0.104
6	0.0884	0.0939	0.0949	0.0954	0.0957	0.0958	0.0959	0.0961	0.0962	0.0962	0.0963
7	0.109	0.118	0.119	0.120	0.120	0.120	0.120	0.120	0.120	0.121	0.121
8	0.116	0.125	0.127	0.127	0.128	0.128	0.128	0.128	0.128	0.128	0.128
9	0.112	0.124	0.126	0.127	0.127	0.127	0.127	0.128	0.128	0.128	0.128
10	0.119	0.135	0.138	0.139	0.139	0.139	0.140	0.140	0.140	0.140	0.140
12.5	0.123	0.151	0.154	0.155	0.156	0.156	0.157	0.157	0.157	0.157	0.157
15	0.103	0.136	0.140	0.142	0.143	0.143	0.143	0.144	0.144	0.144	0.144
20	0.0813	0.124	0.130	0.133	0.134	0.135	0.135	0.136	0.136	0.136	0.136
25	0.0756	0.116	0.125	0.128	0.130	0.131	0.131	0.132	0.132	0.133	0.133
30	0.0739	0.116	0.126	0.131	0.133	0.135	0.135	0.136	0.137	0.137	0.137
35	0.0721	0.107	0.119	0.125	0.127	0.129	0.130	0.131	0.132	0.133	0.133
40	0.0712	0.101	0.115	0.124	0.127	0.130	0.131	0.133	0.135	0.135	0.136
45	0.0711	0.102	0.117	0.128	0.133	0.136	0.138	0.141	0.143	0.145	0.145
50	0.0711	0.101	0.117	0.129	0.135	0.138	0.141	0.145	0.147	0.149	0.150
60	0.0708	0.0977	0.111	0.122	0.127	0.131	0.133	0.137	0.140	0.141	0.143
70	0.0706	0.0959	0.107	0.116	0.121	0.124	0.127	0.130	0.133	0.134	0.135
80	0.0704	0.0947	0.104	0.112	0.115	0.118	0.120	0.123	0.125	0.127	0.128
90	0.0703	0.0940	0.103	0.109	0.112	0.115	0.116	0.119	0.120	0.121	0.122
100	0.0703	0.0935	0.102	0.107	0.110	0.112	0.114	0.116	0.117	0.118	0.119

Table 2.3.6-4. Median amplification factors (for 5% damped PSA) developed for the BC-Deep-BC profile (base case velocity with deep hard rock and base case kappa), at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g using the single-corner seismological model.

Frequency [Hz]	Loading Level										
	G001	G005	G010	G020	G030	G040	G050	G075	G100	G125	G150
0.1	1.070	1.074	1.075	1.075	1.074	1.074	1.074	1.073	1.073	1.073	1.073
0.125	1.078	1.084	1.085	1.085	1.084	1.084	1.084	1.083	1.082	1.082	1.082
0.167	1.100	1.104	1.104	1.104	1.104	1.104	1.104	1.104	1.103	1.103	1.103
0.2	1.121	1.123	1.123	1.122	1.122	1.122	1.122	1.122	1.122	1.122	1.121
0.3	1.180	1.178	1.177	1.176	1.175	1.175	1.175	1.174	1.174	1.174	1.174
0.4	1.203	1.200	1.198	1.197	1.196	1.196	1.195	1.195	1.194	1.194	1.194
0.5	1.195	1.191	1.189	1.188	1.187	1.187	1.186	1.186	1.185	1.185	1.185
0.6	1.181	1.178	1.176	1.175	1.174	1.174	1.173	1.173	1.172	1.172	1.172
0.7	1.180	1.177	1.175	1.174	1.173	1.173	1.172	1.172	1.171	1.171	1.171
0.8	1.186	1.182	1.180	1.179	1.178	1.177	1.177	1.176	1.176	1.176	1.176
0.9	1.183	1.180	1.178	1.176	1.175	1.175	1.175	1.174	1.173	1.173	1.173
1	1.172	1.168	1.167	1.165	1.164	1.164	1.164	1.163	1.163	1.162	1.162
1.25	1.153	1.149	1.148	1.146	1.146	1.145	1.145	1.144	1.144	1.144	1.143
1.5	1.143	1.140	1.138	1.136	1.136	1.135	1.135	1.134	1.134	1.134	1.133
2	1.143	1.139	1.137	1.135	1.134	1.134	1.134	1.133	1.133	1.132	1.132
2.5	1.163	1.158	1.156	1.154	1.154	1.153	1.153	1.152	1.151	1.151	1.151
3	1.143	1.138	1.136	1.134	1.133	1.132	1.132	1.131	1.131	1.131	1.131
4	1.117	1.110	1.108	1.106	1.105	1.104	1.104	1.103	1.103	1.103	1.102
5	1.080	1.073	1.070	1.069	1.068	1.067	1.067	1.066	1.066	1.066	1.066
6	1.082	1.073	1.070	1.068	1.067	1.067	1.066	1.065	1.065	1.065	1.065
7	1.100	1.091	1.088	1.086	1.085	1.084	1.084	1.083	1.083	1.082	1.082
8	1.097	1.086	1.082	1.080	1.079	1.078	1.078	1.077	1.076	1.076	1.076
9	1.073	1.057	1.053	1.051	1.049	1.049	1.048	1.047	1.047	1.046	1.046
10	1.055	1.034	1.030	1.027	1.026	1.025	1.025	1.024	1.023	1.023	1.023
12.5	1.017	0.976	0.970	0.966	0.965	0.964	0.963	0.962	0.961	0.961	0.961
15	1.001	0.939	0.930	0.926	0.924	0.923	0.922	0.921	0.920	0.920	0.919
20	0.992	0.867	0.851	0.844	0.841	0.840	0.839	0.837	0.836	0.835	0.835
25	1.019	0.844	0.821	0.811	0.807	0.805	0.804	0.801	0.800	0.799	0.799
30	1.043	0.829	0.795	0.781	0.775	0.772	0.770	0.767	0.765	0.764	0.763
35	1.058	0.814	0.764	0.742	0.734	0.730	0.727	0.722	0.720	0.719	0.718
40	1.067	0.809	0.741	0.711	0.700	0.693	0.689	0.683	0.680	0.678	0.677
45	1.072	0.814	0.728	0.688	0.674	0.665	0.660	0.652	0.648	0.645	0.643
50	1.075	0.824	0.723	0.673	0.655	0.643	0.637	0.627	0.621	0.618	0.615
60	1.078	0.857	0.736	0.669	0.642	0.625	0.616	0.600	0.592	0.587	0.583
70	1.079	0.891	0.766	0.687	0.654	0.633	0.620	0.600	0.589	0.582	0.577
80	1.078	0.917	0.803	0.719	0.682	0.657	0.642	0.617	0.604	0.595	0.589
90	1.077	0.934	0.838	0.760	0.722	0.696	0.680	0.654	0.639	0.629	0.622
100	1.080	0.948	0.867	0.801	0.768	0.745	0.730	0.704	0.689	0.679	0.672

Table 2.3.6-5. Log-SD of the amplification factors (for 5% damped PSA) developed for the BC-Deep-BC profile (base case velocity with deep hard rock and base case kappa), at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g using the single-corner seismological model.

Freq. [Hz]	Loading Level										
	G001	G005	G010	G020	G030	G040	G050	G075	G100	G125	G150
0.1	0.0166	0.0181	0.0181	0.0183	0.0183	0.0183	0.0183	0.0183	0.0183	0.0183	0.0183
0.125	0.0190	0.0203	0.0208	0.0210	0.0211	0.0211	0.0211	0.0210	0.0210	0.0210	0.0209
0.167	0.0251	0.0256	0.0258	0.0260	0.0261	0.0262	0.0262	0.0262	0.0263	0.0263	0.0263
0.2	0.0304	0.0304	0.0305	0.0306	0.0306	0.0306	0.0306	0.0307	0.0307	0.0307	0.0307
0.3	0.0426	0.0420	0.0418	0.0417	0.0417	0.0416	0.0416	0.0416	0.0416	0.0416	0.0415
0.4	0.0546	0.0534	0.0529	0.0526	0.0524	0.0523	0.0523	0.0522	0.0521	0.0521	0.0520
0.5	0.0695	0.0676	0.0668	0.0662	0.0660	0.0658	0.0656	0.0654	0.0653	0.0652	0.0652
0.6	0.0780	0.0758	0.0748	0.0742	0.0739	0.0737	0.0735	0.0733	0.0731	0.0730	0.0730
0.7	0.0850	0.0830	0.0822	0.0816	0.0813	0.0811	0.0810	0.0808	0.0806	0.0805	0.0805
0.8	0.0942	0.0926	0.0919	0.0914	0.0912	0.0910	0.0909	0.0907	0.0906	0.0905	0.0904
0.9	0.100	0.0991	0.0986	0.0983	0.0981	0.0980	0.0979	0.0977	0.0976	0.0976	0.0975
1	0.110	0.110	0.109	0.109	0.109	0.109	0.109	0.108	0.108	0.108	0.108
1.25	0.118	0.117	0.117	0.117	0.117	0.116	0.116	0.116	0.116	0.116	0.116
1.5	0.121	0.120	0.120	0.119	0.119	0.119	0.119	0.119	0.119	0.119	0.119
2	0.144	0.144	0.143	0.143	0.143	0.143	0.142	0.142	0.142	0.142	0.142
2.5	0.140	0.141	0.141	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140
3	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.138	0.138	0.138	0.138
4	0.111	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114
5	0.0897	0.0934	0.0941	0.0945	0.0947	0.0948	0.0948	0.0949	0.0950	0.0950	0.0951
6	0.107	0.114	0.115	0.116	0.116	0.116	0.116	0.117	0.117	0.117	0.117
7	0.137	0.146	0.148	0.148	0.148	0.149	0.149	0.149	0.149	0.149	0.149
8	0.135	0.145	0.147	0.147	0.147	0.148	0.148	0.148	0.148	0.148	0.148
9	0.130	0.143	0.144	0.145	0.145	0.145	0.146	0.146	0.146	0.146	0.146
10	0.125	0.140	0.142	0.143	0.143	0.143	0.143	0.144	0.144	0.144	0.144
12.5	0.124	0.148	0.150	0.151	0.152	0.152	0.152	0.152	0.153	0.153	0.153
15	0.104	0.131	0.134	0.135	0.136	0.136	0.136	0.137	0.137	0.137	0.137
20	0.086	0.116	0.121	0.122	0.123	0.123	0.124	0.124	0.124	0.124	0.124
25	0.084	0.116	0.121	0.123	0.123	0.124	0.124	0.124	0.125	0.125	0.125
30	0.080	0.109	0.115	0.117	0.118	0.119	0.119	0.120	0.120	0.120	0.120
35	0.078	0.101	0.107	0.111	0.112	0.113	0.113	0.114	0.115	0.115	0.115
40	0.077	0.100	0.110	0.115	0.117	0.119	0.119	0.121	0.121	0.122	0.122
45	0.077	0.101	0.110	0.116	0.119	0.120	0.121	0.123	0.124	0.124	0.125
50	0.077	0.100	0.109	0.116	0.118	0.120	0.121	0.123	0.124	0.125	0.125
60	0.077	0.099	0.107	0.113	0.116	0.118	0.120	0.122	0.123	0.124	0.125
70	0.076	0.098	0.105	0.111	0.114	0.116	0.117	0.120	0.122	0.123	0.124
80	0.076	0.097	0.103	0.108	0.110	0.112	0.113	0.116	0.117	0.118	0.119
90	0.076	0.097	0.103	0.106	0.108	0.109	0.110	0.112	0.113	0.114	0.114
100	0.076	0.097	0.102	0.105	0.107	0.108	0.109	0.110	0.111	0.111	0.112

Table 2.3.6-6. Weighted average median amplification factors (for 5% damped PSA) at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g using the single-corner seismological model.

Frequency	Loading Level										
[Hz]	G001	G005	G010	G020	G030	G040	G050	G075	G100	G125	G150
0.1	1.089	1.093	1.094	1.094	1.094	1.094	1.094	1.093	1.093	1.093	1.093
0.125	1.095	1.101	1.102	1.102	1.102	1.101	1.101	1.100	1.100	1.100	1.100
0.167	1.106	1.110	1.111	1.111	1.111	1.111	1.111	1.111	1.112	1.112	1.112
0.2	1.116	1.119	1.119	1.119	1.119	1.119	1.119	1.119	1.119	1.119	1.119
0.3	1.162	1.162	1.161	1.160	1.160	1.159	1.159	1.159	1.159	1.159	1.159
0.4	1.218	1.215	1.213	1.212	1.211	1.210	1.210	1.210	1.210	1.210	1.210
0.5	1.261	1.255	1.253	1.250	1.249	1.249	1.248	1.248	1.247	1.247	1.247
0.6	1.278	1.271	1.268	1.265	1.264	1.263	1.262	1.261	1.261	1.260	1.260
0.7	1.266	1.258	1.255	1.253	1.251	1.250	1.250	1.249	1.248	1.248	1.248
0.8	1.242	1.235	1.232	1.230	1.229	1.228	1.227	1.226	1.226	1.225	1.225
0.9	1.213	1.206	1.204	1.201	1.200	1.199	1.199	1.198	1.198	1.197	1.197
1	1.187	1.181	1.179	1.177	1.176	1.175	1.174	1.174	1.173	1.173	1.172
1.25	1.158	1.153	1.150	1.149	1.148	1.147	1.147	1.146	1.146	1.145	1.145
1.5	1.170	1.164	1.162	1.160	1.159	1.158	1.158	1.157	1.156	1.156	1.156
2	1.145	1.139	1.137	1.135	1.134	1.133	1.133	1.132	1.132	1.132	1.131
2.5	1.170	1.164	1.161	1.159	1.158	1.157	1.157	1.156	1.156	1.155	1.155
3	1.142	1.134	1.131	1.129	1.128	1.128	1.127	1.126	1.126	1.126	1.125
4	1.128	1.120	1.117	1.115	1.114	1.113	1.113	1.112	1.112	1.111	1.111
5	1.102	1.093	1.090	1.088	1.086	1.086	1.085	1.084	1.084	1.084	1.083
6	1.082	1.070	1.066	1.064	1.063	1.062	1.062	1.061	1.060	1.060	1.060
7	1.071	1.057	1.053	1.051	1.050	1.049	1.048	1.047	1.047	1.047	1.046
8	1.062	1.044	1.040	1.038	1.036	1.036	1.035	1.034	1.034	1.033	1.033
9	1.045	1.021	1.017	1.014	1.012	1.012	1.011	1.010	1.009	1.009	1.009
10	1.022	0.992	0.986	0.983	0.982	0.981	0.980	0.979	0.978	0.978	0.978
12.5	0.986	0.932	0.925	0.920	0.919	0.917	0.917	0.915	0.915	0.914	0.914
15	0.972	0.889	0.878	0.873	0.871	0.869	0.868	0.867	0.866	0.866	0.865
20	0.980	0.828	0.808	0.799	0.795	0.793	0.792	0.790	0.789	0.788	0.787
25	1.008	0.794	0.762	0.747	0.742	0.738	0.736	0.733	0.732	0.730	0.730
30	1.034	0.778	0.731	0.709	0.701	0.696	0.694	0.689	0.686	0.685	0.684
35	1.052	0.772	0.707	0.677	0.666	0.659	0.655	0.649	0.645	0.643	0.641
40	1.063	0.776	0.694	0.654	0.640	0.630	0.625	0.616	0.612	0.609	0.607
45	1.069	0.788	0.690	0.642	0.623	0.611	0.605	0.594	0.588	0.584	0.582
50	1.073	0.804	0.694	0.637	0.615	0.601	0.593	0.579	0.573	0.568	0.565
60	1.077	0.842	0.717	0.646	0.617	0.598	0.587	0.569	0.560	0.553	0.549
70	1.078	0.877	0.753	0.672	0.638	0.616	0.602	0.580	0.569	0.561	0.555
80	1.079	0.902	0.790	0.708	0.671	0.646	0.631	0.606	0.593	0.584	0.577
90	1.078	0.918	0.823	0.748	0.711	0.686	0.671	0.645	0.630	0.620	0.613
100	1.080	0.931	0.850	0.785	0.753	0.731	0.716	0.692	0.678	0.668	0.661

Table 2.3.6-7. Total Log-SD of the amplification factors (for 5% damped PSA) at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g using the single-corner seismological model.

Frequency	Loading Level										
[Hz]	G001	G005	G010	G020	G030	G040	G050	G075	G100	G125	G150
0.1	0.102	0.101	0.101	0.101	0.100	0.100	0.100	0.100	0.100	0.100	0.100
0.125	0.112	0.111	0.110	0.109	0.109	0.109	0.109	0.109	0.109	0.110	0.110
0.167	0.115	0.113	0.113	0.112	0.112	0.112	0.112	0.113	0.114	0.114	0.114
0.2	0.113	0.112	0.111	0.111	0.110	0.110	0.111	0.111	0.111	0.112	0.112
0.3	0.132	0.130	0.130	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129
0.4	0.174	0.171	0.169	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.169
0.5	0.204	0.199	0.197	0.196	0.195	0.195	0.195	0.195	0.195	0.195	0.195
0.6	0.202	0.197	0.195	0.193	0.193	0.192	0.192	0.191	0.191	0.190	0.190
0.7	0.177	0.172	0.170	0.169	0.168	0.168	0.168	0.167	0.167	0.167	0.166
0.8	0.154	0.150	0.149	0.147	0.147	0.147	0.146	0.146	0.146	0.145	0.145
0.9	0.137	0.134	0.133	0.132	0.132	0.131	0.131	0.131	0.131	0.130	0.130
1	0.132	0.129	0.128	0.128	0.127	0.127	0.127	0.127	0.126	0.126	0.126
1.25	0.131	0.130	0.129	0.128	0.128	0.128	0.127	0.127	0.127	0.127	0.127
1.5	0.173	0.171	0.169	0.169	0.168	0.168	0.168	0.167	0.167	0.167	0.167
2	0.149	0.147	0.146	0.146	0.145	0.145	0.145	0.145	0.145	0.145	0.144
2.5	0.150	0.148	0.147	0.147	0.146	0.146	0.146	0.146	0.145	0.145	0.145
3	0.147	0.146	0.146	0.145	0.145	0.145	0.145	0.145	0.145	0.144	0.144
4	0.133	0.133	0.132	0.132	0.132	0.132	0.132	0.131	0.131	0.131	0.131
5	0.134	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136
6	0.133	0.136	0.136	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137
7	0.137	0.143	0.144	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145
8	0.137	0.146	0.147	0.148	0.148	0.148	0.148	0.149	0.149	0.149	0.149
9	0.133	0.146	0.148	0.149	0.149	0.150	0.150	0.150	0.150	0.150	0.150
10	0.133	0.151	0.153	0.155	0.155	0.156	0.156	0.156	0.157	0.157	0.157
12.5	0.132	0.167	0.173	0.175	0.176	0.177	0.177	0.178	0.179	0.179	0.179
15	0.122	0.175	0.184	0.188	0.189	0.190	0.191	0.192	0.192	0.193	0.193
20	0.112	0.198	0.215	0.223	0.226	0.228	0.229	0.231	0.232	0.233	0.234
25	0.105	0.213	0.242	0.257	0.262	0.266	0.268	0.271	0.273	0.274	0.275
30	0.102	0.220	0.263	0.285	0.294	0.300	0.303	0.309	0.312	0.313	0.315
35	0.102	0.218	0.274	0.305	0.317	0.325	0.330	0.338	0.342	0.344	0.346
40	0.103	0.209	0.276	0.315	0.331	0.341	0.347	0.358	0.363	0.367	0.370
45	0.104	0.198	0.273	0.318	0.338	0.351	0.358	0.371	0.378	0.383	0.386
50	0.104	0.186	0.266	0.317	0.339	0.354	0.363	0.378	0.386	0.392	0.396
60	0.105	0.164	0.243	0.301	0.328	0.346	0.357	0.376	0.386	0.393	0.398
70	0.105	0.148	0.217	0.276	0.305	0.325	0.337	0.358	0.370	0.379	0.384
80	0.105	0.138	0.193	0.247	0.275	0.295	0.308	0.330	0.343	0.351	0.358
90	0.105	0.132	0.176	0.220	0.245	0.263	0.275	0.296	0.308	0.317	0.323
100	0.105	0.128	0.163	0.198	0.218	0.233	0.243	0.261	0.271	0.279	0.284

Table 2.3.6-8. Input 5% damped PSA values at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g using the double-corner seismological model.

Freq.	Loading Level										
[Hz]	G001	G005	G010	G020	G030	G040	G050	G075	G100	G125	G150
0.1	0.000184	0.000303	0.000395	0.000573	0.000744	0.000908	0.00105	0.00143	0.00178	0.00213	0.00249
0.125	0.000278	0.000461	0.000594	0.000848	0.00109	0.00133	0.00154	0.00206	0.00257	0.00306	0.00357
0.167	0.000452	0.000771	0.000991	0.00141	0.00180	0.00218	0.00252	0.00336	0.00417	0.00495	0.00577
0.2	0.000596	0.00104	0.00135	0.00191	0.00245	0.00296	0.00342	0.00455	0.00565	0.00670	0.00781
0.3	0.00107	0.00199	0.00262	0.00375	0.00482	0.00584	0.00675	0.00901	0.0112	0.0133	0.0155
0.4	0.00162	0.0031	0.0042	0.0061	0.0079	0.0095	0.0110	0.0148	0.0184	0.0218	0.0255
0.5	0.00226	0.00456	0.00616	0.00900	0.0117	0.0142	0.0164	0.0220	0.0274	0.0326	0.0381
0.6	0.00300	0.00624	0.00851	0.0125	0.0162	0.0198	0.0230	0.0309	0.0385	0.0459	0.0536
0.7	0.00384	0.00818	0.0113	0.0167	0.0217	0.0265	0.0307	0.0414	0.0516	0.0615	0.0719
0.8	0.00474	0.0104	0.0144	0.0214	0.0279	0.0341	0.0396	0.0534	0.0667	0.0795	0.0930
0.9	0.00571	0.0127	0.0178	0.0266	0.0348	0.0425	0.0495	0.0669	0.0836	0.100	0.117
1	0.00672	0.0153	0.0215	0.0322	0.0422	0.0517	0.0603	0.0815	0.102	0.122	0.142
1.25	0.00930	0.0221	0.0316	0.0478	0.0628	0.0772	0.0900	0.122	0.153	0.183	0.214
1.5	0.0118	0.0293	0.0423	0.0645	0.0851	0.105	0.122	0.167	0.209	0.250	0.293
2	0.0164	0.0435	0.0641	0.0991	0.131	0.162	0.190	0.260	0.326	0.391	0.459
2.5	0.0200	0.0564	0.0845	0.132	0.176	0.218	0.256	0.350	0.441	0.529	0.622
3	0.0227	0.0676	0.103	0.162	0.217	0.270	0.317	0.435	0.549	0.660	0.775
4	0.0260	0.0854	0.134	0.214	0.289	0.360	0.425	0.586	0.741	0.892	1.050
5	0.0274	0.098	0.157	0.256	0.347	0.435	0.514	0.712	0.904	1.089	1.284
6	0.0279	0.108	0.177	0.291	0.397	0.499	0.592	0.823	1.046	1.262	1.490
7	0.0277	0.115	0.193	0.322	0.441	0.556	0.660	0.921	1.173	1.417	1.674
8	0.0271	0.121	0.206	0.348	0.479	0.605	0.720	1.008	1.286	1.556	1.840
9	0.0264	0.125	0.217	0.370	0.512	0.650	0.774	1.087	1.390	1.683	1.992
10	0.0254	0.128	0.226	0.389	0.540	0.687	0.820	1.155	1.479	1.793	2.124
12.5	0.0224	0.128	0.235	0.415	0.582	0.745	0.892	1.264	1.625	1.976	2.344
15	0.0197	0.125	0.238	0.428	0.606	0.779	0.937	1.335	1.724	2.100	2.495
20	0.0158	0.115	0.233	0.435	0.625	0.812	0.983	1.416	1.839	2.249	2.682
25	0.0134	0.104	0.221	0.427	0.622	0.815	0.993	1.443	1.884	2.313	2.766
30	0.0122	0.0942	0.207	0.411	0.606	0.801	0.980	1.437	1.885	2.322	2.783
35	0.0115	0.0853	0.193	0.392	0.584	0.777	0.955	1.410	1.858	2.296	2.758
40	0.0112	0.0778	0.179	0.371	0.558	0.747	0.921	1.370	1.813	2.246	2.704
45	0.0109	0.0717	0.167	0.350	0.531	0.714	0.884	1.322	1.755	2.180	2.629
50	0.0108	0.0668	0.155	0.330	0.503	0.679	0.844	1.269	1.691	2.104	2.542
60	0.0107	0.0601	0.137	0.293	0.450	0.612	0.763	1.158	1.550	1.935	2.345
70	0.0106	0.0562	0.123	0.261	0.402	0.548	0.686	1.044	1.403	1.756	2.131
80	0.0106	0.0541	0.113	0.235	0.361	0.491	0.613	0.934	1.256	1.574	1.911
90	0.0106	0.0528	0.107	0.215	0.326	0.441	0.549	0.833	1.117	1.398	1.698
100	0.0105	0.0519	0.103	0.201	0.300	0.402	0.497	0.746	0.996	1.241	1.503

Table 2.3.6-9. Weighted average median amplification factors (for 5% damped PSA) at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g using the double-corner seismological model.

Frequency [Hz]	Loading Level										
	G001	G005	G010	G020	G030	G040	G050	G075	G100	G125	G150
0.1	1.066	1.072	1.071	1.070	1.068	1.068	1.068	1.067	1.067	1.066	1.066
0.125	1.082	1.082	1.081	1.080	1.079	1.079	1.079	1.078	1.078	1.077	1.077
0.167	1.096	1.095	1.095	1.095	1.094	1.094	1.094	1.093	1.093	1.093	1.092
0.2	1.107	1.106	1.106	1.106	1.105	1.105	1.105	1.105	1.104	1.104	1.104
0.3	1.156	1.154	1.153	1.153	1.153	1.153	1.153	1.153	1.153	1.153	1.153
0.4	1.216	1.212	1.210	1.208	1.207	1.206	1.206	1.205	1.204	1.204	1.204
0.5	1.261	1.256	1.253	1.250	1.249	1.248	1.247	1.246	1.245	1.245	1.245
0.6	1.277	1.270	1.266	1.263	1.262	1.261	1.260	1.259	1.259	1.258	1.258
0.7	1.260	1.253	1.250	1.247	1.246	1.245	1.244	1.243	1.243	1.242	1.242
0.8	1.234	1.227	1.224	1.221	1.220	1.219	1.219	1.218	1.217	1.216	1.216
0.9	1.202	1.196	1.193	1.191	1.190	1.189	1.189	1.188	1.187	1.187	1.187
1	1.176	1.170	1.168	1.166	1.165	1.164	1.164	1.163	1.163	1.162	1.162
1.25	1.148	1.144	1.141	1.140	1.139	1.138	1.138	1.137	1.137	1.137	1.136
1.5	1.161	1.156	1.153	1.152	1.151	1.150	1.150	1.149	1.148	1.148	1.148
2	1.135	1.130	1.127	1.125	1.124	1.124	1.123	1.123	1.122	1.122	1.122
2.5	1.162	1.156	1.153	1.151	1.150	1.149	1.149	1.148	1.148	1.147	1.147
3	1.132	1.125	1.122	1.120	1.119	1.118	1.118	1.117	1.116	1.116	1.116
4	1.120	1.113	1.109	1.107	1.106	1.105	1.105	1.104	1.103	1.103	1.102
5	1.094	1.086	1.083	1.080	1.079	1.078	1.077	1.077	1.076	1.076	1.075
6	1.072	1.063	1.060	1.057	1.056	1.055	1.054	1.053	1.053	1.052	1.052
7	1.061	1.051	1.047	1.044	1.043	1.042	1.042	1.041	1.040	1.040	1.039
8	1.051	1.039	1.035	1.032	1.030	1.029	1.029	1.028	1.027	1.027	1.026
9	1.032	1.016	1.011	1.008	1.007	1.006	1.005	1.004	1.003	1.003	1.002
10	1.007	0.986	0.981	0.977	0.976	0.975	0.974	0.973	0.972	0.972	0.972
12.5	0.966	0.927	0.919	0.915	0.913	0.912	0.911	0.910	0.909	0.908	0.908
15	0.948	0.884	0.873	0.867	0.865	0.864	0.863	0.861	0.860	0.860	0.859
20	0.955	0.824	0.803	0.793	0.790	0.788	0.786	0.784	0.783	0.782	0.781
25	0.986	0.793	0.758	0.742	0.736	0.732	0.730	0.727	0.725	0.724	0.723
30	1.015	0.782	0.729	0.704	0.695	0.690	0.687	0.682	0.680	0.678	0.677
35	1.030	0.782	0.709	0.673	0.661	0.653	0.649	0.642	0.638	0.635	0.634
40	1.039	0.792	0.699	0.652	0.635	0.625	0.619	0.610	0.604	0.601	0.598
45	1.044	0.810	0.700	0.642	0.620	0.607	0.599	0.587	0.580	0.576	0.573
50	1.047	0.830	0.709	0.640	0.613	0.598	0.588	0.573	0.565	0.560	0.556
60	1.049	0.869	0.740	0.654	0.619	0.599	0.586	0.565	0.553	0.546	0.540
70	1.049	0.897	0.778	0.684	0.644	0.619	0.603	0.578	0.564	0.554	0.547
80	1.049	0.914	0.812	0.722	0.679	0.652	0.635	0.606	0.589	0.578	0.570
90	1.049	0.924	0.838	0.759	0.719	0.692	0.674	0.644	0.627	0.615	0.606
100	1.050	0.931	0.857	0.791	0.757	0.733	0.717	0.690	0.673	0.662	0.653

Table 2.3.6-10. Total Log-SD of the amplification factors (for 5% damped PSA) at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g using the double-corner seismological model.

Freq.	Loading Level										
[Hz]	G001	G005	G010	G020	G030	G040	G050	G075	G100	G125	G150
0.1	0.0965	0.0953	0.0939	0.0929	0.0923	0.0919	0.0918	0.0913	0.0911	0.0909	0.0908
0.125	0.110	0.109	0.107	0.106	0.106	0.105	0.105	0.105	0.104	0.104	0.104
0.167	0.113	0.112	0.111	0.110	0.109	0.109	0.109	0.109	0.108	0.108	0.108
0.2	0.110	0.108	0.108	0.108	0.107	0.107	0.107	0.107	0.106	0.106	0.106
0.3	0.129	0.127	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
0.4	0.174	0.171	0.169	0.168	0.167	0.167	0.166	0.166	0.165	0.165	0.165
0.5	0.205	0.201	0.199	0.197	0.197	0.196	0.196	0.195	0.194	0.194	0.194
0.6	0.201	0.196	0.194	0.192	0.191	0.191	0.190	0.190	0.189	0.189	0.189
0.7	0.173	0.168	0.167	0.165	0.164	0.164	0.164	0.163	0.163	0.162	0.162
0.8	0.150	0.147	0.145	0.144	0.143	0.143	0.143	0.142	0.142	0.142	0.142
0.9	0.135	0.133	0.131	0.130	0.130	0.130	0.129	0.129	0.129	0.129	0.129
1	0.131	0.129	0.128	0.127	0.127	0.127	0.126	0.126	0.126	0.126	0.126
1.25	0.132	0.131	0.130	0.129	0.129	0.129	0.129	0.128	0.128	0.128	0.128
1.5	0.176	0.174	0.173	0.172	0.172	0.172	0.172	0.171	0.171	0.171	0.171
2	0.150	0.148	0.147	0.146	0.146	0.145	0.145	0.145	0.145	0.145	0.145
2.5	0.151	0.149	0.148	0.148	0.147	0.147	0.147	0.147	0.146	0.146	0.146
3	0.149	0.148	0.148	0.147	0.147	0.147	0.147	0.146	0.146	0.146	0.146
4	0.135	0.134	0.133	0.133	0.133	0.132	0.132	0.132	0.132	0.132	0.132
5	0.136	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137
6	0.136	0.138	0.138	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139
7	0.142	0.146	0.147	0.147	0.147	0.147	0.148	0.148	0.148	0.148	0.148
8	0.144	0.149	0.151	0.151	0.151	0.152	0.152	0.152	0.152	0.152	0.152
9	0.142	0.150	0.152	0.153	0.153	0.153	0.153	0.154	0.154	0.154	0.154
10	0.143	0.155	0.158	0.159	0.160	0.160	0.160	0.161	0.161	0.161	0.161
12.5	0.147	0.173	0.178	0.181	0.182	0.182	0.183	0.183	0.184	0.184	0.184
15	0.140	0.182	0.190	0.194	0.195	0.196	0.197	0.198	0.198	0.198	0.199
20	0.128	0.205	0.222	0.230	0.233	0.235	0.236	0.238	0.239	0.240	0.240
25	0.117	0.218	0.249	0.265	0.270	0.274	0.276	0.280	0.282	0.283	0.284
30	0.113	0.222	0.269	0.294	0.304	0.309	0.313	0.319	0.322	0.324	0.326
35	0.112	0.216	0.277	0.313	0.326	0.335	0.340	0.349	0.353	0.357	0.359
40	0.112	0.204	0.276	0.321	0.340	0.351	0.358	0.369	0.376	0.380	0.383
45	0.112	0.192	0.270	0.323	0.346	0.359	0.368	0.382	0.391	0.396	0.400
50	0.112	0.180	0.260	0.320	0.346	0.362	0.372	0.389	0.399	0.406	0.411
60	0.112	0.160	0.234	0.300	0.331	0.350	0.363	0.385	0.398	0.406	0.413
70	0.112	0.149	0.209	0.273	0.305	0.327	0.341	0.366	0.380	0.390	0.398
80	0.112	0.143	0.190	0.245	0.276	0.297	0.311	0.336	0.352	0.362	0.370
90	0.112	0.140	0.177	0.221	0.247	0.266	0.279	0.302	0.317	0.327	0.335
100	0.112	0.138	0.169	0.204	0.224	0.239	0.250	0.269	0.282	0.290	0.297

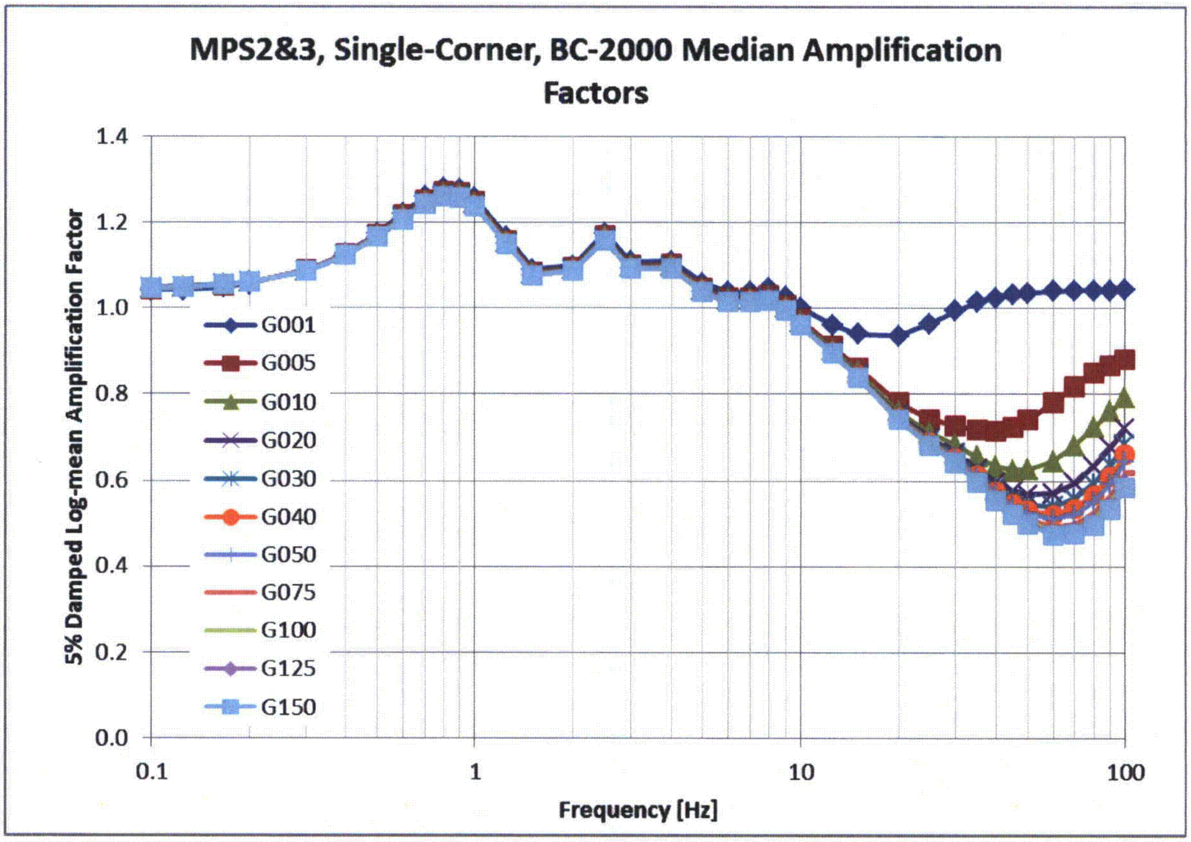

Figure 2.3.6-1. Median amplification factors (for 5% damped PSA) developed for the BC-2000 profile (base case velocity with 2000 ft mean depth to hard rock), at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g using the single-corner seismological model.

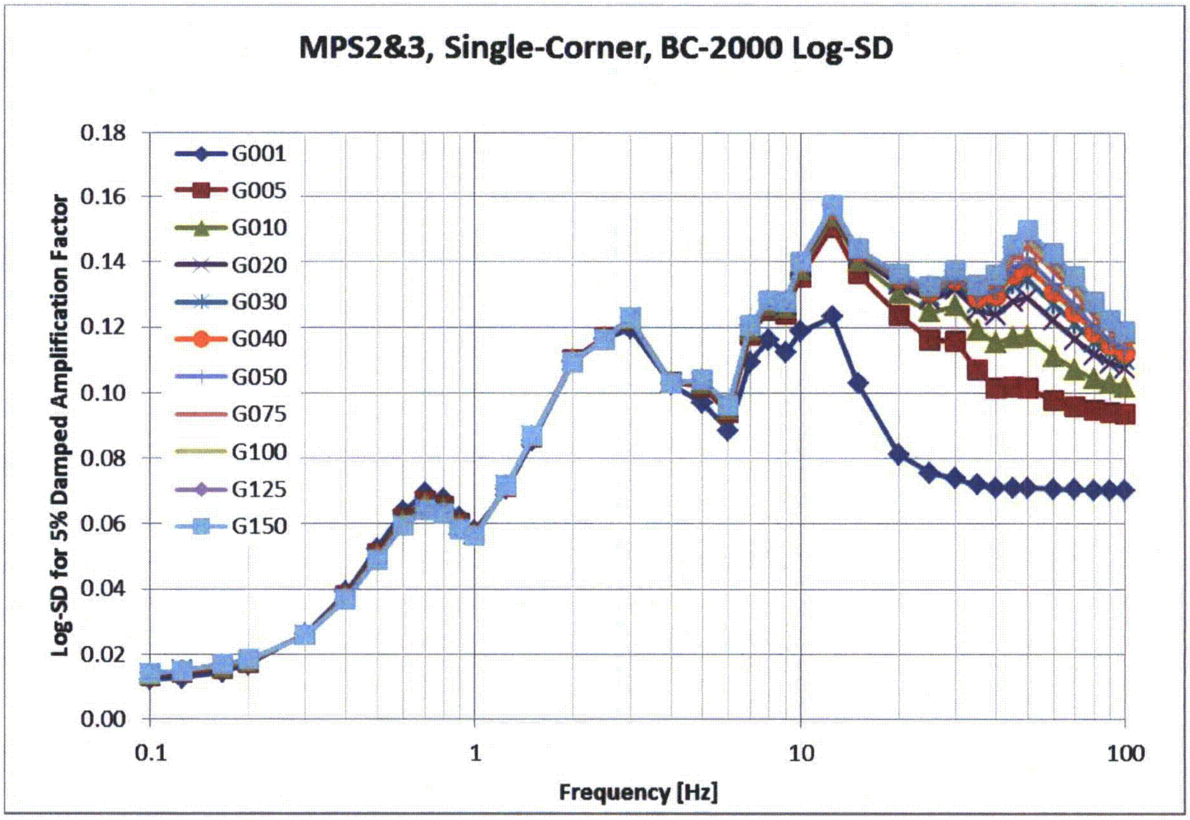

Figure 2.3.6-2. Log-SD of the amplification factors (for 5% damped PSA) developed for the BC-2000 profile (base case velocity with 2000 ft mean depth to hard rock), at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g using the single-corner seismological model.

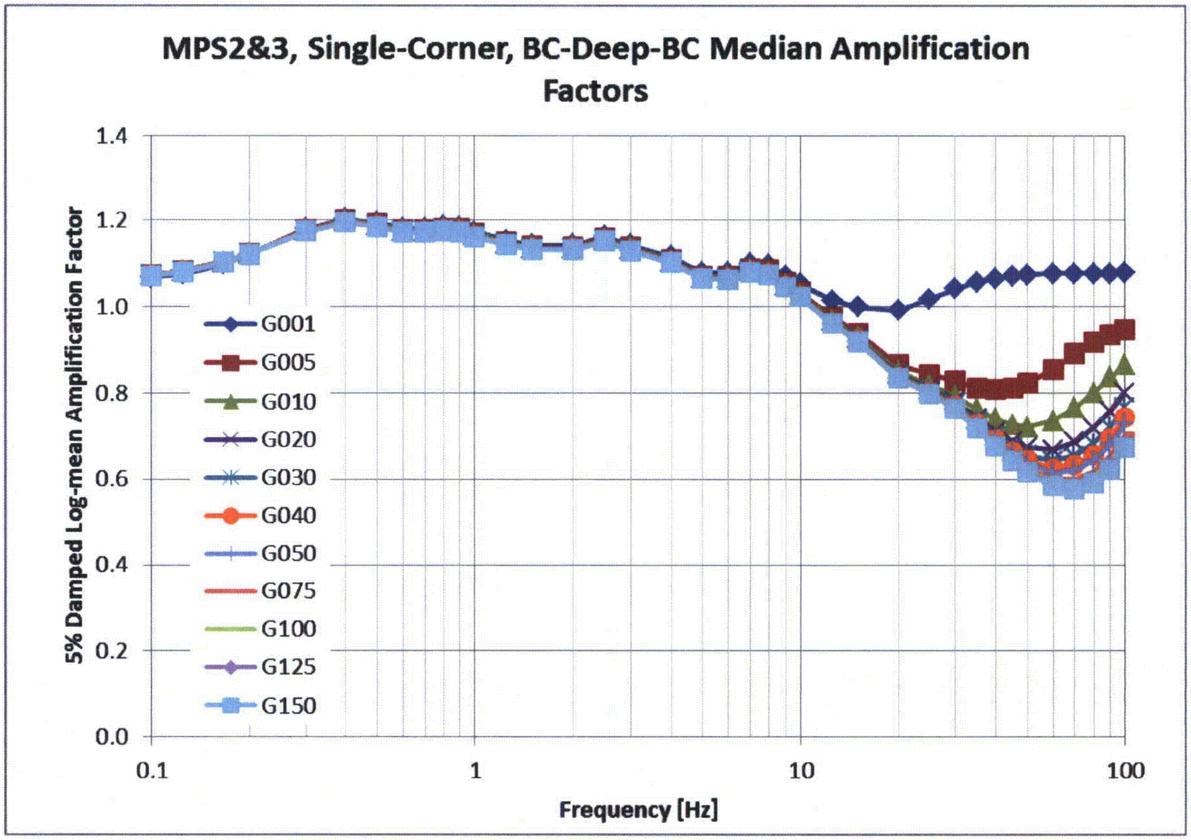

Figure 2.3.6-3. **Median amplification factors (for 5% damped PSA) developed for the BC-Deep-BC profile (base case velocity with deep hard rock and base case kappa), at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g using the single-corner seismological model.**

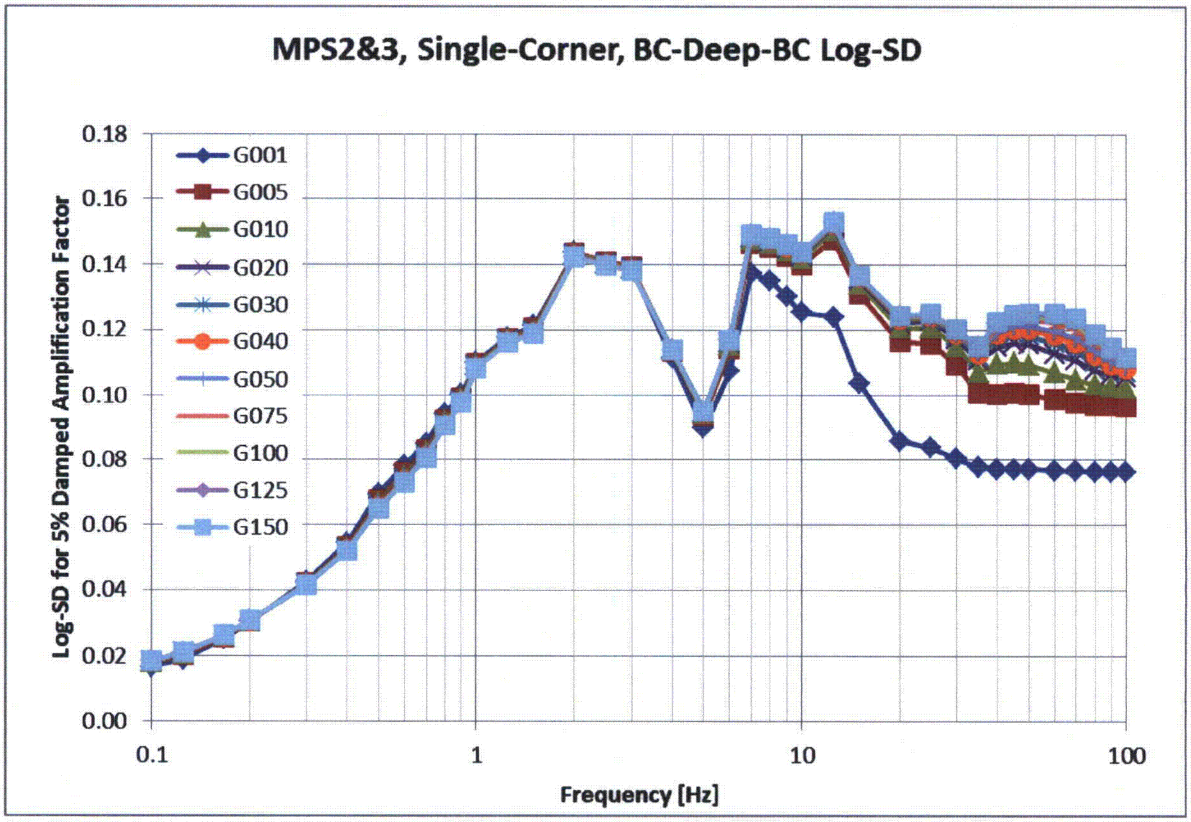

Figure 2.3.6-4. Log-SD of the amplification factors (for 5% damped PSA) developed for the BC-Deep-BC profile (base case velocity with deep hard rock and base case kappa), at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g using the single-corner seismological model.

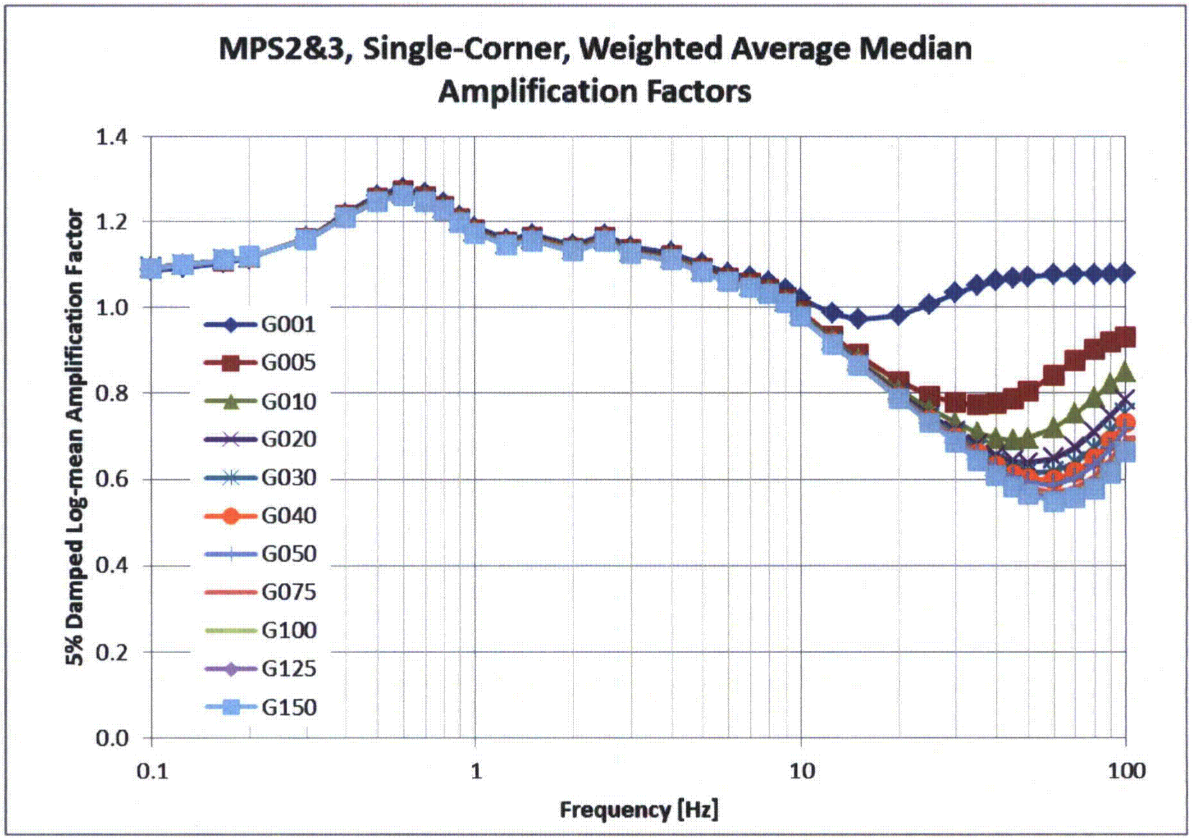

Figure 2.3.6-5. Weighted average median amplification factors (for 5% damped PSA) at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g using the single-corner seismological model.

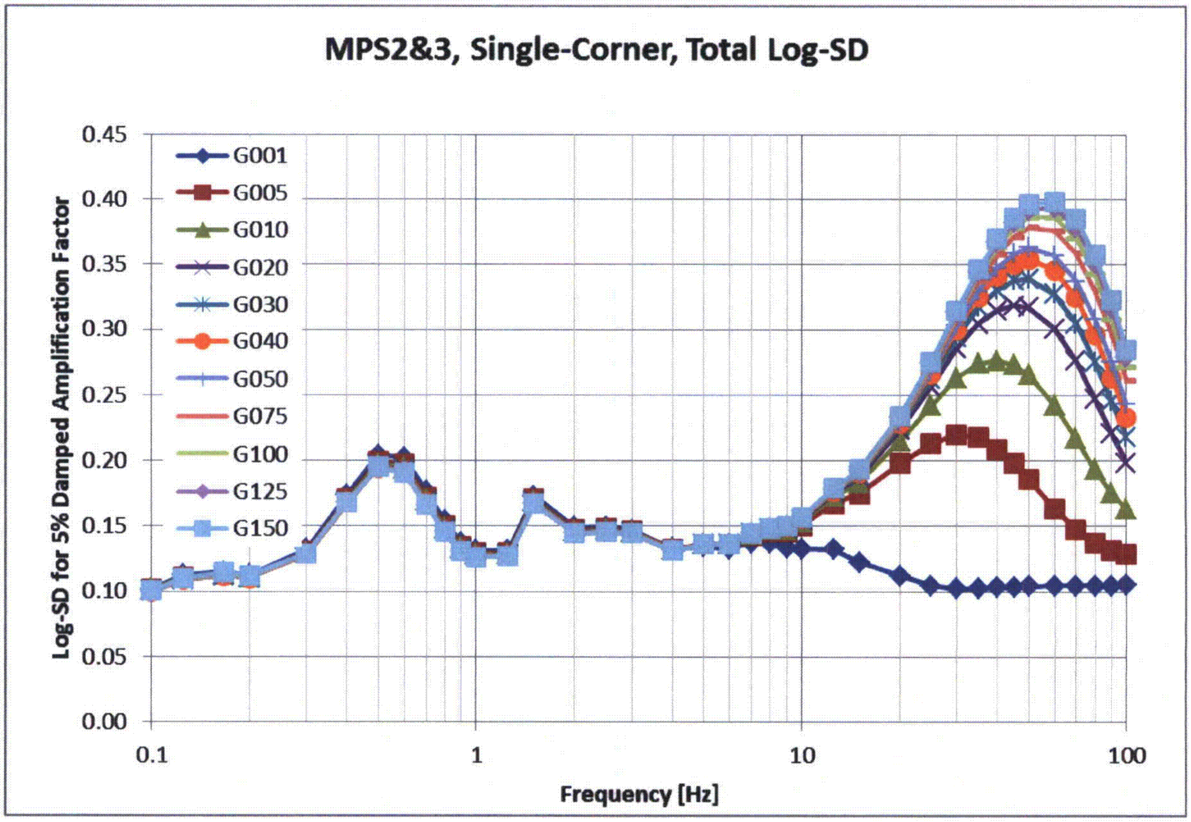

Figure 2.3.6-6. **Weighted average Log-SD of the amplification factors (for 5% damped PSA) at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g using the single-corner seismological model.**

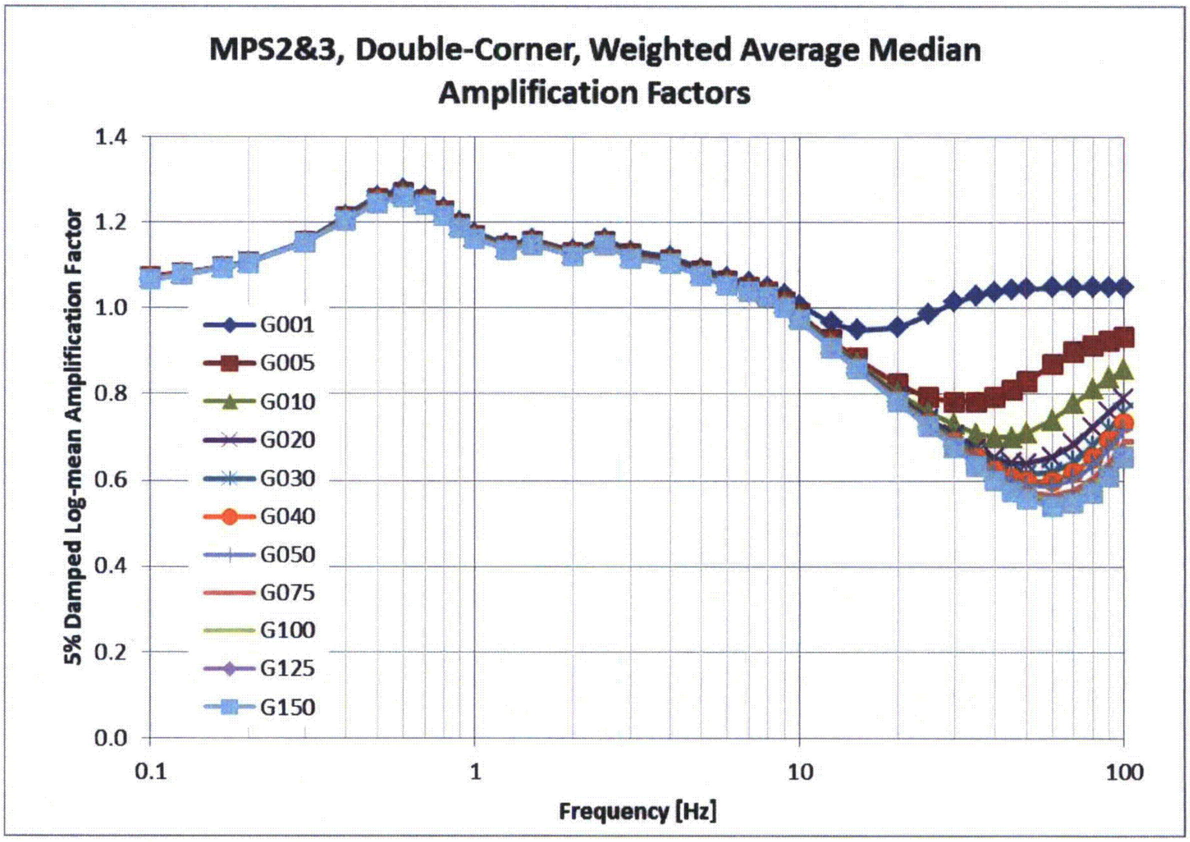

Figure 2.3.6-7. **Weighted average median amplification factors (for 5% damped PSA) at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g using the double-corner seismological model.**

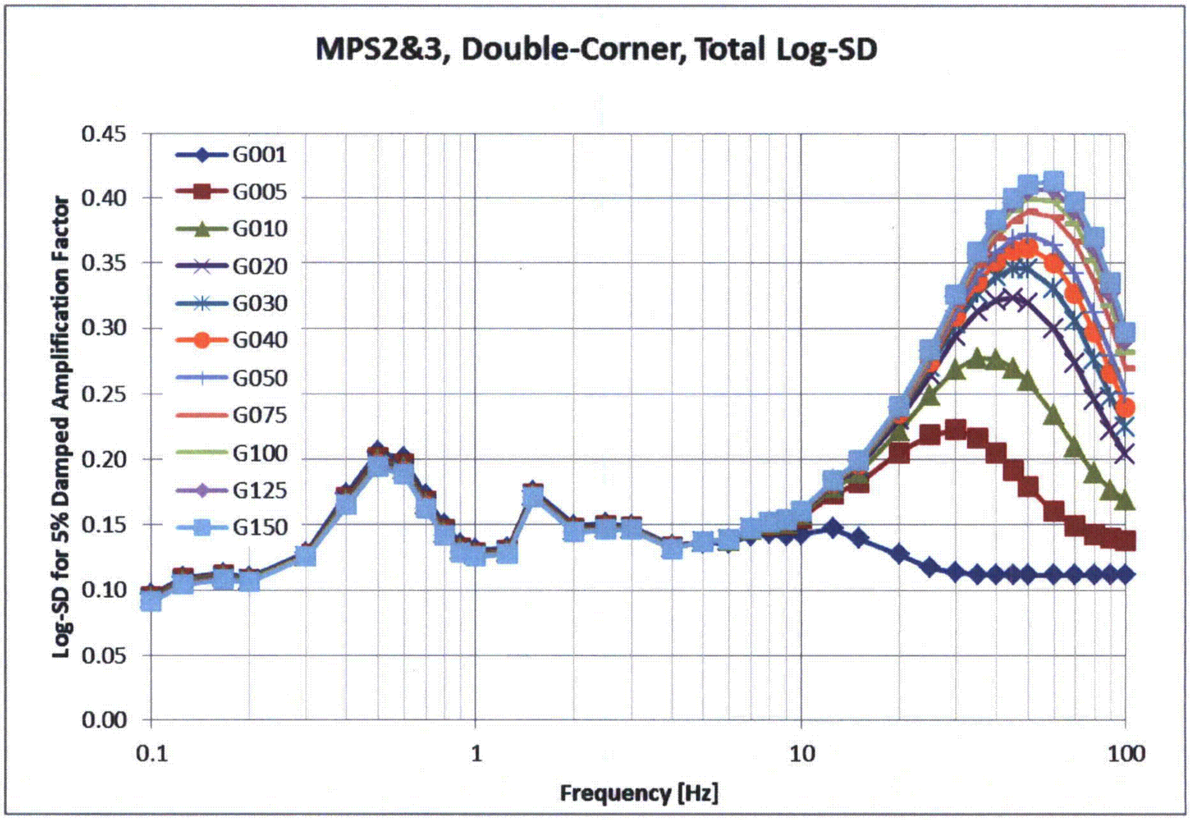

Figure 2.3.6-8. Weighted average Log-SD of the amplification factors (for 5% damped PSA) at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g using the double-corner seismological model.

2.3.7 CONTROL POINT SEISMIC HAZARD CURVES

The procedure to develop probabilistic site-specific control point hazard curves used in the present analysis followed the methodology described in McGuire et al. (Reference 7.18) and Section B-6.0 of the SPID. This procedure (referred to as Method 3) computed 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 (i.e., median amplification factors) and associated uncertainties (i.e., sigma in natural log units) presented in the previous section.

As part of the implementation of Method 3, base rock hazard curves for 31 spectral frequencies in addition to the original seven frequencies of 100 Hz (PGA), 25 Hz, 10 Hz, 5 Hz, 2.5 Hz, 1 Hz, and 0.5 Hz were initially developed and used in the application of Method 3 to capture the resulting expected site resonance characteristics from the site response analysis. Given the base rock hazard curves from the seven reference spectral frequencies, UHRS were developed for a suite of 38 spectral frequencies over the range of 0.1 – 100 Hz. UHRS are computed for annual frequencies of exceedance (AFE) of 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7}, and 10^{-8}. For the interpolation of ground motions at the additional 31 spectral frequencies, the average of the CEUS base rock single-corner and double-corner spectral shape models (Reference 7.18) was used with a magnitude 6.5 at a distance of 50 km. This average spectral shape for each UHRS was constrained to be equal to the ground motion value for each of the seven reference spectral frequencies. For frequencies less than 0.5 Hz, a constant slope of 1/T was adopted, where T is the spectral period. This methodology for the interpolation of additional spectral frequencies for the base rock hazard curves was applied to both the mean and fractile sets of base rock hazard curves.

The resulting 38 base rock hazard curve sets (i.e., mean and five fractile levels of 5^{th}, 16^{th}, 50^{th}, 84^{th}, and 95^{th}) was used in the Method 3 approach (Reference 7.18) to estimate the control point seismic hazard curves for 38 spectral frequencies along with the median site amplification factors and associated sigma values from the single-corner and double-corner seismic source input spectra. The resulting Method 3 control point hazard curves from the single-corner and double-corner site amplification factors and sigma were combined based on equal weights as recommended in the SPID. The mean control point hazard curves for the seven reference spectral frequencies for the Millstone site are shown in Figure 2.3.7-1. Tabulated values of the site response amplification functions and control point hazard curves are provided in Appendix A to this report.

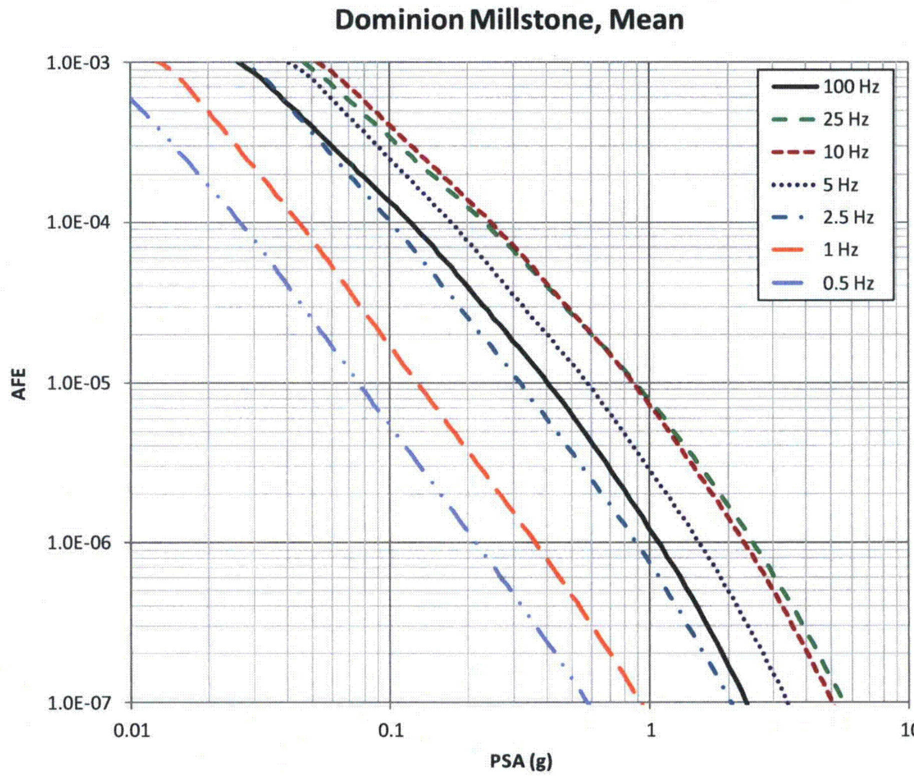

Figure 2.3.7-1. Control point mean hazard curves for spectral frequencies of 0.5, 1, 2.5, 5, 10, 25 and 100 Hz at the Millstone site.

2.4 CONTROL POINT RESPONSE SPECTRA

The control point hazard curves provided above have been used to develop uniform hazard response spectra (UHRS) and the ground motion response spectrum (GMRS). The UHRS were obtained through linear interpolation in log-log space to estimate the spectral acceleration at each of the 38 oscillator frequencies for the 1E-4 and 1E-5 per year hazard levels.

The 1E-4 and 1E-5 UHRS, along with a design factor (DF) are used to compute the GMRS at the control point using the criteria in Regulatory Guide 1.208 (Reference 7.23). Table 2.4-1 shows the UHRS and GMRS spectral accelerations and these spectra, which are also plotted in Figure 2.4-1.

Table 2.4-1. Horizontal Direction, 5% Damped UHRS for 10^{-4} and 10^{-5} and GMRS at control point for Millstone

Frequency (Hz)	Mean UHRS (g) (AEP=10^{-4})	Mean UHRS (g) (AEP=10^{-5})	GMRS (g)
100.000	0.1201	0.4047	0.1904
90.000	0.1248	0.4154	0.1960
80.000	0.1344	0.4482	0.2114
70.000	0.1499	0.5088	0.2391
60.000	0.1700	0.5935	0.2773
50.000	0.1911	0.6889	0.3199
45.000	0.2007	0.7344	0.3400
40.000	0.2098	0.7778	0.3591
35.000	0.2186	0.8203	0.3778
30.000	0.2264	0.8568	0.3940
25.000	0.2313	0.8797	0.4041
20.000	0.2419	0.9043	0.4168
15.000	0.2493	0.9107	0.4217
12.500	0.2493	0.8975	0.4168
10.000	0.2449	0.8659	0.4036
9.000	0.2373	0.8319	0.3884
8.000	0.2259	0.7850	0.3671
7.000	0.2098	0.7212	0.3380
6.000	0.1914	0.6489	0.3050
5.000	0.1724	0.5748	0.2710
4.000	0.1476	0.4831	0.2286
3.000	0.1169	0.3729	0.1774
2.500	0.1010	0.3163	0.1511
2.000	0.0850	0.2599	0.1247
1.500	0.0686	0.2038	0.0984
1.250	0.0559	0.1629	0.0789
1.000	0.0446	0.1275	0.0620
0.900	0.0423	0.1206	0.0587
0.800	0.0396	0.1129	0.0549
0.700	0.0362	0.1034	0.0503
0.600	0.0320	0.0916	0.0445
0.500	0.0265	0.0758	0.0368
0.400	0.0203	0.0580	0.0282
0.300	0.0144	0.0412	0.0200
0.200	0.0092	0.0263	0.0128
0.167	0.0076	0.0217	0.0106
0.125	0.0056	0.0161	0.0078
0.100	0.0045	0.0127	0.0062

AEP – Annual exceedance probability

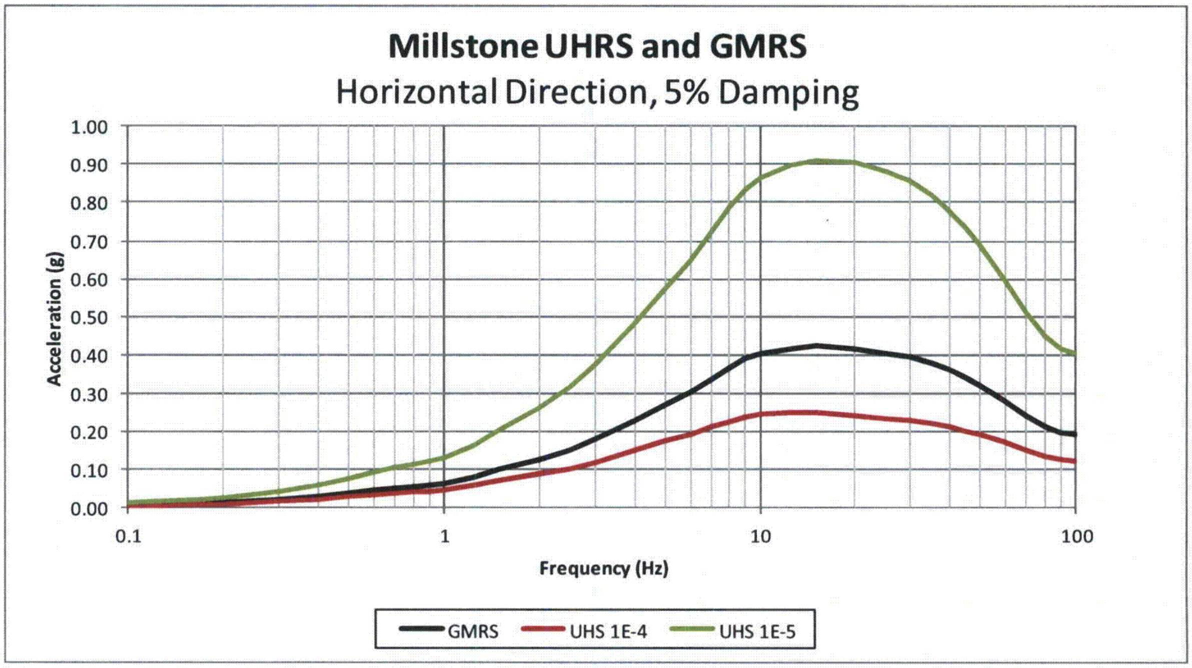

Figure 2.4-1. UHRS for 1E-4 and 1E-5 and GMRS at control point for Millstone.

3.0 DESIGN BASIS EARTHQUAKE

The design basis for MPS2 is identified in the MPS2 Final Safely Analysis Report (Reference 7.24).

The design basis for MPS3 is identified in the MPS3 Final Safely Analysis Report (Reference 7.19).

An evaluation for beyond design basis ground motions was performed in the IPEEE for MPS2 (Reference 7.5) and MPS3 (Reference 7.7). The MPS2 and MPS3 IPEEE plant level HCLPF response spectra are included in Sections 3.3.1 and 3.3.2, respectively, for screening purposes.

3.1 SSE DESCRIPTION OF SPECTRAL SHAPE

3.1.1 SSE DESCRIPTION OF SPECTRAL SHAPE FOR MPS2

The MPS2 FSAR Section 5.8 describes the development of the DBE (SSE) spectrum and FSAR Figure 5.8-2 provides the rock SSE response spectrum. The digitized SSE response spectrum data provided in Table 3.1.1-1 are based on FSAR Figure 5.8-2. The horizontal direction, 5% damped SSE response spectrum is plotted in Figure 3.1.1-1.

Table 3.1.1-1. SSE Data for MPS2 (Horizontal Direction, 5% Damped, Rock Founded Structures)

Freq (Hz)	SSE (g)
0.50	0.090
0.60	0.105
0.70	0.120
0.80	0.135
0.90	0.148
1.00	0.160
1.50	0.210
2.00	0.240
3.00	0.285
4.00	0.300
10.00	0.300
15.00	0.280
17.00	0.270
20.00	0.260
22.00	0.245
24.00	0.230
28.00	0.185
30.00	0.170
33.00	0.170
100.0	0.170

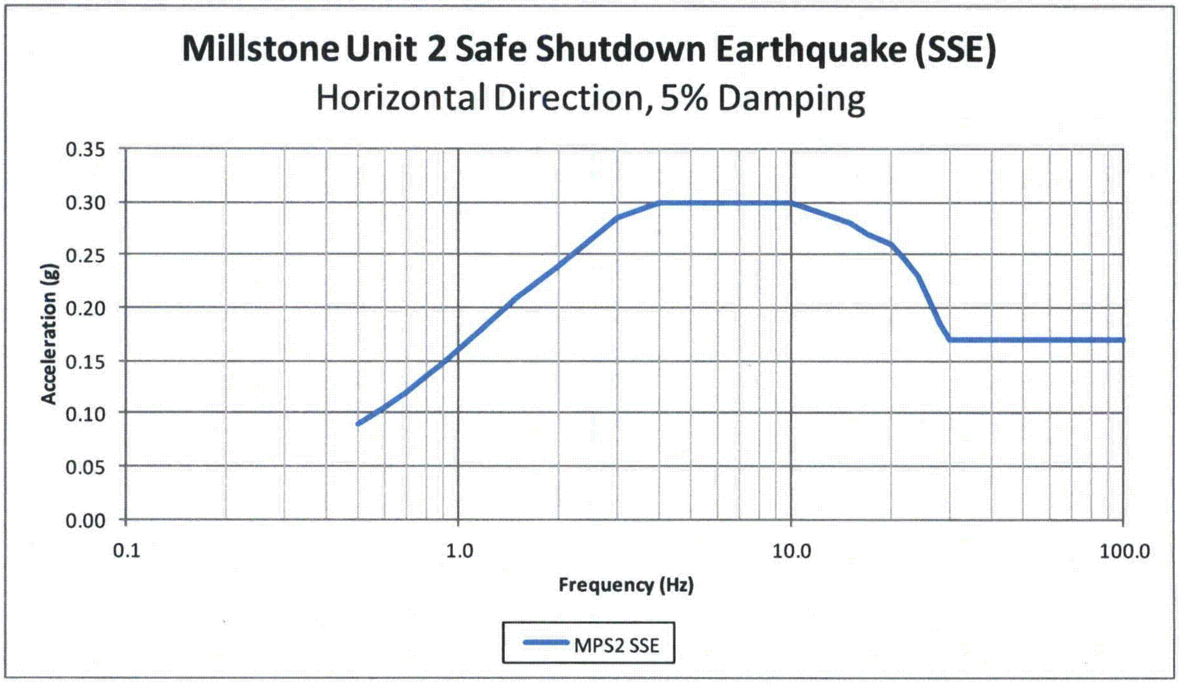

Figure 3.1.1-1. SSE Response Spectra for MPS2 (Rock Founded Structures)

3.1.2 SSE DESCRIPTION OF SPECTRAL SHAPE FOR MPS3

The MPS3 FSAR Section 3.7B.1 describes the development of the SSE spectrum. FSAR Figure 3.7B-1 contains the SSE response spectrum. As described in FSAR Section 2.5.2.6, the maximum earthquake potential at the site is an Intensity VII event occurring 10 to 20 km away, which corresponds to an average horizontal component peak acceleration of 0.10g. For the MPS3 plant design, the PGA of the SSE was conservatively chosen as 0.17g. The digitized SSE response spectrum data provided in Table 3.1.2-1 are consistent with FSAR Figure 3.7B-1. The 5% damped horizontal SSE is plotted in Figure 3.1.2-1.

Table 3.1.2-1. SSE for MPS3 (Horizontal Direction, 5% Damped)

Freq [Hz]	Accel [g]		Freq [Hz]	Accel [g]
0.200	0.017		2.868	0.459
0.220	0.021		3.154	0.459
0.242	0.025		3.469	0.459
0.266	0.031		3.815	0.459
0.293	0.037		4.195	0.459
0.322	0.045		4.614	0.459
0.354	0.054		5.074	0.459
0.389	0.065		5.581	0.459
0.428	0.079		6.138	0.451
0.471	0.096		6.750	0.421
0.518	0.116		7.423	0.393
0.569	0.134		8.164	0.367
0.626	0.148		8.979	0.342
0.689	0.162		9.875	0.319
0.757	0.178		10.860	0.298
0.833	0.196		11.943	0.278
0.916	0.216		13.135	0.260
1.007	0.237		14.446	0.242
1.108	0.261		15.887	0.226
1.219	0.287		17.472	0.211
1.340	0.316		19.216	0.197
1.474	0.347		21.133	0.184
1.621	0.382		23.241	0.171
1.783	0.420		25.560	0.170
1.960	0.459		28.111	0.170
2.456	0.459		30.915	0.170
2.371	0.459		34.000	0.170
2.608	0.459		100.00	0.170

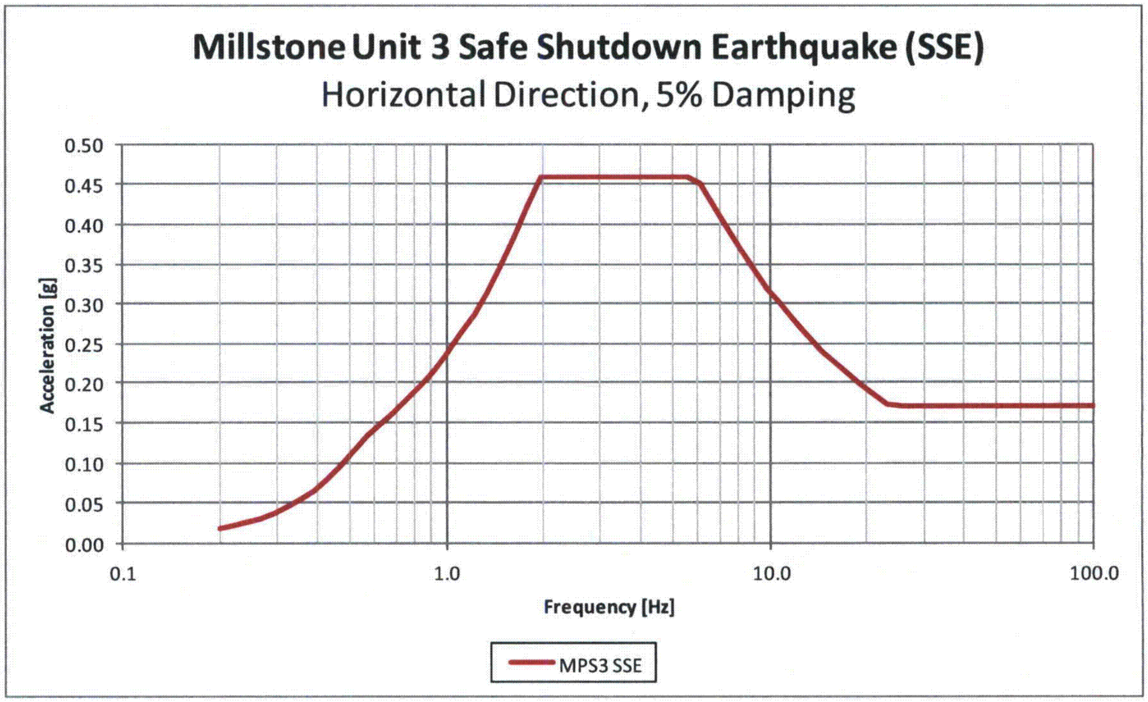

Figure 3.1.2-1. SSE Response Spectra for MPS3

3.2 CONTROL POINT ELEVATION

EPRI 1025287 (SPID) provides very specific guidelines on how a nuclear power facility is to identify the SSE Control Point elevation for a plant or unit if this control point was not identified in the FSAR. In the case of a plant designated as a rock site, or where the key safety-related structures are rock-founded (as is the case for MPS2 and MPS3), the SSE control point is defined as the foundation bearing elevation of the highest rock-supported, safety-related structure. At MPS2 the Turbine Building has various columns bearing on the bedrock formation as high as El. -2 ft (plant grade is El. +14 ft). For MPS3, the Refueling Water Storage Tank is founded on bedrock at El. +15 ft (plant grade is El. +24 ft) and is the highest rock-founded, safety-related structure for this unit. Thus, the SSE Control Point for GMRS screening for MPS2 is at El. -2 ft and for MPS3 is at El. +15 ft.

As discussed in Section 2.3.3, the site response associated with the soil profiles corresponding to the MPS2 and MPS3 control points are very similar and only the MPS3 profile was used in the site amplification calculations. This results in a single GMRS for the site, which is applicable to screening for both MPS2 and MPS3.

3.3 IPEEE DESCRIPTION AND CAPACITY RESPONSE SPECTRUM

3.3.1 IPEEE DESCRIPTION AND CAPACITY RESPONSE SPECTRUM FOR MPS2

MPS2 was a focused scope plant for the IPEEE, binned to 0.3g PGA (Reference 7.3). A seismic margin assessment (SMA) was performed in accordance with the EPRI NP-6041-SL (Reference 7.4) methodology using the NUREG/CR-0098 (Reference 7.14) median rock spectrum per NUREG-1407 (Reference 7.3). The development of the IHS and a summary and results of the IPEEE Adequacy Determination for MPS2 are included in Appendix B to this report

The 5% damped horizontal IHS spectral acceleration data is provided in Table 3.3.1-1. The IHS is plotted in Figure 3.3.1-1.

Table 3.3.1-1 - MPS2 Tabulated IHS Data

IPEEE HCLPF SPECTRUM				
Freq [Hz]	**Accel [g] ***		**Freq [Hz]**	**Accel [g] ***
0.120	0.011		2.208	0.530
0.130	0.013		7.886	0.530
0.140	0.014		8.080	0.527
0.150	0.017		8.500	0.513
0.160	0.018		8.934	0.500
0.170	0.021		9.390	0.487
0.200	0.028		10.370	0.462
0.300	0.065		11.180	0.443
0.400	0.096		12.050	0.427
0.500	0.121		13.000	0.410
0.600	0.145		14.000	0.394
0.700	0.169		15.090	0.378
0.800	0.193		16.260	0.364
0.900	0.218		17.530	0.349
1.000	0.243		18.890	0.336
1.126	0.273		20.360	0.323
1.213	0.293		21.940	0.311
1.308	0.316		24.246	0.294
1.409	0.340		27.468	0.276
1.519	0.367		30.352	0.262
1.637	0.395		32.710	0.252
1.809	0.437		33.538	0.250
1.901	0.459		50.000	0.250
2.049	0.495		100.000	0.250
2.100	0.508			

* NUREG/CR-0098 shape scaled to 0.25g HCLPF for MPS2 (plotted in Figure 3.3.1-1)

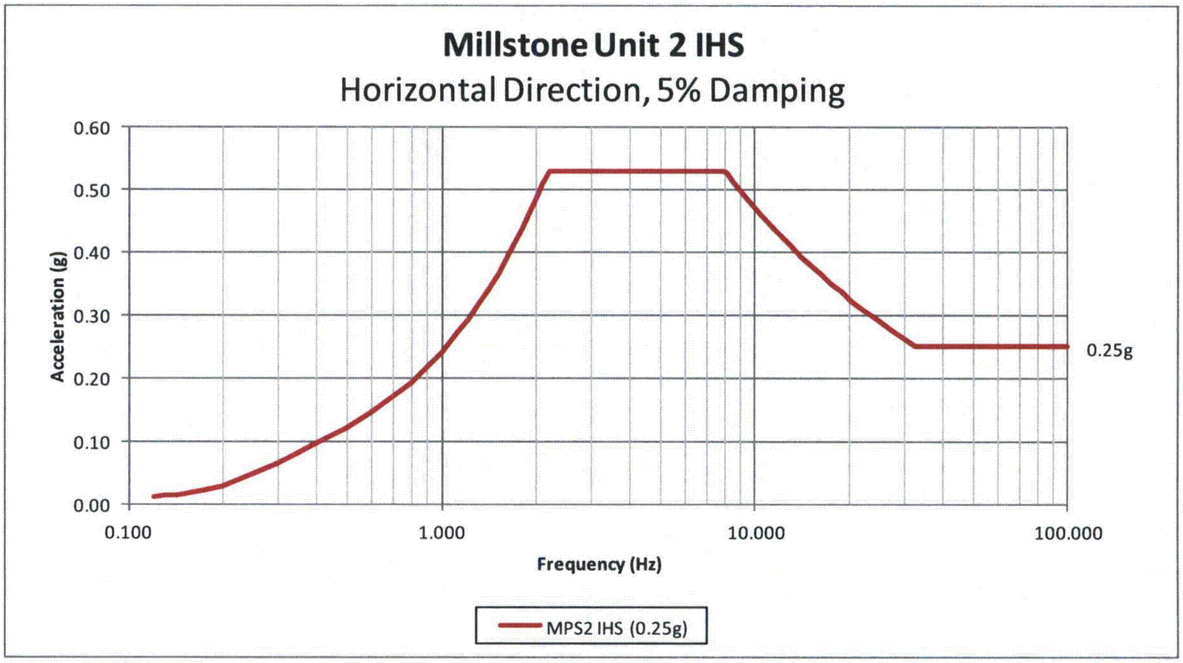

Figure 3.3.1-1. IPEEE HCLPF Spectrum for MPS2

3.3.2 IPEEE Description and Capacity Response Spectrum for MPS3

MPS3 was designated as a focused scope plant for the IPEEE in NUREG-1407. A probabilistic safety study (PSS) was performed for MPS3 initial licensing that was based on a Level III probabilistic risk assessment (PRA) and included evaluations of flooding, seismic, and other external events. This existing seismic PRA was used to address IPEEE for MPS3 in accordance with Section 3.1.2 of NUREG-1407.

The development of the IHS and a summary and results of the IPEEE Adequacy Determination for MPS3 are included in Appendix C to this report.

As described in Appendix C, the response spectrum curve used for the MPS3 PRA was a site-specific shape. The IHS for screening is the site-specific curve anchored to the plant HCLPF capacity of 0.26g, which is the lowest plant damage state HCLPF capacity. The spectral acceleration data for horizontal IHS at 5% spectral damping anchored at 0.26g are provided in Table 3.3.2-1. The IHS is plotted in Figure 3.3.2-1.

Table 3.3.2-1 - MPS3 Tabulated IHS Data

Freq (Hz)	Spectral Accelerations (g) PGA=0.26g
0.500	0.065
1.000	0.156
1.330	0.213
1.915	0.331
2.500	0.458
2.900	0.503
3.300	0.546
3.725	0.552
4.150	0.557
4.575	0.562
5.000	0.567
7.700	0.567
8.275	0.549
8.850	0.533
9.425	0.518
10.000	0.504
11.250	0.442
12.500	0.393
13.900	0.364
15.300	0.341
17.650	0.313
20.000	0.291
25.000	0.286
100.000	0.260

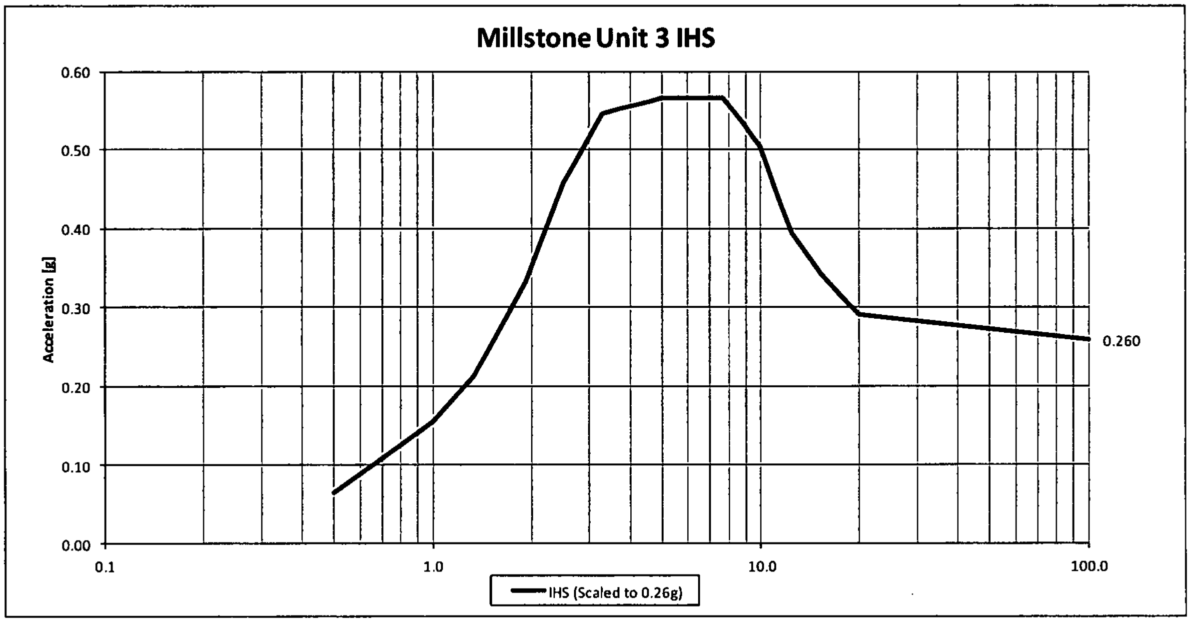

Figure 3.3.2-1. IPEEE HCLPF Spectrum for MPS3

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 MPS2 and MPS3 IHS both exceed the GMRS. Based on this comparison, a risk evaluation will not be performed for either MPS2 or MPS3.

4.2 HIGH FREQUENCY SCREENING (> 10 HZ)

For a portion of the range above 10 Hz, the GMRS exceeds the SSE and IHS for both MPS2 and MPS3. Therefore, MPS2 and MPS3 screen in for 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 MPS2 and the MPS3 SSE. Therefore, MPS2 and MPS3 screen in for a spent fuel pool evaluation.

5.0 INTERIM ACTIONS

Consistent with NRC letter dated February 20, 2014 (Reference 7.26), the seismic hazard reevaluations presented herein are distinct from the current design and licensing bases of MPS2 and MPS3. Therefore, the results do not call into question the operability or functionality of SSCs and are not reportable pursuant to 10 CFR 50.72, "Immediate notification requirements for operating nuclear power reactors," and10 CFR 50.73, "Licensee event report system".

The NRC 10 CFR 50.54(f) letter (Reference 7.1) requests that licensees provide "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 evaluation." Although the results of MPS2 and MPS3 screening do not require the performance of a risk evaluation, the following evaluations and actions have been completed or are in-progress.

5.1 EXPEDITED SEISMIC EVALUATION PROCESS

Based on the screening evaluation, the expedited seismic evaluation process (ESEP) is being performed at MPS2 and MPS3 in accordance with the methodology in EPRI 3002000704 (Reference 7.10) as proposed in Nuclear Energy Institute (NEI) letter to NRC dated April 9, 2013 (Reference 7.20) and confirmed in NRC letter dated May 7, 2013 (Reference 7.21).

5.2 RISK ESTIMATES

NEI letter to NRC dated March 12, 2014 (Reference 7.30) provides overall seismic core damage risk estimates using the same approach as used in NRC Information Notice (IN) 2010-18 (Reference 7.31), with the updated site seismic hazard curves for the operating nuclear plants in the Central and Eastern United States, including MPS2 and MPS3. Dominion's estimates of the seismic core damage frequencies (CDF) are consistent with the conclusions in Reference 7.30, i.e., the weighted seismic CDFs using the methods in Reference 7.31 for MPS2 and MPS3 are less than 1E-4 per year. 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} per 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.*

5.3 PREVIOUS EVALUATIONS INCLUDING THOSE WITH BEYOND DESIGN BASIS SEISMIC INPUTS

5.3.1 MPS2 PREVIOUS EVALUATIONS

5.3.1.1 IPEEE AND USI A-46 EFFORTS

MPS2 conducted an IPEEE using the EPRI SMA method to a NUREG-CR/0098 median spectral shape anchored to 0.3g PGA. This PGA level is 1.7 times the PGA (0.17g) of the MPS2 SSE. The vast majority of components had capacity above a HCLPF of 0.3g. The IPEEE program and the USI A-46 program for MPS2 resulted in comprehensive walkdowns of safe-shutdown equipment, relay evaluations and walkdown and analyses of tanks, cable trays and conduit systems. As a result of these evaluations, plant enhancements were made at MPS2, as identified in the IPEEE Summary Report (Reference 7.5) and in the responses to subsequent NRC requests for information. The IHS, and its comparison with the SSE, is shown in Figure 5.3.1-1 below.

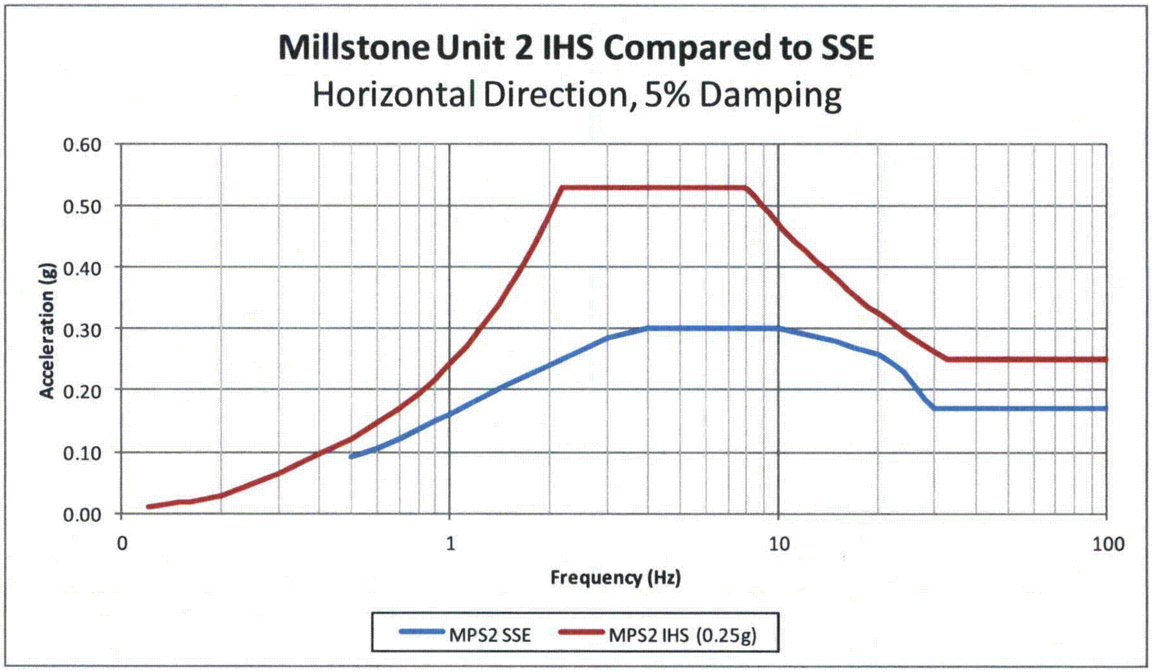

Figure 5.3.1-1: MPS2 IHS Compared to SSE

5.3.1.2 WALKDOWNS TO ADDRESS NRC FUKUSHIMA NTTF RECOMMENDATION 2.3

MPS2 has recently performed walkdowns for NTTF 2.3 and submitted a summary report to NRC (Reference 7.27). There were no significant findings as they relate to the confirmation that MPS2 meets the seismic design basis. The IPEEE commitments were met, as stated in the NTTF 2.3 walkdown report. NRC has reviewed the MPS2 NTTF 2.3 Seismic Walkdown Submittal Report and the results of their staff assessment conclude that sufficient information was provided to be responsive to the requirements of the 10 CFR 50.54(f) letter, as documented in Reference 7.28.

5.3.2 MPS3 PREVIOUS EVALUATIONS

5.3.2.1 IPEEE EFFORT

MPS3 conducted a seismic PRA with a site-specific response spectrum. This seismic PRA was submitted as part of the IPEEE response to the NRC Generic Letter (GL) 88-20 Supplements 4 and 5. The plant HCLPF is reported as 0.26g and the site spectrum shape is anchored to this value. However, since the limiting seismic capacity item that was identified during the performance of fragility evaluations had been replaced prior to the IPEEE Summary Report, the plant HCLPF could be considered as 0.3g based upon the judgment of a leading industry expert (Reference 7.32), which is 1.7 times the PGA (0.17g) of the MPS3 SSE. The Seismic PRA that was performed for MPS3 resulted in walkdowns, relay evaluations, and fragility calculations of components in the logic model. The IHS, and its comparison with the SSE, is shown in Figure 5.3.2-1 below.

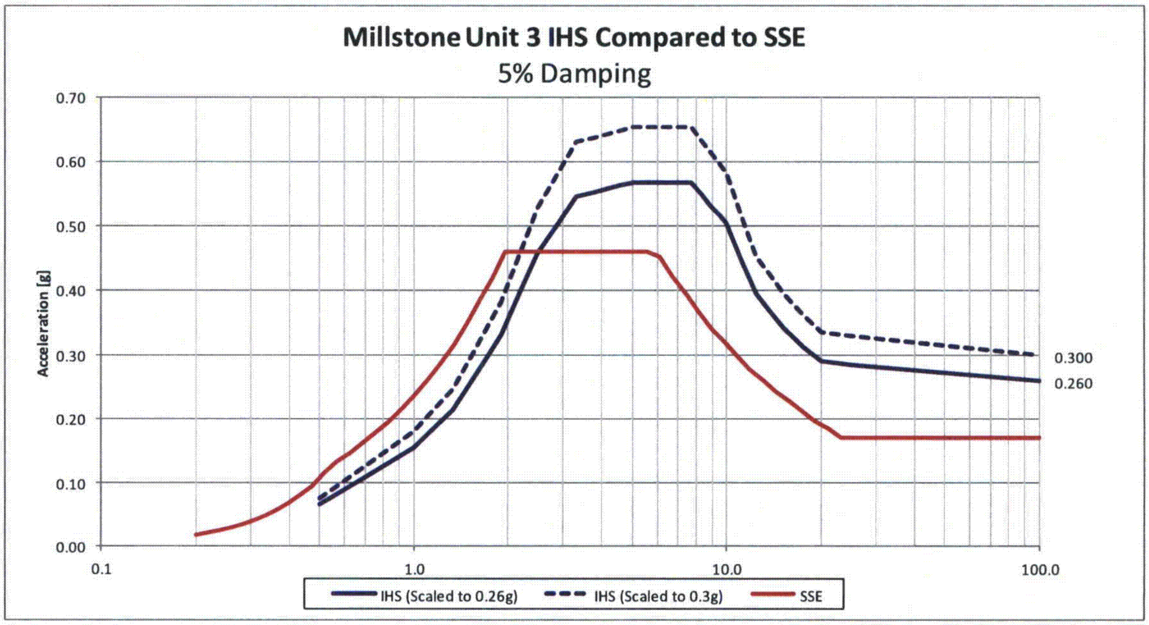

Figure 5.3.2-1: MPS3 IHS Compared to SSE

5.3.2.2 WALKDOWNS TO ADDRESS NRC FUKUSHIMA NTTF RECOMMENDATION 2.3

MPS3 has recently performed walkdowns for NTTF 2.3 and submitted a summary report to NRC (Reference 7.27). There were no significant findings as they relate to the confirmation that MPS3 meets the seismic design basis. The IPEEE commitments were met, as stated in the NTTF 2.3 walkdown report. NRC has reviewed the MPS3 NTTF 2.3 Seismic Walkdown Submittal Report and the results of their staff assessment conclude that sufficient information was provided to be responsive to the requirements of the 10 CFR 50.54(f) letter, as documented in Reference 7.29.

6.0 CONCLUSIONS

In accordance with the 10 CFR 50.54(f) request for information letter (Reference 7.1), a seismic hazard and screening evaluation was performed for MPS2 and MPS3. A GMRS was developed solely for the purpose of screening for additional evaluations in accordance with the SPID.

Consistent with the guidance provided in the SPID (Reference 7.2), an IPEEE adequacy review has been performed with satisfactory results and an IPEEE HCLPF Spectrum has been generated for comparison to the GMRS for purposes of screening. The IHS bounds the GMRS in the 1-10 Hz region of the spectrum. Therefore, MPS2 and MPS3 screen out from further risk evaluation.

MPS2 and MPS3 screen in for Spent Fuel Pool evaluation and a High Frequency Confirmation.

7.0 REFERENCES

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7.6 Jacob I. Zimmerman, NRC Letter to R. G. Lizotte, Northeast Nuclear Energy Company, "Millstone Nuclear Power Station Unit No. 2 – Individual Plant Examination of External Events (IPEEE) (TAC NO. M83642)," dated January 12, 2001.

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7.8 Northeast Utilities Letter to NRC Document Control Desk, "Response to Generic Letter 88-20 Individual Plant Examination for Severe Accident Vulnerabilities Summary Report Submittal," Serial No. B13596, dated August 31, 1990.

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7.22 Toro, G.R. "Probabilistic Models of Site Velocity Profiles for Generic and Site-Specific Ground Motion Amplification Studies," 1996. Published as an appendix in Silva, W.J., N. Abrahamson, G. Toro and C. Costantino. "Description and validation of the stochastic ground motion model," Report Submitted to Brookhaven National Laboratory, 1996.

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8.0 APPENDICES

Appendix A - Tabulated Data

Appendix B - MPS2 IPEEE Adequacy Evaluation and IHS Development

Appendix C - MPS3 IPEEE Adequacy Evaluation and IHS Development

Appendix A

Tabulated Data

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Table A-2b. Computed median and logarithmic standard deviation of the site amplification at frequencies of 0.5, 1.0, 2.5, 5.0, 10, 25, and 100 Hz for the double-corner seismological model

Appendix A

Table A-1a. PGA Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PGA (g)	AEP	PGA (g)	AEP	PGA (g)	AEP	PGA (g)	AEP	PGA (g)	AEP	PGA (g)	AEP
0.0261	1.000E-03	0.0122	1.029E-03	0.0157	1.011E-03	0.0218	1.000E-03	0.0348	1.000E-03	0.0604	1.000E-03
0.0284	9.189E-04	0.0128	9.852E-04	0.0166	9.618E-04	0.0233	9.344E-04	0.0387	8.897E-04	0.0712	7.814E-04
0.0300	8.600E-04	0.0135	9.267E-04	0.0175	9.006E-04	0.0246	8.748E-04	0.0407	8.319E-04	0.0748	7.206E-04
0.0317	7.986E-04	0.0143	8.588E-04	0.0185	8.327E-04	0.0260	8.113E-04	0.0429	7.727E-04	0.0786	6.615E-04
0.0335	7.381E-04	0.0151	7.877E-04	0.0195	7.635E-04	0.0274	7.482E-04	0.0452	7.147E-04	0.0826	6.056E-04
0.0354	6.807E-04	0.0159	7.183E-04	0.0206	6.969E-04	0.0290	6.881E-04	0.0477	6.594E-04	0.0868	5.537E-04
0.0373	6.271E-04	0.0168	6.533E-04	0.0217	6.349E-04	0.0306	6.320E-04	0.0502	6.075E-04	0.0912	5.059E-04
0.0394	5.775E-04	0.0177	5.936E-04	0.0229	5.780E-04	0.0323	5.803E-04	0.0529	5.594E-04	0.0959	4.622E-04
0.0417	5.315E-04	0.0187	5.392E-04	0.0242	5.261E-04	0.0341	5.327E-04	0.0558	5.149E-04	0.1007	4.222E-04
0.0440	4.889E-04	0.0197	4.897E-04	0.0255	4.789E-04	0.0360	4.891E-04	0.0587	4.739E-04	0.1058	3.858E-04
0.0465	4.494E-04	0.0208	4.448E-04	0.0269	4.359E-04	0.0380	4.489E-04	0.0619	4.362E-04	0.1112	3.525E-04
0.0491	4.128E-04	0.0219	4.040E-04	0.0284	3.967E-04	0.0401	4.119E-04	0.0652	4.015E-04	0.1168	3.221E-04
0.0518	3.790E-04	0.0231	3.670E-04	0.0300	3.610E-04	0.0424	3.778E-04	0.0687	3.696E-04	0.1228	2.944E-04
0.0547	3.479E-04	0.0244	3.333E-04	0.0316	3.286E-04	0.0447	3.463E-04	0.0724	3.403E-04	0.1290	2.691E-04
0.0578	3.192E-04	0.0257	3.028E-04	0.0333	2.991E-04	0.0472	3.172E-04	0.0763	3.133E-04	0.1355	2.460E-04
0.0611	2.929E-04	0.0271	2.750E-04	0.0352	2.722E-04	0.0499	2.904E-04	0.0804	2.885E-04	0.1424	2.248E-04
0.0645	2.689E-04	0.0286	2.498E-04	0.0371	2.477E-04	0.0526	2.656E-04	0.0847	2.657E-04	0.1496	2.055E-04
0.0681	2.468E-04	0.0302	2.269E-04	0.0392	2.254E-04	0.0556	2.430E-04	0.0892	2.447E-04	0.1572	1.878E-04
0.0719	2.265E-04	0.0319	2.061E-04	0.0413	2.050E-04	0.0587	2.222E-04	0.0940	2.254E-04	0.1652	1.716E-04
0.0760	2.080E-04	0.0336	1.872E-04	0.0436	1.864E-04	0.0619	2.032E-04	0.0991	2.077E-04	0.1736	1.567E-04
0.0802	1.909E-04	0.0354	1.700E-04	0.0460	1.692E-04	0.0654	1.859E-04	0.1044	1.913E-04	0.1824	1.431E-04
0.0847	1.752E-04	0.0374	1.544E-04	0.0485	1.536E-04	0.0690	1.700E-04	0.1100	1.762E-04	0.1916	1.305E-04
0.0895	1.608E-04	0.0394	1.401E-04	0.0512	1.393E-04	0.0729	1.555E-04	0.1159	1.623E-04	0.2014	1.189E-04
0.0945	1.476E-04	0.0416	1.271E-04	0.0540	1.263E-04	0.0770	1.422E-04	0.1221	1.494E-04	0.2116	1.083E-04
0.0998	1.354E-04	0.0439	1.152E-04	0.0570	1.145E-04	0.0813	1.300E-04	0.1287	1.374E-04	0.2223	9.844E-05
0.1054	1.240E-04	0.0463	1.042E-04	0.0601	1.038E-04	0.0858	1.187E-04	0.1356	1.263E-04	0.2336	8.937E-05
0.1113	1.134E-04	0.0488	9.410E-05	0.0635	9.403E-05	0.0906	1.084E-04	0.1428	1.159E-04	0.2455	8.103E-05
0.1176	1.036E-04	0.0515	8.485E-05	0.0669	8.523E-05	0.0956	9.887E-05	0.1505	1.061E-04	0.2579	7.336E-05
0.1242	9.439E-05	0.0543	7.643E-05	0.0706	7.726E-05	0.1010	9.009E-05	0.1586	9.694E-05	0.2710	6.633E-05
0.1312	8.582E-05	0.0573	6.879E-05	0.0745	7.004E-05	0.1066	8.201E-05	0.1671	8.839E-05	0.2847	5.991E-05
0.1385	7.785E-05	0.0605	6.188E-05	0.0786	6.349E-05	0.1125	7.459E-05	0.1760	8.041E-05	0.2992	5.406E-05
0.1463	7.048E-05	0.0638	5.566E-05	0.0830	5.757E-05	0.1188	6.778E-05	0.1855	7.299E-05	0.3144	4.874E-05
0.1545	6.371E-05	0.0673	5.007E-05	0.0875	5.221E-05	0.1255	6.156E-05	0.1954	6.613E-05	0.3303	4.393E-05
0.1632	5.751E-05	0.0710	4.504E-05	0.0924	4.735E-05	0.1325	5.589E-05	0.2059	5.982E-05	0.3471	3.957E-05
0.1724	5.188E-05	0.0749	4.052E-05	0.0974	4.296E-05	0.1398	5.074E-05	0.2170	5.404E-05	0.3647	3.564E-05
0.1820	4.677E-05	0.0790	3.646E-05	0.1028	3.897E-05	0.1476	4.606E-05	0.2286	4.879E-05	0.3832	3.210E-05

Appendix A

Table A-1a. PGA Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PGA (g)	AEP	PGA (g)	AEP	PGA (g)	AEP	PGA (g)	AEP	PGA (g)	AEP	PGA (g)	AEP
0.1923	4.216E-05	0.0833	3.280E-05	0.1085	3.537E-05	0.1559	4.180E-05	0.2409	4.401E-05	0.4026	2.890E-05
0.2030	3.801E-05	0.0879	2.953E-05	0.1144	3.210E-05	0.1646	3.795E-05	0.2538	3.970E-05	0.4231	2.602E-05
0.2144	3.426E-05	0.0927	2.658E-05	0.1207	2.914E-05	0.1738	3.445E-05	0.2674	3.580E-05	0.4445	2.343E-05
0.2265	3.088E-05	0.0978	2.393E-05	0.1274	2.645E-05	0.1834	3.128E-05	0.2818	3.229E-05	0.4671	2.109E-05
0.2392	2.784E-05	0.1032	2.155E-05	0.1344	2.401E-05	0.1937	2.841E-05	0.2969	2.911E-05	0.4908	1.898E-05
0.2526	2.510E-05	0.1088	1.940E-05	0.1418	2.179E-05	0.2045	2.579E-05	0.3128	2.625E-05	0.5157	1.708E-05
0.2668	2.262E-05	0.1148	1.748E-05	0.1496	1.978E-05	0.2159	2.342E-05	0.3296	2.367E-05	0.5418	1.535E-05
0.2818	2.039E-05	0.1211	1.573E-05	0.1579	1.795E-05	0.2279	2.127E-05	0.3473	2.133E-05	0.5693	1.379E-05
0.2976	1.837E-05	0.1278	1.416E-05	0.1666	1.628E-05	0.2407	1.930E-05	0.3659	1.922E-05	0.5982	1.238E-05
0.3143	1.654E-05	0.1348	1.274E-05	0.1757	1.475E-05	0.2541	1.751E-05	0.3855	1.731E-05	0.6286	1.111E-05
0.3320	1.488E-05	0.1422	1.144E-05	0.1854	1.335E-05	0.2683	1.587E-05	0.4062	1.557E-05	0.6605	9.950E-06
0.3506	1.337E-05	0.1500	1.028E-05	0.1956	1.207E-05	0.2832	1.437E-05	0.4280	1.400E-05	0.6940	8.904E-06
0.3703	1.199E-05	0.1582	9.215E-06	0.2064	1.090E-05	0.2990	1.299E-05	0.4510	1.256E-05	0.7292	7.959E-06
0.3911	1.073E-05	0.1669	8.255E-06	0.2178	9.811E-06	0.3157	1.171E-05	0.4752	1.126E-05	0.7662	7.105E-06
0.4130	9.589E-06	0.1761	7.388E-06	0.2298	8.816E-06	0.3333	1.054E-05	0.5007	1.007E-05	0.8050	6.336E-06
0.4362	8.548E-06	0.1857	6.606E-06	0.2424	7.904E-06	0.3519	9.458E-06	0.5276	8.982E-06	0.8459	5.644E-06
0.4607	7.600E-06	0.1959	5.901E-06	0.2558	7.069E-06	0.3715	8.463E-06	0.5559	7.996E-06	0.8888	5.023E-06
0.4866	6.741E-06	0.2067	5.269E-06	0.2699	6.310E-06	0.3923	7.550E-06	0.5857	7.102E-06	0.9339	4.466E-06
0.5139	5.965E-06	0.2180	4.702E-06	0.2847	5.622E-06	0.4142	6.715E-06	0.6171	6.293E-06	0.9813	3.969E-06
0.5427	5.268E-06	0.2300	4.195E-06	0.3004	5.002E-06	0.4373	5.955E-06	0.6502	5.564E-06	1.0311	3.524E-06
0.5732	4.643E-06	0.2426	3.743E-06	0.3170	4.445E-06	0.4617	5.267E-06	0.6851	4.910E-06	1.0834	3.128E-06
0.6054	4.087E-06	0.2559	3.339E-06	0.3344	3.947E-06	0.4874	4.648E-06	0.7219	4.325E-06	1.1383	2.775E-06
0.6394	3.592E-06	0.2699	2.978E-06	0.3528	3.502E-06	0.5146	4.094E-06	0.7606	3.804E-06	1.1961	2.461E-06
0.6753	3.155E-06	0.2848	2.655E-06	0.3723	3.106E-06	0.5433	3.601E-06	0.8014	3.342E-06	1.2568	2.182E-06
0.7132	2.768E-06	0.3004	2.367E-06	0.3928	2.753E-06	0.5736	3.163E-06	0.8444	2.933E-06	1.3205	1.933E-06
0.7532	2.428E-06	0.3169	2.110E-06	0.4144	2.440E-06	0.6056	2.776E-06	0.8897	2.572E-06	1.3875	1.711E-06
0.7955	2.127E-06	0.3343	1.878E-06	0.4372	2.160E-06	0.6394	2.434E-06	0.9375	2.254E-06	1.4579	1.513E-06
0.8402	1.863E-06	0.3526	1.671E-06	0.4613	1.911E-06	0.6751	2.132E-06	0.9878	1.973E-06	1.5319	1.336E-06
0.8873	1.630E-06	0.3720	1.483E-06	0.4867	1.688E-06	0.7127	1.866E-06	1.0407	1.726E-06	1.6096	1.178E-06
0.9371	1.425E-06	0.3924	1.315E-06	0.5135	1.489E-06	0.7525	1.631E-06	1.0966	1.509E-06	1.6913	1.037E-06
0.9898	1.243E-06	0.4139	1.162E-06	0.5418	1.310E-06	0.7945	1.423E-06	1.1554	1.316E-06	1.7771	9.111E-07
1.0453	1.083E-06	0.4366	1.025E-06	0.5717	1.150E-06	0.8388	1.240E-06	1.2174	1.147E-06	1.8673	7.988E-07
1.1040	9.419E-07	0.4606	9.000E-07	0.6031	1.006E-06	0.8856	1.078E-06	1.2827	9.971E-07	1.9620	6.988E-07
1.1660	8.172E-07	0.4859	7.879E-07	0.6364	8.771E-07	0.9350	9.346E-07	1.3516	8.649E-07	2.0616	6.099E-07
1.2314	7.073E-07	0.5125	6.872E-07	0.6714	7.618E-07	0.9872	8.084E-07	1.4241	7.484E-07	2.1662	5.310E-07
1.3006	6.104E-07	0.5406	5.970E-07	0.7084	6.591E-07	1.0422	6.972E-07	1.5005	6.457E-07	2.2761	4.612E-07

Appendix A

Table A-1a. PGA Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PGA (g)	AEP	PGA (g)	AEP	PGA (g)	AEP	PGA (g)	AEP	PGA (g)	AEP	PGA (g)	AEP
1.3736	5.253E-07	0.5703	5.167E-07	0.7474	5.678E-07	1.1004	5.994E-07	1.5810	5.554E-07	2.3915	3.995E-07
1.4507	4.508E-07	0.6016	4.455E-07	0.7886	4.872E-07	1.1618	5.137E-07	1.6658	4.762E-07	2.5129	3.453E-07
1.5322	3.856E-07	0.6346	3.828E-07	0.8320	4.164E-07	1.2266	4.389E-07	1.7552	4.070E-07	2.6404	2.975E-07
1.6182	3.288E-07	0.6695	3.278E-07	0.8779	3.545E-07	1.2950	3.737E-07	1.8494	3.467E-07	2.7743	2.558E-07
1.7090	2.795E-07	0.7062	2.798E-07	0.9262	3.007E-07	1.3673	3.171E-07	1.9486	2.943E-07	2.9151	2.193E-07
1.8050	2.369E-07	0.7450	2.381E-07	0.9772	2.542E-07	1.4435	2.681E-07	2.0532	2.490E-07	3.0630	1.873E-07
1.9063	2.000E-07	0.7858	2.020E-07	1.0310	2.141E-07	1.5241	2.259E-07	2.1633	2.099E-07	3.2184	1.596E-07
2.0133	1.683E-07	0.8290	1.707E-07	1.0878	1.797E-07	1.6091	1.896E-07	2.2794	1.762E-07	3.3817	1.354E-07
2.1264	1.410E-07	0.8745	1.437E-07	1.1478	1.503E-07	1.6989	1.585E-07	2.4017	1.474E-07	3.5533	1.145E-07
2.2457	1.177E-07	0.9225	1.205E-07	1.2110	1.251E-07	1.7937	1.319E-07	2.5306	1.227E-07	3.7335	9.626E-08
2.3718	9.764E-08	0.9731	1.005E-07	1.2777	1.038E-07	1.8937	1.092E-07	2.6663	1.016E-07	3.9230	8.054E-08
2.5050	8.057E-08	1.0265	8.337E-08	1.3480	8.550E-08	1.9994	8.986E-08	2.8094	8.366E-08	4.1220	6.698E-08
2.6456	6.605E-08	1.0828	6.869E-08	1.4223	7.004E-08	2.1109	7.348E-08	2.9601	6.847E-08	4.3311	5.534E-08
2.7941	5.374E-08	1.1423	5.616E-08	1.5006	5.697E-08	2.2287	5.964E-08	3.1189	5.562E-08	4.5509	4.537E-08
2.9510	4.336E-08	1.2049	4.552E-08	1.5833	4.595E-08	2.3530	4.800E-08	3.2863	4.483E-08	4.7818	3.690E-08
3.1167	3.465E-08	1.2711	3.653E-08	1.6705	3.673E-08	2.4843	3.827E-08	3.4626	3.580E-08	5.0244	2.973E-08
3.2916	2.741E-08	1.3408	2.901E-08	1.7625	2.905E-08	2.6229	3.020E-08	3.6484	2.831E-08	5.2793	2.372E-08
3.4764	2.142E-08	1.4144	2.276E-08	1.8596	2.271E-08	2.7692	2.355E-08	3.8442	2.214E-08	5.5471	1.872E-08
3.6716	1.653E-08	1.4920	1.762E-08	1.9620	1.754E-08	2.9237	1.814E-08	4.0504	1.711E-08	5.8286	1.461E-08
3.8777	1.258E-08	1.5739	1.345E-08	2.0701	1.336E-08	3.0868	1.377E-08	4.2677	1.305E-08	6.1243	1.125E-08
4.0954	9.425E-09	1.6603	1.012E-08	2.1841	1.001E-08	3.2590	1.031E-08	4.4967	9.808E-09	6.4350	8.548E-09
4.3254	6.948E-09	1.7514	7.484E-09	2.3044	7.394E-09	3.4408	7.584E-09	4.7380	7.263E-09	6.7615	6.404E-09
4.5682	5.032E-09	1.8475	5.441E-09	2.4313	5.365E-09	3.6328	5.486E-09	4.9922	5.291E-09	7.1046	4.726E-09
4.8246	3.577E-09	1.9489	3.883E-09	2.5652	3.822E-09	3.8354	3.895E-09	5.2601	3.788E-09	7.4650	3.432E-09
5.0955	2.491E-09	2.0559	2.719E-09	2.7065	2.671E-09	4.0494	2.711E-09	5.5423	2.663E-09	7.8438	2.451E-09
5.3816	1.699E-09	2.1687	1.864E-09	2.8556	1.828E-09	4.2753	1.849E-09	5.8397	1.836E-09	8.2417	1.720E-09
5.6837	1.134E-09	2.2877	1.252E-09	3.0129	1.226E-09	4.5138	1.234E-09	6.1530	1.240E-09	8.6599	1.185E-09
6.0028	7.390E-10	2.4133	8.217E-10	3.1789	8.033E-10	4.7656	8.043E-10	6.4831	8.207E-10	9.0993	8.008E-10

Appendix A

Table A-1b. 0.5 Hz Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP
0.0057	1.066E-03	0.0021	1.050E-03	0.0032	1.053E-03	0.0051	1.059E-03	0.0080	1.061E-03	0.0106	1.068E-03
0.0061	1.049E-03	0.0022	1.038E-03	0.0033	1.040E-03	0.0053	1.045E-03	0.0084	1.046E-03	0.0112	1.051E-03
0.0064	1.027E-03	0.0023	1.021E-03	0.0035	1.023E-03	0.0055	1.025E-03	0.0088	1.026E-03	0.0118	1.028E-03
0.0067	9.961E-04	0.0024	9.997E-04	0.0037	9.999E-04	0.0058	9.997E-04	0.0092	9.986E-04	0.0125	9.964E-04
0.0071	9.580E-04	0.0025	9.734E-04	0.0038	9.723E-04	0.0061	9.687E-04	0.0097	9.652E-04	0.0131	9.577E-04
0.0075	9.129E-04	0.0026	9.421E-04	0.0040	9.392E-04	0.0064	9.315E-04	0.0102	9.256E-04	0.0138	9.117E-04
0.0079	8.617E-04	0.0028	9.061E-04	0.0042	9.012E-04	0.0067	8.889E-04	0.0107	8.803E-04	0.0146	8.595E-04
0.0083	8.061E-04	0.0029	8.659E-04	0.0044	8.588E-04	0.0070	8.418E-04	0.0112	8.305E-04	0.0154	8.029E-04
0.0088	7.480E-04	0.0030	8.226E-04	0.0046	8.132E-04	0.0073	7.914E-04	0.0118	7.776E-04	0.0162	7.438E-04
0.0093	6.894E-04	0.0032	7.769E-04	0.0048	7.654E-04	0.0077	7.391E-04	0.0124	7.233E-04	0.0171	6.842E-04
0.0098	6.319E-04	0.0033	7.302E-04	0.0050	7.165E-04	0.0080	6.862E-04	0.0130	6.689E-04	0.0180	6.258E-04
0.0103	5.768E-04	0.0035	6.833E-04	0.0053	6.677E-04	0.0084	6.340E-04	0.0136	6.158E-04	0.0190	5.700E-04
0.0109	5.250E-04	0.0036	6.372E-04	0.0055	6.199E-04	0.0088	5.834E-04	0.0143	5.650E-04	0.0200	5.175E-04
0.0115	4.769E-04	0.0038	5.926E-04	0.0058	5.738E-04	0.0093	5.353E-04	0.0150	5.171E-04	0.0211	4.689E-04
0.0121	4.327E-04	0.0040	5.499E-04	0.0060	5.300E-04	0.0097	4.901E-04	0.0158	4.724E-04	0.0222	4.244E-04
0.0128	3.924E-04	0.0041	5.096E-04	0.0063	4.887E-04	0.0102	4.479E-04	0.0166	4.311E-04	0.0234	3.839E-04
0.0135	3.556E-04	0.0043	4.718E-04	0.0066	4.502E-04	0.0106	4.091E-04	0.0174	3.931E-04	0.0246	3.470E-04
0.0142	3.223E-04	0.0045	4.365E-04	0.0069	4.144E-04	0.0111	3.733E-04	0.0183	3.584E-04	0.0260	3.137E-04
0.0150	2.920E-04	0.0047	4.037E-04	0.0072	3.813E-04	0.0117	3.406E-04	0.0192	3.266E-04	0.0274	2.835E-04
0.0158	2.646E-04	0.0050	3.732E-04	0.0075	3.508E-04	0.0122	3.106E-04	0.0202	2.977E-04	0.0289	2.563E-04
0.0167	2.397E-04	0.0052	3.450E-04	0.0079	3.226E-04	0.0128	2.833E-04	0.0212	2.713E-04	0.0304	2.316E-04
0.0176	2.172E-04	0.0054	3.189E-04	0.0082	2.967E-04	0.0134	2.582E-04	0.0222	2.472E-04	0.0321	2.094E-04
0.0186	1.967E-04	0.0057	2.948E-04	0.0086	2.728E-04	0.0141	2.355E-04	0.0234	2.253E-04	0.0338	1.892E-04
0.0196	1.782E-04	0.0059	2.725E-04	0.0090	2.509E-04	0.0147	2.147E-04	0.0245	2.052E-04	0.0356	1.710E-04
0.0207	1.613E-04	0.0062	2.518E-04	0.0094	2.307E-04	0.0154	1.956E-04	0.0257	1.869E-04	0.0375	1.546E-04
0.0218	1.459E-04	0.0065	2.327E-04	0.0099	2.121E-04	0.0162	1.782E-04	0.0270	1.702E-04	0.0395	1.397E-04
0.0230	1.318E-04	0.0068	2.151E-04	0.0103	1.949E-04	0.0169	1.623E-04	0.0284	1.549E-04	0.0417	1.262E-04
0.0243	1.189E-04	0.0071	1.987E-04	0.0108	1.791E-04	0.0177	1.477E-04	0.0298	1.409E-04	0.0439	1.140E-04
0.0256	1.071E-04	0.0074	1.836E-04	0.0113	1.644E-04	0.0186	1.343E-04	0.0313	1.280E-04	0.0463	1.030E-04
0.0270	9.631E-05	0.0078	1.695E-04	0.0118	1.508E-04	0.0195	1.219E-04	0.0329	1.161E-04	0.0488	9.299E-05
0.0285	8.641E-05	0.0081	1.564E-04	0.0124	1.382E-04	0.0204	1.105E-04	0.0345	1.052E-04	0.0514	8.394E-05
0.0300	7.735E-05	0.0085	1.442E-04	0.0129	1.264E-04	0.0214	1.000E-04	0.0362	9.508E-05	0.0542	7.576E-05
0.0317	6.910E-05	0.0089	1.327E-04	0.0135	1.155E-04	0.0224	9.033E-05	0.0381	8.579E-05	0.0571	6.836E-05
0.0334	6.162E-05	0.0093	1.220E-04	0.0142	1.052E-04	0.0235	8.143E-05	0.0400	7.726E-05	0.0602	6.167E-05
0.0352	5.488E-05	0.0097	1.120E-04	0.0148	9.559E-05	0.0246	7.325E-05	0.0420	6.944E-05	0.0635	5.563E-05
0.0372	4.881E-05	0.0102	1.025E-04	0.0155	8.665E-05	0.0257	6.578E-05	0.0441	6.231E-05	0.0669	5.017E-05

Appendix A

Table A-1b. 0.5 Hz Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP
0.0392	4.338E-05	0.0107	9.357E-05	0.0162	7.832E-05	0.0270	5.896E-05	0.0463	5.583E-05	0.0705	4.526E-05
0.0414	3.854E-05	0.0112	8.522E-05	0.0170	7.061E-05	0.0283	5.279E-05	0.0486	4.996E-05	0.0743	4.081E-05
0.0436	3.422E-05	0.0117	7.740E-05	0.0177	6.349E-05	0.0296	4.720E-05	0.0510	4.468E-05	0.0783	3.681E-05
0.0460	3.038E-05	0.0122	7.012E-05	0.0186	5.696E-05	0.0310	4.217E-05	0.0536	3.993E-05	0.0825	3.320E-05
0.0485	2.697E-05	0.0128	6.338E-05	0.0194	5.100E-05	0.0325	3.766E-05	0.0562	3.567E-05	0.0870	2.994E-05
0.0512	2.395E-05	0.0134	5.716E-05	0.0203	4.560E-05	0.0340	3.361E-05	0.0590	3.186E-05	0.0917	2.700E-05
0.0540	2.126E-05	0.0140	5.145E-05	0.0212	4.072E-05	0.0357	2.999E-05	0.0620	2.845E-05	0.0966	2.435E-05
0.0570	1.888E-05	0.0146	4.625E-05	0.0222	3.633E-05	0.0374	2.676E-05	0.0651	2.540E-05	0.1018	2.196E-05
0.0601	1.676E-05	0.0153	4.153E-05	0.0232	3.239E-05	0.0391	2.387E-05	0.0684	2.269E-05	0.1073	1.980E-05
0.0634	1.488E-05	0.0160	3.726E-05	0.0243	2.887E-05	0.0410	2.129E-05	0.0718	2.026E-05	0.1131	1.786E-05
0.0669	1.321E-05	0.0167	3.341E-05	0.0254	2.571E-05	0.0430	1.899E-05	0.0754	1.809E-05	0.1192	1.610E-05
0.0705	1.173E-05	0.0175	2.995E-05	0.0266	2.290E-05	0.0450	1.693E-05	0.0791	1.615E-05	0.1256	1.451E-05
0.0744	1.042E-05	0.0183	2.684E-05	0.0278	2.039E-05	0.0471	1.509E-05	0.0831	1.441E-05	0.1324	1.307E-05
0.0785	9.254E-06	0.0192	2.404E-05	0.0291	1.816E-05	0.0494	1.345E-05	0.0873	1.286E-05	0.1395	1.178E-05
0.0828	8.221E-06	0.0200	2.153E-05	0.0305	1.616E-05	0.0517	1.198E-05	0.0916	1.148E-05	0.1471	1.060E-05
0.0873	7.303E-06	0.0210	1.928E-05	0.0319	1.438E-05	0.0542	1.067E-05	0.0962	1.024E-05	0.1550	9.533E-06
0.0921	6.488E-06	0.0219	1.725E-05	0.0333	1.278E-05	0.0568	9.488E-06	0.1010	9.129E-06	0.1634	8.570E-06
0.0972	5.765E-06	0.0229	1.543E-05	0.0349	1.136E-05	0.0595	8.437E-06	0.1061	8.139E-06	0.1722	7.699E-06
0.1025	5.122E-06	0.0240	1.379E-05	0.0365	1.009E-05	0.0623	7.498E-06	0.1114	7.253E-06	0.1815	6.912E-06
0.1081	4.552E-06	0.0251	1.232E-05	0.0381	8.945E-06	0.0653	6.659E-06	0.1170	6.462E-06	0.1912	6.203E-06
0.1140	4.045E-06	0.0263	1.099E-05	0.0399	7.929E-06	0.0684	5.911E-06	0.1228	5.757E-06	0.2016	5.563E-06
0.1203	3.594E-06	0.0275	9.785E-06	0.0417	7.022E-06	0.0716	5.244E-06	0.1290	5.127E-06	0.2124	4.988E-06
0.1269	3.193E-06	0.0287	8.704E-06	0.0437	6.213E-06	0.0751	4.651E-06	0.1354	4.565E-06	0.2239	4.472E-06
0.1338	2.838E-06	0.0301	7.732E-06	0.0457	5.494E-06	0.0786	4.123E-06	0.1422	4.064E-06	0.2360	4.008E-06
0.1412	2.521E-06	0.0315	6.859E-06	0.0478	4.854E-06	0.0824	3.655E-06	0.1493	3.618E-06	0.2487	3.591E-06
0.1489	2.240E-06	0.0329	6.076E-06	0.0500	4.287E-06	0.0863	3.239E-06	0.1568	3.220E-06	0.2621	3.218E-06
0.1571	1.990E-06	0.0344	5.376E-06	0.0523	3.784E-06	0.0904	2.870E-06	0.1646	2.866E-06	0.2763	2.883E-06
0.1657	1.768E-06	0.0360	4.752E-06	0.0547	3.340E-06	0.0947	2.543E-06	0.1729	2.551E-06	0.2912	2.583E-06
0.1748	1.570E-06	0.0377	4.197E-06	0.0572	2.946E-06	0.0992	2.253E-06	0.1815	2.271E-06	0.3069	2.314E-06
0.1843	1.395E-06	0.0394	3.705E-06	0.0599	2.599E-06	0.1040	1.996E-06	0.1906	2.020E-06	0.3234	2.072E-06
0.1945	1.238E-06	0.0412	3.268E-06	0.0626	2.292E-06	0.1089	1.767E-06	0.2002	1.797E-06	0.3409	1.855E-06
0.2051	1.099E-06	0.0431	2.882E-06	0.0655	2.021E-06	0.1141	1.565E-06	0.2102	1.598E-06	0.3592	1.660E-06
0.2164	9.756E-07	0.0451	2.540E-06	0.0685	1.781E-06	0.1195	1.385E-06	0.2207	1.420E-06	0.3786	1.484E-06
0.2282	8.657E-07	0.0472	2.239E-06	0.0717	1.570E-06	0.1252	1.225E-06	0.2317	1.262E-06	0.3990	1.326E-06
0.2407	7.679E-07	0.0494	1.972E-06	0.0750	1.382E-06	0.1312	1.083E-06	0.2433	1.120E-06	0.4206	1.183E-06
0.2539	6.810E-07	0.0516	1.736E-06	0.0784	1.217E-06	0.1374	9.571E-07	0.2555	9.932E-07	0.4433	1.053E-06

Appendix A

Table A-1b. 0.5 Hz Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP
0.2679	6.037E-07	0.0540	1.528E-06	0.0820	1.070E-06	0.1440	8.453E-07	0.2683	8.800E-07	0.4672	9.364E-07
0.2825	5.350E-07	0.0565	1.343E-06	0.0858	9.403E-07	0.1508	7.461E-07	0.2817	7.790E-07	0.4924	8.307E-07
0.2980	4.739E-07	0.0591	1.179E-06	0.0898	8.257E-07	0.1580	6.581E-07	0.2958	6.889E-07	0.5189	7.353E-07
0.3144	4.197E-07	0.0618	1.034E-06	0.0939	7.242E-07	0.1655	5.800E-07	0.3106	6.086E-07	0.5469	6.497E-07
0.3316	3.715E-07	0.0647	9.055E-07	0.0982	6.347E-07	0.1734	5.110E-07	0.3262	5.372E-07	0.5764	5.729E-07
0.3498	3.288E-07	0.0677	7.918E-07	0.1028	5.557E-07	0.1817	4.499E-07	0.3425	4.737E-07	0.6075	5.044E-07
0.3690	2.908E-07	0.0708	6.913E-07	0.1075	4.861E-07	0.1903	3.958E-07	0.3596	4.175E-07	0.6403	4.435E-07
0.3892	2.571E-07	0.0741	6.025E-07	0.1125	4.249E-07	0.1994	3.481E-07	0.3776	3.677E-07	0.6748	3.896E-07
0.4105	2.271E-07	0.0775	5.244E-07	0.1176	3.710E-07	0.2089	3.059E-07	0.3965	3.236E-07	0.7112	3.418E-07
0.4330	2.004E-07	0.0811	4.558E-07	0.1231	3.237E-07	0.2188	2.686E-07	0.4164	2.846E-07	0.7496	2.997E-07
0.4568	1.768E-07	0.0848	3.956E-07	0.1287	2.823E-07	0.2292	2.357E-07	0.4372	2.501E-07	0.7900	2.626E-07
0.4818	1.557E-07	0.0887	3.429E-07	0.1347	2.459E-07	0.2401	2.066E-07	0.4591	2.196E-07	0.8326	2.298E-07
0.5083	1.369E-07	0.0928	2.969E-07	0.1409	2.139E-07	0.2516	1.809E-07	0.4820	1.926E-07	0.8775	2.009E-07
0.5361	1.201E-07	0.0971	2.567E-07	0.1474	1.859E-07	0.2636	1.582E-07	0.5062	1.686E-07	0.9249	1.754E-07
0.5655	1.051E-07	0.1015	2.216E-07	0.1541	1.613E-07	0.2761	1.380E-07	0.5315	1.474E-07	0.9747	1.528E-07
0.5965	9.164E-08	0.1062	1.910E-07	0.1613	1.397E-07	0.2893	1.202E-07	0.5581	1.285E-07	1.0273	1.328E-07
0.6292	7.965E-08	0.1111	1.643E-07	0.1687	1.207E-07	0.3030	1.043E-07	0.5860	1.116E-07	1.0827	1.150E-07
0.6637	6.895E-08	0.1162	1.410E-07	0.1765	1.040E-07	0.3175	9.028E-08	0.6153	9.662E-08	1.1411	9.917E-08
0.7001	5.941E-08	0.1216	1.206E-07	0.1846	8.934E-08	0.3326	7.784E-08	0.6461	8.326E-08	1.2027	8.511E-08
0.7385	5.094E-08	0.1272	1.027E-07	0.1931	7.644E-08	0.3484	6.681E-08	0.6785	7.137E-08	1.2676	7.261E-08
0.7790	4.344E-08	0.1331	8.705E-08	0.2020	6.512E-08	0.3650	5.707E-08	0.7124	6.082E-08	1.3359	6.155E-08
0.8217	3.681E-08	0.1392	7.340E-08	0.2113	5.518E-08	0.3824	4.848E-08	0.7481	5.148E-08	1.4080	5.179E-08
0.8668	3.098E-08	0.1456	6.150E-08	0.2210	4.650E-08	0.4006	4.092E-08	0.7855	4.326E-08	1.4839	4.322E-08
0.9143	2.587E-08	0.1523	5.115E-08	0.2312	3.892E-08	0.4197	3.430E-08	0.8248	3.606E-08	1.5640	3.575E-08
0.9644	2.139E-08	0.1594	4.220E-08	0.2419	3.233E-08	0.4396	2.852E-08	0.8661	2.979E-08	1.6483	2.928E-08
1.0173	1.748E-08	0.1667	3.449E-08	0.2530	2.662E-08	0.4606	2.349E-08	0.9094	2.435E-08	1.7373	2.370E-08
1.0731	1.409E-08	0.1744	2.788E-08	0.2647	2.170E-08	0.4825	1.914E-08	0.9549	1.966E-08	1.8310	1.892E-08
1.1319	1.116E-08	0.1825	2.227E-08	0.2769	1.748E-08	0.5055	1.540E-08	1.0027	1.565E-08	1.9297	1.486E-08

Appendix A

Table A-1c. 1 Hz Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP
0.0114	1.079E-03	0.0051	1.065E-03	0.0072	1.070E-03	0.0104	1.074E-03	0.0147	1.075E-03	0.0185	1.079E-03
0.0120	1.061E-03	0.0053	1.051E-03	0.0075	1.055E-03	0.0109	1.058E-03	0.0154	1.058E-03	0.0194	1.062E-03
0.0126	1.032E-03	0.0056	1.030E-03	0.0079	1.032E-03	0.0114	1.033E-03	0.0162	1.032E-03	0.0205	1.032E-03
0.0132	9.912E-04	0.0058	1.000E-03	0.0082	9.998E-04	0.0119	9.971E-04	0.0170	9.936E-04	0.0215	9.894E-04
0.0139	9.379E-04	0.0061	9.607E-04	0.0086	9.577E-04	0.0125	9.511E-04	0.0179	9.445E-04	0.0227	9.347E-04
0.0147	8.752E-04	0.0064	9.132E-04	0.0090	9.069E-04	0.0131	8.956E-04	0.0187	8.861E-04	0.0238	8.706E-04
0.0154	8.072E-04	0.0067	8.596E-04	0.0094	8.498E-04	0.0137	8.340E-04	0.0197	8.221E-04	0.0251	8.013E-04
0.0162	7.380E-04	0.0070	8.026E-04	0.0098	7.893E-04	0.0144	7.696E-04	0.0207	7.560E-04	0.0264	7.312E-04
0.0171	6.709E-04	0.0073	7.447E-04	0.0103	7.282E-04	0.0151	7.055E-04	0.0217	6.912E-04	0.0278	6.636E-04
0.0180	6.081E-04	0.0076	6.881E-04	0.0108	6.689E-04	0.0158	6.439E-04	0.0228	6.297E-04	0.0292	6.005E-04
0.0189	5.502E-04	0.0080	6.343E-04	0.0113	6.128E-04	0.0165	5.864E-04	0.0239	5.726E-04	0.0308	5.426E-04
0.0199	4.976E-04	0.0084	5.838E-04	0.0118	5.605E-04	0.0173	5.333E-04	0.0251	5.203E-04	0.0324	4.899E-04
0.0210	4.499E-04	0.0087	5.369E-04	0.0123	5.123E-04	0.0181	4.847E-04	0.0264	4.726E-04	0.0341	4.423E-04
0.0221	4.067E-04	0.0091	4.937E-04	0.0129	4.682E-04	0.0190	4.405E-04	0.0277	4.292E-04	0.0359	3.993E-04
0.0232	3.676E-04	0.0096	4.538E-04	0.0135	4.278E-04	0.0199	4.002E-04	0.0291	3.899E-04	0.0377	3.605E-04
0.0244	3.323E-04	0.0100	4.172E-04	0.0141	3.908E-04	0.0209	3.636E-04	0.0305	3.541E-04	0.0397	3.255E-04
0.0257	3.004E-04	0.0104	3.835E-04	0.0148	3.570E-04	0.0219	3.303E-04	0.0320	3.216E-04	0.0418	2.939E-04
0.0271	2.716E-04	0.0109	3.525E-04	0.0154	3.261E-04	0.0229	3.001E-04	0.0336	2.921E-04	0.0440	2.653E-04
0.0285	2.455E-04	0.0114	3.240E-04	0.0161	2.979E-04	0.0240	2.726E-04	0.0353	2.653E-04	0.0463	2.395E-04
0.0300	2.219E-04	0.0119	2.978E-04	0.0169	2.722E-04	0.0252	2.477E-04	0.0371	2.409E-04	0.0487	2.163E-04
0.0315	2.006E-04	0.0125	2.738E-04	0.0177	2.486E-04	0.0264	2.250E-04	0.0389	2.189E-04	0.0513	1.953E-04
0.0332	1.814E-04	0.0131	2.516E-04	0.0185	2.271E-04	0.0276	2.045E-04	0.0409	1.988E-04	0.0539	1.763E-04
0.0349	1.639E-04	0.0137	2.313E-04	0.0193	2.074E-04	0.0289	1.858E-04	0.0429	1.805E-04	0.0568	1.592E-04
0.0368	1.482E-04	0.0143	2.126E-04	0.0202	1.894E-04	0.0303	1.687E-04	0.0451	1.639E-04	0.0597	1.437E-04
0.0387	1.339E-04	0.0149	1.954E-04	0.0211	1.730E-04	0.0318	1.533E-04	0.0473	1.489E-04	0.0629	1.298E-04
0.0407	1.208E-04	0.0156	1.796E-04	0.0221	1.579E-04	0.0333	1.391E-04	0.0497	1.351E-04	0.0662	1.172E-04
0.0428	1.089E-04	0.0163	1.650E-04	0.0231	1.441E-04	0.0349	1.262E-04	0.0522	1.225E-04	0.0696	1.060E-04
0.0451	9.800E-05	0.0171	1.516E-04	0.0242	1.314E-04	0.0365	1.144E-04	0.0548	1.110E-04	0.0733	9.575E-05
0.0474	8.803E-05	0.0179	1.391E-04	0.0253	1.196E-04	0.0383	1.034E-04	0.0575	1.003E-04	0.0771	8.657E-05
0.0499	7.893E-05	0.0187	1.275E-04	0.0265	1.087E-04	0.0401	9.335E-05	0.0604	9.059E-05	0.0811	7.830E-05
0.0525	7.067E-05	0.0195	1.167E-04	0.0277	9.859E-05	0.0420	8.409E-05	0.0634	8.163E-05	0.0854	7.084E-05
0.0553	6.321E-05	0.0204	1.066E-04	0.0289	8.916E-05	0.0440	7.562E-05	0.0666	7.343E-05	0.0899	6.410E-05
0.0582	5.650E-05	0.0213	9.709E-05	0.0303	8.043E-05	0.0461	6.789E-05	0.0699	6.598E-05	0.0946	5.801E-05
0.0612	5.049E-05	0.0223	8.814E-05	0.0317	7.240E-05	0.0483	6.087E-05	0.0734	5.924E-05	0.0995	5.249E-05
0.0644	4.511E-05	0.0233	7.978E-05	0.0331	6.504E-05	0.0506	5.455E-05	0.0771	5.316E-05	0.1047	4.751E-05
0.0678	4.030E-05	0.0244	7.201E-05	0.0346	5.836E-05	0.0530	4.887E-05	0.0809	4.770E-05	0.1102	4.300E-05

Appendix A

Table A-1c. 1 Hz Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP
0.0714	3.601E-05	0.0255	6.487E-05	0.0362	5.232E-05	0.0556	4.377E-05	0.0850	4.279E-05	0.1160	3.891E-05
0.0751	3.217E-05	0.0267	5.834E-05	0.0379	4.688E-05	0.0582	3.920E-05	0.0892	3.839E-05	0.1220	3.522E-05
0.0790	2.874E-05	0.0279	5.242E-05	0.0396	4.200E-05	0.0610	3.511E-05	0.0937	3.444E-05	0.1284	3.187E-05
0.0832	2.568E-05	0.0292	4.708E-05	0.0415	3.762E-05	0.0639	3.144E-05	0.0984	3.090E-05	0.1352	2.885E-05
0.0875	2.294E-05	0.0305	4.227E-05	0.0434	3.370E-05	0.0670	2.816E-05	0.1033	2.772E-05	0.1422	2.611E-05
0.0921	2.050E-05	0.0319	3.795E-05	0.0453	3.019E-05	0.0702	2.522E-05	0.1084	2.487E-05	0.1497	2.363E-05
0.0969	1.832E-05	0.0333	3.407E-05	0.0474	2.704E-05	0.0735	2.259E-05	0.1138	2.230E-05	0.1575	2.139E-05
0.1020	1.636E-05	0.0349	3.059E-05	0.0496	2.422E-05	0.0770	2.023E-05	0.1195	2.001E-05	0.1658	1.936E-05
0.1073	1.462E-05	0.0365	2.745E-05	0.0519	2.170E-05	0.0807	1.812E-05	0.1255	1.795E-05	0.1745	1.752E-05
0.1130	1.307E-05	0.0381	2.465E-05	0.0543	1.944E-05	0.0845	1.623E-05	0.1318	1.610E-05	0.1836	1.586E-05
0.1189	1.168E-05	0.0399	2.212E-05	0.0568	1.741E-05	0.0886	1.453E-05	0.1384	1.445E-05	0.1932	1.434E-05
0.1251	1.043E-05	0.0417	1.986E-05	0.0594	1.559E-05	0.0928	1.300E-05	0.1453	1.296E-05	0.2033	1.298E-05
0.1317	9.324E-06	0.0436	1.783E-05	0.0621	1.395E-05	0.0972	1.164E-05	0.1525	1.162E-05	0.2140	1.173E-05
0.1385	8.334E-06	0.0456	1.599E-05	0.0650	1.248E-05	0.1019	1.041E-05	0.1602	1.042E-05	0.2252	1.060E-05
0.1458	7.451E-06	0.0477	1.435E-05	0.0679	1.115E-05	0.1067	9.303E-06	0.1682	9.343E-06	0.2369	9.558E-06
0.1534	6.662E-06	0.0498	1.285E-05	0.0711	9.958E-06	0.1118	8.310E-06	0.1766	8.375E-06	0.2494	8.614E-06
0.1615	5.957E-06	0.0521	1.150E-05	0.0743	8.876E-06	0.1172	7.419E-06	0.1854	7.507E-06	0.2624	7.755E-06
0.1699	5.326E-06	0.0545	1.027E-05	0.0777	7.903E-06	0.1227	6.620E-06	0.1946	6.727E-06	0.2761	6.976E-06
0.1788	4.763E-06	0.0570	9.159E-06	0.0813	7.028E-06	0.1286	5.905E-06	0.2044	6.028E-06	0.2906	6.270E-06
0.1882	4.259E-06	0.0596	8.149E-06	0.0850	6.244E-06	0.1347	5.266E-06	0.2146	5.401E-06	0.3058	5.635E-06
0.1980	3.808E-06	0.0623	7.236E-06	0.0890	5.544E-06	0.1412	4.696E-06	0.2253	4.840E-06	0.3218	5.063E-06
0.2084	3.405E-06	0.0651	6.416E-06	0.0930	4.920E-06	0.1479	4.187E-06	0.2366	4.336E-06	0.3387	4.549E-06
0.2193	3.045E-06	0.0681	5.681E-06	0.0973	4.366E-06	0.1550	3.733E-06	0.2484	3.885E-06	0.3564	4.086E-06
0.2308	2.723E-06	0.0712	5.027E-06	0.1018	3.873E-06	0.1624	3.328E-06	0.2608	3.481E-06	0.3751	3.671E-06
0.2429	2.434E-06	0.0745	4.446E-06	0.1065	3.435E-06	0.1701	2.967E-06	0.2738	3.118E-06	0.3947	3.298E-06
0.2556	2.176E-06	0.0779	3.931E-06	0.1114	3.047E-06	0.1782	2.645E-06	0.2875	2.793E-06	0.4154	2.963E-06
0.2690	1.945E-06	0.0814	3.475E-06	0.1165	2.703E-06	0.1867	2.358E-06	0.3019	2.503E-06	0.4371	2.661E-06
0.2831	1.739E-06	0.0851	3.072E-06	0.1218	2.397E-06	0.1957	2.103E-06	0.3169	2.242E-06	0.4600	2.390E-06
0.2979	1.554E-06	0.0890	2.716E-06	0.1274	2.126E-06	0.2050	1.874E-06	0.3328	2.008E-06	0.4841	2.147E-06
0.3135	1.388E-06	0.0931	2.400E-06	0.1333	1.885E-06	0.2148	1.670E-06	0.3494	1.798E-06	0.5094	1.929E-06
0.3299	1.239E-06	0.0973	2.121E-06	0.1394	1.671E-06	0.2250	1.488E-06	0.3669	1.610E-06	0.5361	1.732E-06
0.3472	1.105E-06	0.1018	1.874E-06	0.1458	1.481E-06	0.2358	1.325E-06	0.3852	1.441E-06	0.5642	1.554E-06
0.3654	9.836E-07	0.1064	1.656E-06	0.1525	1.312E-06	0.2470	1.178E-06	0.4044	1.288E-06	0.5937	1.394E-06
0.3845	8.742E-07	0.1113	1.462E-06	0.1595	1.161E-06	0.2588	1.048E-06	0.4246	1.150E-06	0.6248	1.248E-06
0.4046	7.758E-07	0.1164	1.288E-06	0.1668	1.026E-06	0.2712	9.295E-07	0.4459	1.025E-06	0.6575	1.115E-06
0.4258	6.874E-07	0.1217	1.135E-06	0.1745	9.057E-07	0.2841	8.237E-07	0.4681	9.106E-07	0.6919	9.925E-07

Appendix A

Table A-1c. 1 Hz Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP
0.4481	6.084E-07	0.1272	9.965E-07	0.1825	7.985E-07	0.2977	7.289E-07	0.4915	8.074E-07	0.7282	8.801E-07
0.4716	5.381E-07	0.1330	8.734E-07	0.1909	7.029E-07	0.3119	6.442E-07	0.5161	7.142E-07	0.7663	7.773E-07
0.4963	4.756E-07	0.1391	7.638E-07	0.1997	6.181E-07	0.3268	5.689E-07	0.5419	6.306E-07	0.8064	6.841E-07
0.5223	4.202E-07	0.1455	6.664E-07	0.2088	5.430E-07	0.3423	5.020E-07	0.5689	5.559E-07	0.8486	6.003E-07
0.5496	3.711E-07	0.1521	5.804E-07	0.2184	4.767E-07	0.3587	4.427E-07	0.5974	4.896E-07	0.8931	5.258E-07
0.5784	3.276E-07	0.1591	5.047E-07	0.2285	4.183E-07	0.3758	3.902E-07	0.6272	4.309E-07	0.9398	4.601E-07
0.6087	2.890E-07	0.1663	4.384E-07	0.2390	3.668E-07	0.3937	3.438E-07	0.6586	3.791E-07	0.9890	4.021E-07
0.6405	2.549E-07	0.1739	3.804E-07	0.2499	3.214E-07	0.4125	3.028E-07	0.6915	3.334E-07	1.0408	3.513E-07
0.6741	2.247E-07	0.1818	3.299E-07	0.2614	2.816E-07	0.4322	2.665E-07	0.7260	2.929E-07	1.0953	3.068E-07
0.7094	1.979E-07	0.1901	2.859E-07	0.2734	2.465E-07	0.4528	2.345E-07	0.7623	2.573E-07	1.1527	2.676E-07
0.7465	1.741E-07	0.1988	2.476E-07	0.2860	2.156E-07	0.4745	2.061E-07	0.8004	2.258E-07	1.2130	2.334E-07
0.7856	1.530E-07	0.2079	2.142E-07	0.2991	1.885E-07	0.4971	1.810E-07	0.8404	1.981E-07	1.2765	2.033E-07
0.8267	1.342E-07	0.2174	1.851E-07	0.3129	1.645E-07	0.5208	1.587E-07	0.8824	1.735E-07	1.3433	1.769E-07
0.8700	1.174E-07	0.2273	1.598E-07	0.3272	1.433E-07	0.5457	1.389E-07	0.9264	1.517E-07	1.4137	1.537E-07
0.9156	1.022E-07	0.2377	1.376E-07	0.3423	1.245E-07	0.5717	1.212E-07	0.9727	1.323E-07	1.4877	1.332E-07
0.9635	8.858E-08	0.2485	1.181E-07	0.3580	1.077E-07	0.5990	1.053E-07	1.0213	1.149E-07	1.5656	1.150E-07
1.0140	7.629E-08	0.2599	1.010E-07	0.3744	9.278E-08	0.6276	9.095E-08	1.0724	9.923E-08	1.6475	9.873E-08
1.0671	6.525E-08	0.2718	8.600E-08	0.3916	7.947E-08	0.6576	7.804E-08	1.1259	8.511E-08	1.7338	8.421E-08
1.1229	5.541E-08	0.2842	7.281E-08	0.4096	6.761E-08	0.6889	6.645E-08	1.1822	7.236E-08	1.8246	7.124E-08
1.1817	4.673E-08	0.2971	6.126E-08	0.4284	5.712E-08	0.7218	5.612E-08	1.2413	6.094E-08	1.9201	5.973E-08
1.2436	3.914E-08	0.3107	5.119E-08	0.4481	4.789E-08	0.7563	4.700E-08	1.3033	5.083E-08	2.0206	4.962E-08
1.3087	3.253E-08	0.3249	4.245E-08	0.4687	3.983E-08	0.7924	3.903E-08	1.3684	4.198E-08	2.1264	4.085E-08
1.3773	2.679E-08	0.3397	3.491E-08	0.4902	3.284E-08	0.8302	3.212E-08	1.4368	3.432E-08	2.2378	3.329E-08
1.4494	2.183E-08	0.3552	2.842E-08	0.5128	2.681E-08	0.8698	2.615E-08	1.5086	2.774E-08	2.3549	2.682E-08
1.5253	1.753E-08	0.3714	2.287E-08	0.5363	2.162E-08	0.9113	2.102E-08	1.5839	2.212E-08	2.4782	2.132E-08
1.6051	1.382E-08	0.3884	1.812E-08	0.5610	1.717E-08	0.9548	1.663E-08	1.6631	1.735E-08	2.6080	1.663E-08
1.6892	1.063E-08	0.4061	1.408E-08	0.5867	1.336E-08	1.0004	1.288E-08	1.7462	1.330E-08	2.7445	1.268E-08
1.7776	7.913E-09	0.4246	1.067E-08	0.6137	1.014E-08	1.0481	9.704E-09	1.8334	9.897E-09	2.8882	9.354E-09

Appendix A

Table A-1d. 2.5 Hz Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP
0.0242	1.062E-03	0.0145	1.057E-03	0.0175	1.058E-03	0.0230	1.059E-03	0.0296	1.059E-03	0.0363	1.060E-03
0.0254	1.041E-03	0.0152	1.038E-03	0.0183	1.039E-03	0.0241	1.039E-03	0.0311	1.039E-03	0.0382	1.039E-03
0.0268	1.010E-03	0.0159	1.012E-03	0.0192	1.012E-03	0.0253	1.011E-03	0.0327	1.010E-03	0.0401	1.009E-03
0.0281	9.696E-04	0.0166	9.771E-04	0.0201	9.758E-04	0.0265	9.734E-04	0.0344	9.706E-04	0.0422	9.685E-04
0.0296	9.197E-04	0.0174	9.346E-04	0.0210	9.320E-04	0.0278	9.276E-04	0.0362	9.229E-04	0.0444	9.191E-04
0.0311	8.626E-04	0.0182	8.853E-04	0.0220	8.812E-04	0.0292	8.747E-04	0.0380	8.682E-04	0.0468	8.627E-04
0.0328	8.012E-04	0.0190	8.310E-04	0.0231	8.255E-04	0.0306	8.172E-04	0.0399	8.090E-04	0.0492	8.020E-04
0.0345	7.384E-04	0.0199	7.740E-04	0.0242	7.673E-04	0.0321	7.575E-04	0.0420	7.483E-04	0.0518	7.401E-04
0.0363	6.768E-04	0.0208	7.165E-04	0.0253	7.088E-04	0.0337	6.981E-04	0.0441	6.885E-04	0.0544	6.794E-04
0.0381	6.182E-04	0.0218	6.602E-04	0.0265	6.519E-04	0.0354	6.408E-04	0.0464	6.313E-04	0.0573	6.218E-04
0.0401	5.635E-04	0.0228	6.065E-04	0.0278	5.979E-04	0.0371	5.868E-04	0.0488	5.776E-04	0.0603	5.679E-04
0.0422	5.131E-04	0.0238	5.561E-04	0.0291	5.473E-04	0.0389	5.365E-04	0.0512	5.280E-04	0.0634	5.183E-04
0.0444	4.670E-04	0.0249	5.093E-04	0.0305	5.006E-04	0.0408	4.902E-04	0.0539	4.824E-04	0.0667	4.727E-04
0.0467	4.250E-04	0.0261	4.661E-04	0.0319	4.576E-04	0.0428	4.478E-04	0.0566	4.406E-04	0.0702	4.311E-04
0.0491	3.867E-04	0.0273	4.264E-04	0.0334	4.183E-04	0.0449	4.089E-04	0.0595	4.024E-04	0.0738	3.931E-04
0.0517	3.519E-04	0.0285	3.901E-04	0.0350	3.822E-04	0.0471	3.735E-04	0.0625	3.675E-04	0.0777	3.585E-04
0.0544	3.202E-04	0.0298	3.568E-04	0.0366	3.493E-04	0.0494	3.411E-04	0.0657	3.357E-04	0.0817	3.269E-04
0.0572	2.913E-04	0.0312	3.264E-04	0.0384	3.191E-04	0.0519	3.114E-04	0.0691	3.065E-04	0.0860	2.982E-04
0.0601	2.651E-04	0.0326	2.985E-04	0.0402	2.916E-04	0.0544	2.844E-04	0.0726	2.800E-04	0.0905	2.718E-04
0.0633	2.412E-04	0.0341	2.730E-04	0.0421	2.665E-04	0.0571	2.597E-04	0.0763	2.557E-04	0.0952	2.479E-04
0.0666	2.195E-04	0.0357	2.497E-04	0.0440	2.435E-04	0.0599	2.372E-04	0.0802	2.335E-04	0.1001	2.261E-04
0.0700	1.997E-04	0.0374	2.283E-04	0.0461	2.226E-04	0.0628	2.166E-04	0.0843	2.132E-04	0.1054	2.061E-04
0.0737	1.817E-04	0.0391	2.088E-04	0.0483	2.033E-04	0.0659	1.978E-04	0.0886	1.947E-04	0.1108	1.880E-04
0.0775	1.653E-04	0.0409	1.910E-04	0.0506	1.858E-04	0.0691	1.806E-04	0.0931	1.778E-04	0.1166	1.714E-04
0.0815	1.504E-04	0.0428	1.746E-04	0.0530	1.697E-04	0.0725	1.649E-04	0.0979	1.624E-04	0.1227	1.563E-04
0.0857	1.367E-04	0.0447	1.596E-04	0.0555	1.550E-04	0.0760	1.505E-04	0.1029	1.483E-04	0.1291	1.425E-04
0.0902	1.242E-04	0.0468	1.458E-04	0.0581	1.415E-04	0.0798	1.373E-04	0.1081	1.353E-04	0.1358	1.299E-04
0.0949	1.129E-04	0.0489	1.331E-04	0.0608	1.291E-04	0.0837	1.252E-04	0.1137	1.234E-04	0.1429	1.184E-04
0.0998	1.024E-04	0.0512	1.214E-04	0.0637	1.176E-04	0.0878	1.141E-04	0.1195	1.125E-04	0.1503	1.079E-04
0.1050	9.282E-05	0.0536	1.105E-04	0.0667	1.071E-04	0.0921	1.038E-04	0.1256	1.025E-04	0.1582	9.819E-05
0.1104	8.405E-05	0.0560	1.004E-04	0.0699	9.727E-05	0.0966	9.435E-05	0.1320	9.323E-05	0.1664	8.934E-05
0.1162	7.605E-05	0.0586	9.104E-05	0.0732	8.823E-05	0.1013	8.564E-05	0.1387	8.473E-05	0.1751	8.123E-05
0.1222	6.875E-05	0.0613	8.237E-05	0.0766	7.988E-05	0.1063	7.764E-05	0.1458	7.694E-05	0.1842	7.383E-05
0.1286	6.211E-05	0.0641	7.437E-05	0.0803	7.222E-05	0.1115	7.032E-05	0.1532	6.979E-05	0.1938	6.707E-05
0.1352	5.610E-05	0.0671	6.703E-05	0.0841	6.520E-05	0.1170	6.363E-05	0.1611	6.328E-05	0.2039	6.092E-05
0.1423	5.066E-05	0.0702	6.033E-05	0.0880	5.881E-05	0.1227	5.754E-05	0.1693	5.735E-05	0.2145	5.532E-05

Appendix A

Table A-1d. 2.5 Hz Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP
0.1497	4.574E-05	0.0734	5.423E-05	0.0922	5.301E-05	0.1287	5.202E-05	0.1779	5.196E-05	0.2257	5.023E-05
0.1574	4.129E-05	0.0768	4.872E-05	0.0965	4.776E-05	0.1350	4.702E-05	0.1870	4.707E-05	0.2374	4.561E-05
0.1656	3.728E-05	0.0803	4.375E-05	0.1011	4.302E-05	0.1416	4.249E-05	0.1966	4.264E-05	0.2498	4.141E-05
0.1742	3.366E-05	0.0840	3.928E-05	0.1059	3.875E-05	0.1486	3.840E-05	0.2066	3.863E-05	0.2628	3.760E-05
0.1833	3.039E-05	0.0878	3.527E-05	0.1109	3.490E-05	0.1559	3.470E-05	0.2172	3.500E-05	0.2765	3.414E-05
0.1928	2.744E-05	0.0919	3.165E-05	0.1161	3.143E-05	0.1635	3.136E-05	0.2282	3.170E-05	0.2909	3.100E-05
0.2028	2.477E-05	0.0961	2.841E-05	0.1216	2.831E-05	0.1715	2.834E-05	0.2399	2.871E-05	0.3061	2.815E-05
0.2133	2.236E-05	0.1005	2.550E-05	0.1273	2.550E-05	0.1799	2.561E-05	0.2522	2.601E-05	0.3220	2.555E-05
0.2244	2.019E-05	0.1052	2.289E-05	0.1333	2.296E-05	0.1887	2.314E-05	0.2650	2.357E-05	0.3388	2.321E-05
0.2361	1.823E-05	0.1100	2.055E-05	0.1396	2.068E-05	0.1980	2.092E-05	0.2786	2.135E-05	0.3564	2.107E-05
0.2483	1.645E-05	0.1151	1.844E-05	0.1462	1.863E-05	0.2077	1.890E-05	0.2928	1.934E-05	0.3750	1.913E-05
0.2612	1.485E-05	0.1204	1.655E-05	0.1531	1.677E-05	0.2178	1.708E-05	0.3077	1.751E-05	0.3945	1.737E-05
0.2748	1.339E-05	0.1259	1.485E-05	0.1604	1.510E-05	0.2285	1.543E-05	0.3234	1.586E-05	0.4151	1.576E-05
0.2891	1.207E-05	0.1317	1.332E-05	0.1680	1.358E-05	0.2397	1.393E-05	0.3400	1.435E-05	0.4367	1.430E-05
0.3041	1.087E-05	0.1378	1.194E-05	0.1759	1.221E-05	0.2515	1.257E-05	0.3573	1.299E-05	0.4594	1.296E-05
0.3199	9.771E-06	0.1441	1.070E-05	0.1842	1.097E-05	0.2638	1.133E-05	0.3756	1.174E-05	0.4834	1.173E-05
0.3365	8.774E-06	0.1507	9.579E-06	0.1929	9.846E-06	0.2767	1.019E-05	0.3947	1.059E-05	0.5086	1.061E-05
0.3539	7.868E-06	0.1577	8.569E-06	0.2020	8.825E-06	0.2903	9.164E-06	0.4149	9.535E-06	0.5351	9.565E-06
0.3723	7.046E-06	0.1649	7.661E-06	0.2115	7.900E-06	0.3045	8.227E-06	0.4361	8.573E-06	0.5629	8.608E-06
0.3917	6.305E-06	0.1725	6.843E-06	0.2215	7.064E-06	0.3194	7.374E-06	0.4583	7.694E-06	0.5923	7.729E-06
0.4120	5.638E-06	0.1805	6.110E-06	0.2320	6.311E-06	0.3351	6.603E-06	0.4817	6.895E-06	0.6231	6.927E-06
0.4334	5.039E-06	0.1888	5.453E-06	0.2430	5.635E-06	0.3515	5.907E-06	0.5063	6.171E-06	0.6556	6.200E-06
0.4559	4.502E-06	0.1975	4.865E-06	0.2544	5.028E-06	0.3687	5.281E-06	0.5322	5.519E-06	0.6897	5.543E-06
0.4796	4.023E-06	0.2065	4.340E-06	0.2665	4.485E-06	0.3868	4.719E-06	0.5594	4.933E-06	0.7256	4.953E-06
0.5045	3.594E-06	0.2160	3.870E-06	0.2790	4.000E-06	0.4057	4.217E-06	0.5879	4.408E-06	0.7634	4.424E-06
0.5307	3.211E-06	0.2260	3.452E-06	0.2922	3.567E-06	0.4256	3.767E-06	0.6179	3.938E-06	0.8032	3.952E-06
0.5583	2.868E-06	0.2364	3.078E-06	0.3060	3.181E-06	0.4465	3.365E-06	0.6495	3.518E-06	0.8451	3.529E-06
0.5873	2.562E-06	0.2473	2.745E-06	0.3205	2.836E-06	0.4683	3.006E-06	0.6826	3.143E-06	0.8891	3.152E-06
0.6178	2.288E-06	0.2586	2.447E-06	0.3356	2.529E-06	0.4913	2.684E-06	0.7175	2.807E-06	0.9354	2.814E-06
0.6499	2.044E-06	0.2705	2.182E-06	0.3515	2.255E-06	0.5154	2.398E-06	0.7541	2.508E-06	0.9841	2.513E-06
0.6836	1.825E-06	0.2830	1.945E-06	0.3681	2.010E-06	0.5406	2.141E-06	0.7926	2.240E-06	1.0354	2.244E-06
0.7192	1.629E-06	0.2960	1.733E-06	0.3855	1.791E-06	0.5671	1.912E-06	0.8331	2.001E-06	1.0893	2.003E-06
0.7565	1.452E-06	0.3096	1.543E-06	0.4037	1.594E-06	0.5949	1.706E-06	0.8756	1.786E-06	1.1461	1.788E-06
0.7958	1.293E-06	0.3239	1.373E-06	0.4227	1.419E-06	0.6240	1.521E-06	0.9204	1.593E-06	1.2058	1.595E-06
0.8371	1.149E-06	0.3388	1.219E-06	0.4427	1.261E-06	0.6546	1.355E-06	0.9673	1.419E-06	1.2686	1.421E-06
0.8806	1.019E-06	0.3544	1.081E-06	0.4636	1.118E-06	0.6867	1.205E-06	1.0167	1.262E-06	1.3346	1.264E-06

Appendix A

Table A-1d. 2.5 Hz Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP
0.9264	9.003E-07	0.3707	9.569E-07	0.4855	9.893E-07	0.7203	1.068E-06	1.0687	1.120E-06	1.4042	1.121E-06
0.9745	7.930E-07	0.3878	8.449E-07	0.5084	8.732E-07	0.7556	9.444E-07	1.1232	9.897E-07	1.4773	9.919E-07
1.0251	6.963E-07	0.4056	7.444E-07	0.5324	7.687E-07	0.7927	8.323E-07	1.1806	8.714E-07	1.5543	8.742E-07
1.0783	6.098E-07	0.4243	6.543E-07	0.5576	6.749E-07	0.8315	7.311E-07	1.2408	7.639E-07	1.6352	7.675E-07
1.1344	5.328E-07	0.4438	5.739E-07	0.5839	5.912E-07	0.8723	6.402E-07	1.3042	6.671E-07	1.7204	6.715E-07
1.1933	4.649E-07	0.4642	5.027E-07	0.6115	5.169E-07	0.9150	5.592E-07	1.3708	5.807E-07	1.8100	5.857E-07
1.2553	4.051E-07	0.4856	4.397E-07	0.6404	4.513E-07	0.9598	4.875E-07	1.4408	5.041E-07	1.9043	5.096E-07
1.3205	3.527E-07	0.5079	3.843E-07	0.6706	3.936E-07	1.0069	4.243E-07	1.5143	4.367E-07	2.0035	4.427E-07
1.3890	3.069E-07	0.5313	3.355E-07	0.7023	3.430E-07	1.0562	3.689E-07	1.5917	3.777E-07	2.1079	3.841E-07
1.4612	2.668E-07	0.5558	2.928E-07	0.7355	2.987E-07	1.1080	3.205E-07	1.6729	3.265E-07	2.2177	3.329E-07
1.5371	2.318E-07	0.5814	2.552E-07	0.7702	2.598E-07	1.1622	2.782E-07	1.7583	2.818E-07	2.3332	2.883E-07
1.6169	2.012E-07	0.6081	2.223E-07	0.8066	2.259E-07	1.2192	2.413E-07	1.8481	2.431E-07	2.4548	2.495E-07
1.7009	1.744E-07	0.6361	1.934E-07	0.8447	1.961E-07	1.2789	2.090E-07	1.9425	2.095E-07	2.5827	2.157E-07
1.7893	1.508E-07	0.6654	1.680E-07	0.8846	1.700E-07	1.3416	1.808E-07	2.0417	1.802E-07	2.7172	1.862E-07
1.8822	1.301E-07	0.6960	1.455E-07	0.9264	1.470E-07	1.4074	1.560E-07	2.1459	1.547E-07	2.8587	1.604E-07
1.9800	1.118E-07	0.7280	1.257E-07	0.9701	1.267E-07	1.4763	1.342E-07	2.2555	1.324E-07	3.0077	1.378E-07
2.0828	9.563E-08	0.7615	1.081E-07	1.0160	1.088E-07	1.5487	1.151E-07	2.3706	1.128E-07	3.1643	1.178E-07
2.1910	8.132E-08	0.7966	9.245E-08	1.0640	9.286E-08	1.6245	9.802E-08	2.4917	9.566E-08	3.3292	1.002E-07
2.3048	6.867E-08	0.8332	7.855E-08	1.1142	7.876E-08	1.7041	8.296E-08	2.6189	8.058E-08	3.5026	8.458E-08
2.4245	5.755E-08	0.8716	6.624E-08	1.1668	6.628E-08	1.7876	6.965E-08	2.7526	6.735E-08	3.6851	7.077E-08
2.5504	4.784E-08	0.9117	5.539E-08	1.2220	5.532E-08	1.8752	5.794E-08	2.8931	5.581E-08	3.8770	5.864E-08
2.6829	3.941E-08	0.9536	4.590E-08	1.2797	4.573E-08	1.9671	4.773E-08	3.0409	4.580E-08	4.0790	4.806E-08
2.8223	3.215E-08	0.9975	3.765E-08	1.3401	3.742E-08	2.0635	3.889E-08	3.1961	3.720E-08	4.2915	3.893E-08
2.9689	2.592E-08	1.0434	3.054E-08	1.4034	3.028E-08	2.1646	3.130E-08	3.3593	2.985E-08	4.5150	3.114E-08
3.1231	2.061E-08	1.0915	2.446E-08	1.4697	2.418E-08	2.2707	2.485E-08	3.5308	2.362E-08	4.7502	2.454E-08
3.2853	1.610E-08	1.1417	1.928E-08	1.5391	1.900E-08	2.3820	1.940E-08	3.7111	1.837E-08	4.9977	1.899E-08
3.4559	1.229E-08	1.1942	1.493E-08	1.6118	1.465E-08	2.4987	1.484E-08	3.9006	1.398E-08	5.2580	1.438E-08
3.6354	9.119E-09	1.2492	1.129E-08	1.6879	1.103E-08	2.6211	1.107E-08	4.0997	1.035E-08	5.5319	1.058E-08

Appendix A

Table A-1e. 5 Hz Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP
0.0385	1.039E-03	0.0220	1.040E-03	0.0273	1.041E-03	0.0370	1.039E-03	0.0474	1.037E-03	0.0603	1.036E-03
0.0405	1.010E-03	0.0230	1.012E-03	0.0287	1.011E-03	0.0389	1.009E-03	0.0499	1.008E-03	0.0634	1.007E-03
0.0427	9.690E-04	0.0242	9.723E-04	0.0301	9.711E-04	0.0408	9.697E-04	0.0524	9.688E-04	0.0667	9.673E-04
0.0449	9.191E-04	0.0254	9.241E-04	0.0316	9.218E-04	0.0429	9.210E-04	0.0551	9.208E-04	0.0701	9.188E-04
0.0473	8.623E-04	0.0266	8.688E-04	0.0332	8.654E-04	0.0451	8.653E-04	0.0580	8.661E-04	0.0738	8.638E-04
0.0497	8.021E-04	0.0279	8.095E-04	0.0349	8.051E-04	0.0473	8.060E-04	0.0610	8.080E-04	0.0776	8.053E-04
0.0523	7.416E-04	0.0293	7.491E-04	0.0366	7.438E-04	0.0497	7.460E-04	0.0641	7.493E-04	0.0816	7.465E-04
0.0551	6.831E-04	0.0308	6.900E-04	0.0384	6.842E-04	0.0523	6.876E-04	0.0674	6.923E-04	0.0858	6.895E-04
0.0580	6.279E-04	0.0323	6.339E-04	0.0403	6.277E-04	0.0549	6.323E-04	0.0709	6.383E-04	0.0902	6.356E-04
0.0610	5.767E-04	0.0339	5.816E-04	0.0423	5.751E-04	0.0577	5.808E-04	0.0746	5.880E-04	0.0949	5.853E-04
0.0642	5.295E-04	0.0355	5.332E-04	0.0444	5.266E-04	0.0606	5.331E-04	0.0784	5.414E-04	0.0998	5.388E-04
0.0676	4.860E-04	0.0373	4.887E-04	0.0467	4.821E-04	0.0637	4.894E-04	0.0824	4.985E-04	0.1050	4.959E-04
0.0711	4.461E-04	0.0391	4.478E-04	0.0490	4.412E-04	0.0669	4.491E-04	0.0867	4.589E-04	0.1104	4.565E-04
0.0748	4.094E-04	0.0411	4.104E-04	0.0514	4.039E-04	0.0703	4.122E-04	0.0912	4.225E-04	0.1161	4.201E-04
0.0788	3.758E-04	0.0431	3.761E-04	0.0540	3.697E-04	0.0738	3.783E-04	0.0959	3.890E-04	0.1221	3.867E-04
0.0829	3.449E-04	0.0452	3.447E-04	0.0567	3.383E-04	0.0775	3.472E-04	0.1008	3.581E-04	0.1284	3.558E-04
0.0872	3.166E-04	0.0475	3.159E-04	0.0595	3.097E-04	0.0815	3.186E-04	0.1060	3.297E-04	0.1351	3.275E-04
0.0918	2.906E-04	0.0498	2.895E-04	0.0625	2.835E-04	0.0856	2.924E-04	0.1115	3.035E-04	0.1421	3.014E-04
0.0966	2.668E-04	0.0523	2.652E-04	0.0656	2.595E-04	0.0899	2.684E-04	0.1172	2.795E-04	0.1494	2.774E-04
0.1017	2.449E-04	0.0549	2.431E-04	0.0688	2.375E-04	0.0944	2.463E-04	0.1233	2.573E-04	0.1572	2.553E-04
0.1070	2.248E-04	0.0576	2.228E-04	0.0723	2.173E-04	0.0992	2.261E-04	0.1296	2.368E-04	0.1653	2.350E-04
0.1126	2.063E-04	0.0604	2.041E-04	0.0759	1.989E-04	0.1042	2.075E-04	0.1363	2.180E-04	0.1738	2.163E-04
0.1185	1.894E-04	0.0634	1.871E-04	0.0796	1.821E-04	0.1095	1.904E-04	0.1433	2.007E-04	0.1828	1.991E-04
0.1248	1.738E-04	0.0665	1.714E-04	0.0836	1.667E-04	0.1150	1.748E-04	0.1507	1.848E-04	0.1923	1.832E-04
0.1313	1.595E-04	0.0698	1.570E-04	0.0878	1.525E-04	0.1208	1.604E-04	0.1585	1.701E-04	0.2022	1.687E-04
0.1382	1.463E-04	0.0732	1.438E-04	0.0921	1.395E-04	0.1270	1.471E-04	0.1666	1.566E-04	0.2127	1.552E-04
0.1454	1.343E-04	0.0769	1.316E-04	0.0967	1.276E-04	0.1334	1.350E-04	0.1752	1.441E-04	0.2237	1.428E-04
0.1531	1.230E-04	0.0807	1.203E-04	0.1015	1.166E-04	0.1401	1.238E-04	0.1843	1.326E-04	0.2353	1.313E-04
0.1611	1.127E-04	0.0846	1.098E-04	0.1066	1.065E-04	0.1472	1.134E-04	0.1938	1.219E-04	0.2474	1.206E-04
0.1695	1.031E-04	0.0888	1.001E-04	0.1119	9.708E-05	0.1546	1.038E-04	0.2038	1.119E-04	0.2602	1.106E-04
0.1784	9.405E-05	0.0932	9.098E-05	0.1175	8.843E-05	0.1625	9.489E-05	0.2143	1.026E-04	0.2737	1.013E-04
0.1878	8.570E-05	0.0978	8.253E-05	0.1233	8.045E-05	0.1707	8.666E-05	0.2253	9.384E-05	0.2878	9.256E-05
0.1976	7.798E-05	0.1026	7.472E-05	0.1295	7.311E-05	0.1793	7.906E-05	0.2369	8.568E-05	0.3027	8.438E-05
0.2080	7.086E-05	0.1077	6.755E-05	0.1359	6.639E-05	0.1884	7.206E-05	0.2491	7.809E-05	0.3184	7.677E-05
0.2189	6.433E-05	0.1130	6.098E-05	0.1427	6.026E-05	0.1979	6.563E-05	0.2620	7.108E-05	0.3349	6.973E-05
0.2304	5.837E-05	0.1186	5.502E-05	0.1498	5.468E-05	0.2079	5.976E-05	0.2755	6.463E-05	0.3522	6.327E-05

Appendix A

Table A-1e. 5 Hz Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP
0.2424	5.295E-05	0.1245	4.962E-05	0.1573	4.961E-05	0.2184	5.440E-05	0.2897	5.872E-05	0.3704	5.737E-05
0.2551	4.802E-05	0.1306	4.474E-05	0.1651	4.501E-05	0.2294	4.952E-05	0.3046	5.334E-05	0.3895	5.201E-05
0.2685	4.355E-05	0.1371	4.034E-05	0.1733	4.083E-05	0.2410	4.507E-05	0.3203	4.845E-05	0.4097	4.713E-05
0.2826	3.950E-05	0.1438	3.637E-05	0.1819	3.704E-05	0.2532	4.102E-05	0.3369	4.400E-05	0.4309	4.271E-05
0.2974	3.582E-05	0.1509	3.279E-05	0.1910	3.361E-05	0.2660	3.734E-05	0.3542	3.996E-05	0.4532	3.871E-05
0.3130	3.249E-05	0.1584	2.956E-05	0.2005	3.049E-05	0.2795	3.399E-05	0.3725	3.629E-05	0.4766	3.508E-05
0.3294	2.947E-05	0.1662	2.666E-05	0.2105	2.766E-05	0.2936	3.093E-05	0.3917	3.296E-05	0.5013	3.179E-05
0.3467	2.673E-05	0.1744	2.403E-05	0.2210	2.510E-05	0.3084	2.816E-05	0.4119	2.993E-05	0.5272	2.881E-05
0.3649	2.424E-05	0.1830	2.167E-05	0.2320	2.277E-05	0.3240	2.563E-05	0.4331	2.719E-05	0.5545	2.611E-05
0.3840	2.199E-05	0.1921	1.954E-05	0.2435	2.066E-05	0.3404	2.333E-05	0.4555	2.469E-05	0.5831	2.366E-05
0.4041	1.994E-05	0.2016	1.761E-05	0.2557	1.874E-05	0.3576	2.123E-05	0.4789	2.243E-05	0.6133	2.144E-05
0.4253	1.809E-05	0.2115	1.588E-05	0.2684	1.700E-05	0.3757	1.932E-05	0.5036	2.036E-05	0.6450	1.943E-05
0.4476	1.640E-05	0.2220	1.431E-05	0.2818	1.542E-05	0.3947	1.758E-05	0.5296	1.849E-05	0.6784	1.760E-05
0.4711	1.486E-05	0.2329	1.289E-05	0.2958	1.397E-05	0.4147	1.600E-05	0.5569	1.679E-05	0.7135	1.595E-05
0.4958	1.346E-05	0.2444	1.160E-05	0.3105	1.266E-05	0.4356	1.455E-05	0.5856	1.524E-05	0.7504	1.444E-05
0.5218	1.217E-05	0.2565	1.044E-05	0.3260	1.145E-05	0.4576	1.322E-05	0.6158	1.382E-05	0.7892	1.306E-05
0.5491	1.099E-05	0.2691	9.378E-06	0.3422	1.033E-05	0.4808	1.199E-05	0.6475	1.252E-05	0.8300	1.179E-05
0.5779	9.888E-06	0.2824	8.417E-06	0.3593	9.307E-06	0.5051	1.085E-05	0.6809	1.131E-05	0.8730	1.062E-05
0.6082	8.874E-06	0.2964	7.547E-06	0.3772	8.366E-06	0.5306	9.788E-06	0.7160	1.020E-05	0.9181	9.541E-06
0.6401	7.940E-06	0.3110	6.761E-06	0.3960	7.504E-06	0.5574	8.804E-06	0.7530	9.154E-06	0.9656	8.544E-06
0.6737	7.087E-06	0.3264	6.053E-06	0.4157	6.720E-06	0.5856	7.893E-06	0.7918	8.191E-06	1.0156	7.629E-06
0.7090	6.311E-06	0.3425	5.417E-06	0.4364	6.010E-06	0.6152	7.056E-06	0.8326	7.306E-06	1.0681	6.794E-06
0.7462	5.613E-06	0.3594	4.846E-06	0.4581	5.370E-06	0.6463	6.293E-06	0.8755	6.498E-06	1.1233	6.039E-06
0.7853	4.988E-06	0.3772	4.336E-06	0.4809	4.796E-06	0.6790	5.604E-06	0.9207	5.769E-06	1.1814	5.361E-06
0.8265	4.431E-06	0.3958	3.878E-06	0.5049	4.283E-06	0.7133	4.986E-06	0.9681	5.116E-06	1.2425	4.756E-06
0.8698	3.935E-06	0.4153	3.469E-06	0.5300	3.824E-06	0.7494	4.434E-06	1.0180	4.533E-06	1.3068	4.218E-06
0.9154	3.494E-06	0.4358	3.103E-06	0.5564	3.414E-06	0.7872	3.942E-06	1.0705	4.016E-06	1.3744	3.740E-06
0.9634	3.102E-06	0.4574	2.775E-06	0.5842	3.047E-06	0.8270	3.504E-06	1.1257	3.557E-06	1.4455	3.315E-06
1.0139	2.755E-06	0.4799	2.481E-06	0.6133	2.721E-06	0.8689	3.114E-06	1.1838	3.151E-06	1.5203	2.939E-06
1.0671	2.445E-06	0.5036	2.219E-06	0.6438	2.428E-06	0.9128	2.768E-06	1.2448	2.790E-06	1.5989	2.605E-06
1.1230	2.171E-06	0.5285	1.985E-06	0.6759	2.167E-06	0.9589	2.460E-06	1.3090	2.471E-06	1.6816	2.310E-06
1.1819	1.927E-06	0.5546	1.774E-06	0.7095	1.934E-06	1.0074	2.186E-06	1.3765	2.188E-06	1.7686	2.047E-06
1.2438	1.710E-06	0.5820	1.585E-06	0.7449	1.725E-06	1.0583	1.942E-06	1.4474	1.937E-06	1.8601	1.814E-06
1.3091	1.516E-06	0.6107	1.414E-06	0.7819	1.538E-06	1.1118	1.724E-06	1.5221	1.714E-06	1.9563	1.606E-06
1.3777	1.342E-06	0.6409	1.259E-06	0.8209	1.368E-06	1.1680	1.529E-06	1.6005	1.516E-06	2.0575	1.421E-06
1.4499	1.185E-06	0.6725	1.119E-06	0.8618	1.215E-06	1.2271	1.355E-06	1.6831	1.338E-06	2.1639	1.254E-06

Appendix A

Table A-1e. 5 Hz Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP
1.5259	1.044E-06	0.7058	9.902E-07	0.9047	1.075E-06	1.2891	1.197E-06	1.7698	1.179E-06	2.2758	1.105E-06
1.6059	9.153E-07	0.7406	8.732E-07	0.9498	9.470E-07	1.3543	1.054E-06	1.8611	1.034E-06	2.3935	9.698E-07
1.6901	7.996E-07	0.7772	7.669E-07	0.9971	8.308E-07	1.4227	9.236E-07	1.9570	9.041E-07	2.5173	8.481E-07
1.7788	6.956E-07	0.8156	6.710E-07	1.0467	7.254E-07	1.4946	8.058E-07	2.0579	7.868E-07	2.6475	7.389E-07
1.8720	6.030E-07	0.8558	5.852E-07	1.0988	6.308E-07	1.5702	6.997E-07	2.1640	6.818E-07	2.7845	6.414E-07
1.9702	5.214E-07	0.8981	5.090E-07	1.1536	5.466E-07	1.6496	6.051E-07	2.2756	5.886E-07	2.9285	5.552E-07
2.0735	4.500E-07	0.9424	4.420E-07	1.2110	4.725E-07	1.7330	5.215E-07	2.3929	5.067E-07	3.0800	4.796E-07
2.1822	3.878E-07	0.9890	3.833E-07	1.2713	4.077E-07	1.8206	4.483E-07	2.5163	4.354E-07	3.2393	4.136E-07
2.2966	3.339E-07	1.0378	3.321E-07	1.3346	3.513E-07	1.9126	3.848E-07	2.6460	3.735E-07	3.4069	3.563E-07
2.4170	2.872E-07	1.0891	2.876E-07	1.4011	3.025E-07	2.0093	3.299E-07	2.7824	3.201E-07	3.5831	3.067E-07
2.5437	2.469E-07	1.1428	2.487E-07	1.4709	2.601E-07	2.1109	2.825E-07	2.9259	2.741E-07	3.7684	2.638E-07
2.6771	2.120E-07	1.1993	2.150E-07	1.5442	2.235E-07	2.2176	2.417E-07	3.0768	2.345E-07	3.9633	2.266E-07
2.8174	1.817E-07	1.2585	1.855E-07	1.6211	1.918E-07	2.3297	2.064E-07	3.2354	2.002E-07	4.1683	1.945E-07
2.9652	1.555E-07	1.3206	1.598E-07	1.7018	1.643E-07	2.4475	1.761E-07	3.4022	1.707E-07	4.3839	1.665E-07
3.1206	1.326E-07	1.3859	1.371E-07	1.7865	1.402E-07	2.5712	1.498E-07	3.5776	1.452E-07	4.6107	1.422E-07
3.2842	1.126E-07	1.4543	1.172E-07	1.8755	1.193E-07	2.7012	1.269E-07	3.7620	1.230E-07	4.8492	1.209E-07
3.4564	9.505E-08	1.5261	9.957E-08	1.9689	1.009E-07	2.8377	1.070E-07	3.9560	1.036E-07	5.1000	1.022E-07
3.6376	7.966E-08	1.6015	8.392E-08	2.0670	8.468E-08	2.9812	8.956E-08	4.1600	8.666E-08	5.3638	8.578E-08
3.8284	6.618E-08	1.6805	7.009E-08	2.1699	7.050E-08	3.1319	7.436E-08	4.3744	7.191E-08	5.6413	7.133E-08
4.0291	5.446E-08	1.7635	5.794E-08	2.2780	5.813E-08	3.2902	6.115E-08	4.6000	5.909E-08	5.9330	5.872E-08
4.2403	4.435E-08	1.8506	4.736E-08	2.3914	4.742E-08	3.4565	4.974E-08	4.8371	4.804E-08	6.2399	4.780E-08
4.4626	3.571E-08	1.9420	3.824E-08	2.5106	3.823E-08	3.6312	3.999E-08	5.0865	3.861E-08	6.5627	3.843E-08
4.6966	2.838E-08	2.0379	3.047E-08	2.6356	3.042E-08	3.8148	3.172E-08	5.3488	3.062E-08	6.9021	3.050E-08
4.9429	2.221E-08	2.1385	2.390E-08	2.7668	2.384E-08	4.0076	2.477E-08	5.6245	2.391E-08	7.2592	2.381E-08
5.2020	1.705E-08	2.2441	1.840E-08	2.9046	1.833E-08	4.2102	1.898E-08	5.9145	1.831E-08	7.6346	1.823E-08
5.4747	1.275E-08	2.3550	1.383E-08	3.0493	1.377E-08	4.4231	1.420E-08	6.2195	1.368E-08	8.0295	1.361E-08
5.7618	9.223E-09	2.4712	1.009E-08	3.2012	1.002E-08	4.6467	1.029E-08	6.5401	9.894E-09	8.4449	9.846E-09
6.0639	6.398E-09	2.5933	7.088E-09	3.3606	7.029E-09	4.8816	7.174E-09	6.8773	6.872E-09	8.8817	6.834E-09

Appendix A

Table A-1f. 10 Hz Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP
0.0524	1.000E-03	0.0278	1.000E-03	0.0352	1.000E-03	0.0485	1.000E-03	0.0670	1.000E-03	0.0901	1.000E-03
0.0567	9.310E-04	0.0297	9.383E-04	0.0378	9.334E-04	0.0524	9.303E-04	0.0729	9.273E-04	0.0984	9.192E-04
0.0597	8.786E-04	0.0313	8.838E-04	0.0398	8.788E-04	0.0551	8.776E-04	0.0767	8.770E-04	0.1036	8.674E-04
0.0629	8.221E-04	0.0329	8.243E-04	0.0419	8.194E-04	0.0580	8.206E-04	0.0807	8.229E-04	0.1090	8.119E-04
0.0663	7.642E-04	0.0346	7.633E-04	0.0441	7.586E-04	0.0611	7.623E-04	0.0850	7.674E-04	0.1147	7.553E-04
0.0699	7.075E-04	0.0365	7.032E-04	0.0464	6.989E-04	0.0643	7.049E-04	0.0894	7.128E-04	0.1207	6.998E-04
0.0737	6.534E-04	0.0384	6.460E-04	0.0488	6.420E-04	0.0677	6.502E-04	0.0941	6.605E-04	0.1270	6.467E-04
0.0776	6.026E-04	0.0404	5.926E-04	0.0514	5.888E-04	0.0713	5.989E-04	0.0991	6.112E-04	0.1337	5.968E-04
0.0818	5.555E-04	0.0425	5.431E-04	0.0540	5.397E-04	0.0751	5.513E-04	0.1043	5.653E-04	0.1407	5.504E-04
0.0862	5.120E-04	0.0447	4.977E-04	0.0569	4.945E-04	0.0790	5.073E-04	0.1098	5.227E-04	0.1480	5.074E-04
0.0909	4.718E-04	0.0471	4.561E-04	0.0599	4.530E-04	0.0832	4.668E-04	0.1155	4.833E-04	0.1558	4.678E-04
0.0957	4.348E-04	0.0496	4.179E-04	0.0630	4.151E-04	0.0876	4.295E-04	0.1216	4.469E-04	0.1639	4.312E-04
0.1009	4.007E-04	0.0522	3.829E-04	0.0663	3.802E-04	0.0922	3.952E-04	0.1280	4.132E-04	0.1725	3.975E-04
0.1063	3.693E-04	0.0549	3.509E-04	0.0698	3.483E-04	0.0971	3.636E-04	0.1347	3.822E-04	0.1815	3.665E-04
0.1121	3.404E-04	0.0578	3.215E-04	0.0734	3.191E-04	0.1022	3.346E-04	0.1418	3.534E-04	0.1910	3.378E-04
0.1181	3.138E-04	0.0608	2.946E-04	0.0773	2.924E-04	0.1076	3.080E-04	0.1493	3.268E-04	0.2010	3.114E-04
0.1245	2.892E-04	0.0640	2.699E-04	0.0813	2.678E-04	0.1133	2.834E-04	0.1571	3.022E-04	0.2115	2.871E-04
0.1312	2.666E-04	0.0673	2.473E-04	0.0856	2.454E-04	0.1192	2.608E-04	0.1654	2.795E-04	0.2226	2.647E-04
0.1382	2.458E-04	0.0709	2.266E-04	0.0901	2.248E-04	0.1255	2.401E-04	0.1740	2.584E-04	0.2343	2.441E-04
0.1457	2.266E-04	0.0746	2.076E-04	0.0948	2.060E-04	0.1322	2.210E-04	0.1832	2.391E-04	0.2465	2.250E-04
0.1535	2.089E-04	0.0785	1.902E-04	0.0997	1.887E-04	0.1391	2.034E-04	0.1928	2.210E-04	0.2594	2.075E-04
0.1618	1.926E-04	0.0826	1.743E-04	0.1050	1.729E-04	0.1465	1.873E-04	0.2030	2.044E-04	0.2730	1.913E-04
0.1705	1.775E-04	0.0869	1.597E-04	0.1105	1.584E-04	0.1542	1.724E-04	0.2136	1.891E-04	0.2873	1.763E-04
0.1797	1.637E-04	0.0915	1.462E-04	0.1162	1.452E-04	0.1623	1.587E-04	0.2248	1.749E-04	0.3023	1.626E-04
0.1893	1.509E-04	0.0963	1.338E-04	0.1223	1.329E-04	0.1709	1.460E-04	0.2367	1.617E-04	0.3181	1.498E-04
0.1995	1.390E-04	0.1014	1.224E-04	0.1287	1.218E-04	0.1799	1.343E-04	0.2491	1.495E-04	0.3348	1.380E-04
0.2103	1.280E-04	0.1067	1.119E-04	0.1355	1.115E-04	0.1894	1.235E-04	0.2622	1.382E-04	0.3523	1.271E-04
0.2216	1.177E-04	0.1123	1.020E-04	0.1426	1.019E-04	0.1994	1.136E-04	0.2759	1.276E-04	0.3707	1.168E-04
0.2335	1.082E-04	0.1181	9.293E-05	0.1501	9.319E-05	0.2099	1.043E-04	0.2904	1.176E-04	0.3901	1.073E-04
0.2461	9.916E-05	0.1243	8.450E-05	0.1579	8.512E-05	0.2210	9.562E-05	0.3057	1.083E-04	0.4105	9.830E-05
0.2594	9.078E-05	0.1309	7.671E-05	0.1662	7.770E-05	0.2327	8.762E-05	0.3218	9.950E-05	0.4320	8.993E-05
0.2733	8.294E-05	0.1377	6.955E-05	0.1749	7.089E-05	0.2449	8.021E-05	0.3387	9.120E-05	0.4546	8.212E-05
0.2881	7.566E-05	0.1449	6.299E-05	0.1841	6.465E-05	0.2579	7.337E-05	0.3565	8.340E-05	0.4784	7.485E-05
0.3036	6.893E-05	0.1525	5.701E-05	0.1937	5.895E-05	0.2715	6.706E-05	0.3752	7.611E-05	0.5035	6.813E-05
0.3199	6.273E-05	0.1605	5.158E-05	0.2039	5.374E-05	0.2858	6.127E-05	0.3949	6.933E-05	0.5298	6.195E-05
0.3372	5.705E-05	0.1690	4.665E-05	0.2145	4.898E-05	0.3009	5.596E-05	0.4157	6.307E-05	0.5575	5.629E-05

Appendix A

Table A-1f. 10 Hz Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP
0.3553	5.187E-05	0.1778	4.220E-05	0.2258	4.465E-05	0.3167	5.111E-05	0.4375	5.732E-05	0.5867	5.112E-05
0.3745	4.714E-05	0.1871	3.816E-05	0.2376	4.071E-05	0.3335	4.667E-05	0.4605	5.207E-05	0.6174	4.642E-05
0.3946	4.285E-05	0.1970	3.451E-05	0.2500	3.711E-05	0.3511	4.262E-05	0.4847	4.729E-05	0.6497	4.215E-05
0.4159	3.894E-05	0.2073	3.122E-05	0.2631	3.383E-05	0.3696	3.892E-05	0.5102	4.294E-05	0.6837	3.827E-05
0.4383	3.540E-05	0.2182	2.823E-05	0.2769	3.084E-05	0.3891	3.554E-05	0.5370	3.899E-05	0.7195	3.474E-05
0.4619	3.218E-05	0.2296	2.553E-05	0.2914	2.811E-05	0.4096	3.245E-05	0.5652	3.540E-05	0.7572	3.155E-05
0.4867	2.924E-05	0.2416	2.310E-05	0.3067	2.563E-05	0.4312	2.963E-05	0.5949	3.214E-05	0.7968	2.864E-05
0.5130	2.658E-05	0.2543	2.089E-05	0.3228	2.336E-05	0.4540	2.706E-05	0.6261	2.918E-05	0.8385	2.600E-05
0.5406	2.416E-05	0.2677	1.889E-05	0.3397	2.130E-05	0.4779	2.472E-05	0.6590	2.649E-05	0.8824	2.361E-05
0.5697	2.196E-05	0.2817	1.709E-05	0.3575	1.941E-05	0.5032	2.257E-05	0.6937	2.406E-05	0.9285	2.143E-05
0.6004	1.995E-05	0.2965	1.545E-05	0.3762	1.769E-05	0.5297	2.061E-05	0.7301	2.184E-05	0.9771	1.946E-05
0.6327	1.813E-05	0.3120	1.397E-05	0.3959	1.612E-05	0.5576	1.882E-05	0.7685	1.983E-05	1.0283	1.765E-05
0.6668	1.647E-05	0.3284	1.261E-05	0.4167	1.468E-05	0.5871	1.717E-05	0.8088	1.800E-05	1.0821	1.602E-05
0.7027	1.496E-05	0.3456	1.138E-05	0.4385	1.336E-05	0.6181	1.567E-05	0.8513	1.633E-05	1.1387	1.452E-05
0.7405	1.356E-05	0.3637	1.026E-05	0.4615	1.213E-05	0.6507	1.428E-05	0.8961	1.481E-05	1.1983	1.315E-05
0.7804	1.228E-05	0.3828	9.236E-06	0.4856	1.100E-05	0.6850	1.301E-05	0.9432	1.341E-05	1.2610	1.188E-05
0.8224	1.109E-05	0.4028	8.305E-06	0.5111	9.952E-06	0.7211	1.182E-05	0.9927	1.212E-05	1.3270	1.071E-05
0.8667	9.981E-06	0.4240	7.458E-06	0.5378	8.977E-06	0.7592	1.070E-05	1.0449	1.093E-05	1.3964	9.628E-06
0.9134	8.955E-06	0.4462	6.691E-06	0.5660	8.075E-06	0.7993	9.658E-06	1.0998	9.821E-06	1.4695	8.627E-06
0.9626	8.006E-06	0.4696	5.998E-06	0.5957	7.244E-06	0.8414	8.684E-06	1.1576	8.798E-06	1.5464	7.705E-06
1.0144	7.134E-06	0.4942	5.374E-06	0.6269	6.485E-06	0.8858	7.778E-06	1.2184	7.854E-06	1.6273	6.861E-06
1.0691	6.338E-06	0.5201	4.813E-06	0.6597	5.795E-06	0.9326	6.942E-06	1.2824	6.988E-06	1.7125	6.095E-06
1.1266	5.619E-06	0.5474	4.310E-06	0.6943	5.173E-06	0.9818	6.178E-06	1.3498	6.201E-06	1.8021	5.405E-06
1.1873	4.975E-06	0.5761	3.859E-06	0.7307	4.615E-06	1.0336	5.485E-06	1.4207	5.490E-06	1.8964	4.787E-06
1.2512	4.400E-06	0.6063	3.454E-06	0.7689	4.114E-06	1.0881	4.863E-06	1.4953	4.854E-06	1.9957	4.236E-06
1.3186	3.890E-06	0.6381	3.092E-06	0.8092	3.668E-06	1.1455	4.307E-06	1.5739	4.288E-06	2.1001	3.747E-06
1.3896	3.438E-06	0.6716	2.768E-06	0.8516	3.269E-06	1.2060	3.813E-06	1.6566	3.786E-06	2.2100	3.314E-06
1.4645	3.038E-06	0.7068	2.478E-06	0.8962	2.914E-06	1.2696	3.374E-06	1.7437	3.342E-06	2.3257	2.930E-06
1.5433	2.684E-06	0.7439	2.218E-06	0.9432	2.596E-06	1.3366	2.986E-06	1.8353	2.949E-06	2.4474	2.591E-06
1.6265	2.371E-06	0.7829	1.984E-06	0.9926	2.313E-06	1.4071	2.642E-06	1.9317	2.602E-06	2.5754	2.290E-06
1.7140	2.094E-06	0.8239	1.774E-06	1.0446	2.061E-06	1.4814	2.337E-06	2.0332	2.296E-06	2.7102	2.024E-06
1.8064	1.849E-06	0.8672	1.585E-06	1.0993	1.835E-06	1.5596	2.067E-06	2.1400	2.025E-06	2.8520	1.788E-06
1.9036	1.631E-06	0.9126	1.415E-06	1.1569	1.633E-06	1.6418	1.827E-06	2.2525	1.785E-06	3.0013	1.578E-06
2.0061	1.437E-06	0.9605	1.259E-06	1.2175	1.450E-06	1.7285	1.613E-06	2.3708	1.572E-06	3.1584	1.391E-06
2.1142	1.264E-06	1.0108	1.118E-06	1.2813	1.286E-06	1.8197	1.423E-06	2.4954	1.381E-06	3.3236	1.223E-06
2.2280	1.109E-06	1.0639	9.876E-07	1.3484	1.137E-06	1.9157	1.252E-06	2.6265	1.211E-06	3.4976	1.072E-06

Appendix A

Table A-1f. 10 Hz Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP
2.3480	9.694E-07	1.1196	8.690E-07	1.4191	1.002E-06	2.0168	1.098E-06	2.7645	1.059E-06	3.6806	9.364E-07
2.4745	8.445E-07	1.1784	7.610E-07	1.4934	8.784E-07	2.1232	9.593E-07	2.9098	9.215E-07	3.8732	8.150E-07
2.6077	7.330E-07	1.2401	6.633E-07	1.5716	7.669E-07	2.2352	8.348E-07	3.0627	7.988E-07	4.0759	7.066E-07
2.7482	6.339E-07	1.3052	5.759E-07	1.6540	6.665E-07	2.3532	7.233E-07	3.2236	6.893E-07	4.2892	6.104E-07
2.8962	5.464E-07	1.3736	4.983E-07	1.7406	5.770E-07	2.4773	6.241E-07	3.3930	5.924E-07	4.5137	5.256E-07
3.0521	4.699E-07	1.4457	4.300E-07	1.8318	4.979E-07	2.6081	5.365E-07	3.5712	5.074E-07	4.7499	4.515E-07
3.2165	4.032E-07	1.5215	3.704E-07	1.9278	4.285E-07	2.7457	4.600E-07	3.7589	4.333E-07	4.9984	3.870E-07
3.3897	3.455E-07	1.6012	3.186E-07	2.0288	3.681E-07	2.8906	3.934E-07	3.9564	3.692E-07	5.2600	3.313E-07
3.5723	2.958E-07	1.6852	2.737E-07	2.1351	3.157E-07	3.0431	3.358E-07	4.1643	3.141E-07	5.5353	2.832E-07
3.7647	2.528E-07	1.7736	2.349E-07	2.2469	2.705E-07	3.2037	2.863E-07	4.3831	2.668E-07	5.8249	2.418E-07
3.9674	2.158E-07	1.8666	2.012E-07	2.3646	2.314E-07	3.3727	2.437E-07	4.6134	2.263E-07	6.1298	2.061E-07
4.1811	1.839E-07	1.9645	1.721E-07	2.4885	1.976E-07	3.5507	2.071E-07	4.8558	1.916E-07	6.4506	1.754E-07
4.4062	1.563E-07	2.0675	1.468E-07	2.6189	1.684E-07	3.7380	1.756E-07	5.1109	1.618E-07	6.7881	1.488E-07
4.6435	1.324E-07	2.1759	1.246E-07	2.7561	1.430E-07	3.9353	1.484E-07	5.3794	1.363E-07	7.1433	1.258E-07
4.8936	1.116E-07	2.2900	1.053E-07	2.9005	1.209E-07	4.1429	1.249E-07	5.6621	1.142E-07	7.5172	1.059E-07
5.1571	9.345E-08	2.4101	8.844E-08	3.0524	1.015E-07	4.3615	1.045E-07	5.9596	9.519E-08	7.9106	8.856E-08
5.4349	7.765E-08	2.5365	7.367E-08	3.2123	8.454E-08	4.5917	8.671E-08	6.2727	7.880E-08	8.3245	7.355E-08
5.7275	6.394E-08	2.6695	6.081E-08	3.3806	6.974E-08	4.8340	7.133E-08	6.6023	6.470E-08	8.7602	6.056E-08
6.0360	5.210E-08	2.8095	4.967E-08	3.5577	5.690E-08	5.0890	5.805E-08	6.9492	5.261E-08	9.2186	4.939E-08
6.3611	4.196E-08	2.9568	4.011E-08	3.7441	4.583E-08	5.3575	4.666E-08	7.3144	4.232E-08	9.7010	3.985E-08
6.7036	3.334E-08	3.1118	3.197E-08	3.9402	3.640E-08	5.6402	3.700E-08	7.6987	3.362E-08	10.2087	3.174E-08
7.0646	2.609E-08	3.2750	2.510E-08	4.1467	2.845E-08	5.9379	2.887E-08	8.1032	2.632E-08	10.7429	2.492E-08
7.4451	2.005E-08	3.4468	1.935E-08	4.3639	2.183E-08	6.2512	2.212E-08	8.5290	2.024E-08	11.3051	1.922E-08
7.8460	1.506E-08	3.6275	1.460E-08	4.5925	1.638E-08	6.5810	1.657E-08	8.9771	1.523E-08	11.8967	1.451E-08
8.2686	1.101E-08	3.8177	1.072E-08	4.8331	1.196E-08	6.9283	1.208E-08	9.4488	1.116E-08	12.5193	1.066E-08
8.7139	7.776E-09	4.0179	7.619E-09	5.0863	8.459E-09	7.2939	8.529E-09	9.9452	7.909E-09	13.1745	7.576E-09
9.1831	5.273E-09	4.2286	5.206E-09	5.3528	5.755E-09	7.6787	5.790E-09	10.4678	5.392E-09	13.8639	5.181E-09
9.6777	3.408E-09	4.4503	3.398E-09	5.6332	3.742E-09	8.0839	3.754E-09	11.0178	3.512E-09	14.5894	3.384E-09

Appendix A

Table A-1g. 25 Hz Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP
0.0471	1.000E-03	0.0234	1.000E-03	0.0299	1.000E-03	0.0421	1.000E-03	0.0609	1.000E-03	0.0917	1.000E-03
0.0589	7.469E-04	0.0270	8.293E-04	0.0355	7.944E-04	0.0520	7.563E-04	0.0787	7.175E-04	0.1225	6.658E-04
0.0623	6.916E-04	0.0285	7.643E-04	0.0375	7.325E-04	0.0549	6.996E-04	0.0831	6.662E-04	0.1291	6.161E-04
0.0658	6.383E-04	0.0301	7.003E-04	0.0396	6.720E-04	0.0580	6.448E-04	0.0877	6.171E-04	0.1361	5.685E-04
0.0696	5.879E-04	0.0319	6.395E-04	0.0418	6.148E-04	0.0613	5.929E-04	0.0926	5.706E-04	0.1435	5.236E-04
0.0736	5.410E-04	0.0337	5.830E-04	0.0442	5.615E-04	0.0647	5.446E-04	0.0977	5.272E-04	0.1512	4.817E-04
0.0778	4.977E-04	0.0356	5.311E-04	0.0467	5.125E-04	0.0684	4.999E-04	0.1032	4.869E-04	0.1594	4.428E-04
0.0822	4.580E-04	0.0376	4.836E-04	0.0493	4.676E-04	0.0722	4.589E-04	0.1089	4.497E-04	0.1680	4.070E-04
0.0869	4.216E-04	0.0397	4.404E-04	0.0521	4.266E-04	0.0763	4.214E-04	0.1150	4.153E-04	0.1771	3.740E-04
0.0919	3.881E-04	0.0420	4.010E-04	0.0551	3.892E-04	0.0806	3.871E-04	0.1214	3.836E-04	0.1867	3.437E-04
0.0971	3.576E-04	0.0444	3.652E-04	0.0582	3.551E-04	0.0851	3.558E-04	0.1281	3.544E-04	0.1968	3.159E-04
0.1027	3.295E-04	0.0469	3.326E-04	0.0615	3.241E-04	0.0899	3.271E-04	0.1352	3.275E-04	0.2075	2.903E-04
0.1085	3.037E-04	0.0496	3.029E-04	0.0649	2.958E-04	0.0950	3.009E-04	0.1428	3.026E-04	0.2187	2.669E-04
0.1147	2.801E-04	0.0524	2.759E-04	0.0686	2.701E-04	0.1004	2.769E-04	0.1507	2.797E-04	0.2306	2.453E-04
0.1213	2.583E-04	0.0554	2.513E-04	0.0725	2.467E-04	0.1060	2.550E-04	0.1591	2.586E-04	0.2430	2.255E-04
0.1282	2.383E-04	0.0586	2.289E-04	0.0766	2.254E-04	0.1120	2.347E-04	0.1679	2.392E-04	0.2562	2.072E-04
0.1355	2.198E-04	0.0619	2.085E-04	0.0809	2.061E-04	0.1183	2.162E-04	0.1773	2.212E-04	0.2701	1.904E-04
0.1433	2.028E-04	0.0654	1.900E-04	0.0855	1.885E-04	0.1250	1.992E-04	0.1872	2.046E-04	0.2847	1.749E-04
0.1514	1.872E-04	0.0691	1.731E-04	0.0903	1.724E-04	0.1320	1.835E-04	0.1976	1.892E-04	0.3001	1.607E-04
0.1601	1.727E-04	0.0731	1.578E-04	0.0954	1.578E-04	0.1395	1.691E-04	0.2086	1.750E-04	0.3163	1.476E-04
0.1692	1.593E-04	0.0772	1.438E-04	0.1008	1.445E-04	0.1473	1.557E-04	0.2202	1.618E-04	0.3335	1.354E-04
0.1789	1.470E-04	0.0816	1.311E-04	0.1065	1.323E-04	0.1556	1.435E-04	0.2324	1.495E-04	0.3515	1.242E-04
0.1891	1.355E-04	0.0862	1.195E-04	0.1125	1.211E-04	0.1644	1.322E-04	0.2453	1.380E-04	0.3705	1.138E-04
0.1999	1.248E-04	0.0912	1.088E-04	0.1189	1.108E-04	0.1737	1.217E-04	0.2590	1.274E-04	0.3906	1.042E-04
0.2113	1.148E-04	0.0963	9.909E-05	0.1256	1.013E-04	0.1835	1.120E-04	0.2734	1.174E-04	0.4117	9.527E-05
0.2234	1.056E-04	0.1018	9.019E-05	0.1327	9.267E-05	0.1938	1.030E-04	0.2886	1.081E-04	0.4340	8.705E-05
0.2361	9.687E-05	0.1076	8.202E-05	0.1402	8.471E-05	0.2047	9.468E-05	0.3047	9.933E-05	0.4575	7.944E-05
0.2496	8.879E-05	0.1137	7.455E-05	0.1481	7.740E-05	0.2163	8.697E-05	0.3216	9.118E-05	0.4823	7.243E-05
0.2639	8.126E-05	0.1202	6.771E-05	0.1565	7.071E-05	0.2285	7.983E-05	0.3395	8.358E-05	0.5084	6.596E-05
0.2789	7.426E-05	0.1271	6.147E-05	0.1653	6.457E-05	0.2414	7.322E-05	0.3584	7.650E-05	0.5359	6.002E-05
0.2948	6.778E-05	0.1343	5.579E-05	0.1747	5.896E-05	0.2550	6.711E-05	0.3783	6.992E-05	0.5649	5.457E-05
0.3117	6.179E-05	0.1419	5.062E-05	0.1846	5.382E-05	0.2694	6.147E-05	0.3994	6.382E-05	0.5955	4.958E-05
0.3295	5.627E-05	0.1500	4.592E-05	0.1950	4.913E-05	0.2845	5.629E-05	0.4216	5.818E-05	0.6278	4.502E-05
0.3483	5.121E-05	0.1585	4.166E-05	0.2060	4.485E-05	0.3006	5.152E-05	0.4451	5.299E-05	0.6617	4.087E-05
0.3682	4.657E-05	0.1676	3.781E-05	0.2176	4.094E-05	0.3175	4.715E-05	0.4698	4.823E-05	0.6976	3.709E-05
0.3892	4.234E-05	0.1771	3.431E-05	0.2299	3.737E-05	0.3354	4.314E-05	0.4959	4.386E-05	0.7353	3.364E-05

Appendix A

Table A-1g. 25 Hz Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP
0.4114	3.848E-05	0.1872	3.114E-05	0.2429	3.411E-05	0.3543	3.947E-05	0.5235	3.988E-05	0.7751	3.052E-05
0.4349	3.497E-05	0.1978	2.827E-05	0.2567	3.114E-05	0.3743	3.611E-05	0.5527	3.624E-05	0.8171	2.767E-05
0.4597	3.177E-05	0.2091	2.566E-05	0.2712	2.842E-05	0.3954	3.304E-05	0.5834	3.293E-05	0.8613	2.509E-05
0.4860	2.886E-05	0.2210	2.330E-05	0.2865	2.594E-05	0.4177	3.022E-05	0.6159	2.992E-05	0.9079	2.275E-05
0.5137	2.621E-05	0.2335	2.115E-05	0.3027	2.368E-05	0.4413	2.765E-05	0.6501	2.717E-05	0.9571	2.061E-05
0.5430	2.381E-05	0.2468	1.919E-05	0.3198	2.161E-05	0.4662	2.529E-05	0.6863	2.467E-05	1.0089	1.867E-05
0.5740	2.162E-05	0.2609	1.742E-05	0.3379	1.972E-05	0.4924	2.313E-05	0.7245	2.240E-05	1.0635	1.690E-05
0.6068	1.962E-05	0.2757	1.580E-05	0.3570	1.798E-05	0.5202	2.115E-05	0.7648	2.033E-05	1.1211	1.530E-05
0.6415	1.780E-05	0.2914	1.432E-05	0.3772	1.639E-05	0.5495	1.933E-05	0.8073	1.843E-05	1.1817	1.382E-05
0.6781	1.613E-05	0.3080	1.297E-05	0.3985	1.493E-05	0.5805	1.766E-05	0.8523	1.671E-05	1.2457	1.248E-05
0.7168	1.461E-05	0.3255	1.174E-05	0.4210	1.358E-05	0.6132	1.611E-05	0.8997	1.513E-05	1.3131	1.125E-05
0.7577	1.322E-05	0.3440	1.062E-05	0.4448	1.235E-05	0.6478	1.469E-05	0.9497	1.367E-05	1.3842	1.014E-05
0.8010	1.193E-05	0.3636	9.584E-06	0.4699	1.120E-05	0.6844	1.338E-05	1.0026	1.235E-05	1.4591	9.109E-06
0.8467	1.076E-05	0.3843	8.644E-06	0.4965	1.014E-05	0.7229	1.216E-05	1.0583	1.112E-05	1.5381	8.176E-06
0.8950	9.676E-06	0.4061	7.786E-06	0.5245	9.168E-06	0.7637	1.102E-05	1.1172	1.000E-05	1.6214	7.326E-06
0.9461	8.687E-06	0.4292	7.005E-06	0.5542	8.270E-06	0.8068	9.974E-06	1.1794	8.972E-06	1.7092	6.553E-06
1.0002	7.781E-06	0.4537	6.295E-06	0.5855	7.444E-06	0.8522	9.001E-06	1.2450	8.029E-06	1.8017	5.852E-06
1.0573	6.953E-06	0.4795	5.650E-06	0.6186	6.686E-06	0.9003	8.101E-06	1.3142	7.167E-06	1.8992	5.218E-06
1.1176	6.199E-06	0.5068	5.067E-06	0.6536	5.994E-06	0.9511	7.271E-06	1.3874	6.382E-06	2.0020	4.647E-06
1.1814	5.516E-06	0.5356	4.540E-06	0.6905	5.364E-06	1.0047	6.508E-06	1.4645	5.670E-06	2.1104	4.134E-06
1.2489	4.899E-06	0.5661	4.066E-06	0.7295	4.793E-06	1.0613	5.810E-06	1.5460	5.026E-06	2.2246	3.673E-06
1.3202	4.344E-06	0.5983	3.639E-06	0.7708	4.277E-06	1.1212	5.174E-06	1.6320	4.446E-06	2.3450	3.260E-06
1.3956	3.847E-06	0.6323	3.256E-06	0.8143	3.812E-06	1.1844	4.598E-06	1.7228	3.927E-06	2.4720	2.892E-06
1.4752	3.402E-06	0.6683	2.911E-06	0.8603	3.394E-06	1.2512	4.078E-06	1.8187	3.462E-06	2.6058	2.563E-06
1.5595	3.006E-06	0.7063	2.602E-06	0.9090	3.020E-06	1.3217	3.612E-06	1.9199	3.049E-06	2.7468	2.269E-06
1.6485	2.653E-06	0.7465	2.324E-06	0.9603	2.686E-06	1.3962	3.195E-06	2.0267	2.683E-06	2.8955	2.007E-06
1.7426	2.340E-06	0.7890	2.075E-06	1.0146	2.386E-06	1.4749	2.822E-06	2.1394	2.357E-06	3.0522	1.773E-06
1.8421	2.061E-06	0.8339	1.851E-06	1.0720	2.118E-06	1.5581	2.490E-06	2.2584	2.069E-06	3.2175	1.564E-06
1.9473	1.814E-06	0.8813	1.648E-06	1.1325	1.878E-06	1.6459	2.195E-06	2.3841	1.813E-06	3.3916	1.378E-06
2.0584	1.595E-06	0.9315	1.466E-06	1.1966	1.663E-06	1.7387	1.932E-06	2.5167	1.587E-06	3.5752	1.211E-06
2.1760	1.400E-06	0.9845	1.301E-06	1.2642	1.471E-06	1.8368	1.699E-06	2.6567	1.388E-06	3.7687	1.062E-06
2.3002	1.226E-06	1.0405	1.153E-06	1.3356	1.298E-06	1.9403	1.490E-06	2.8045	1.211E-06	3.9727	9.296E-07
2.4315	1.071E-06	1.0997	1.018E-06	1.4111	1.143E-06	2.0497	1.305E-06	2.9606	1.053E-06	4.1878	8.113E-07
2.5703	9.333E-07	1.1622	8.960E-07	1.4909	1.003E-06	2.1653	1.141E-06	3.1253	9.145E-07	4.4145	7.059E-07
2.7171	8.111E-07	1.2284	7.863E-07	1.5751	8.781E-07	2.2874	9.936E-07	3.2992	7.920E-07	4.6534	6.124E-07
2.8722	7.028E-07	1.2983	6.877E-07	1.6642	7.662E-07	2.4164	8.630E-07	3.4827	6.839E-07	4.9053	5.297E-07

Appendix A

Table A-1g. 25 Hz Seismic Hazard Curves at Millstone

Mean		5th Fractile		16th Fractile		50th Fractile		84th Fractile		95th Fractile	
PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP	PSA (g)	AEP
3.0362	6.071E-07	1.3721	5.993E-07	1.7582	6.662E-07	2.5526	7.471E-07	3.6765	5.888E-07	5.1709	4.568E-07
3.2095	5.226E-07	1.4502	5.204E-07	1.8576	5.773E-07	2.6965	6.443E-07	3.8810	5.054E-07	5.4508	3.928E-07
3.3928	4.486E-07	1.5327	4.504E-07	1.9626	4.985E-07	2.8486	5.537E-07	4.0969	4.326E-07	5.7458	3.368E-07
3.5865	3.838E-07	1.6199	3.885E-07	2.0735	4.289E-07	3.0092	4.741E-07	4.3248	3.691E-07	6.0568	2.880E-07
3.7912	3.274E-07	1.7121	3.340E-07	2.1907	3.678E-07	3.1788	4.044E-07	4.5654	3.141E-07	6.3847	2.456E-07
4.0077	2.784E-07	1.8095	2.863E-07	2.3145	3.144E-07	3.3581	3.437E-07	4.8194	2.665E-07	6.7303	2.090E-07
4.2365	2.361E-07	1.9125	2.447E-07	2.4453	2.679E-07	3.5474	2.911E-07	5.0876	2.255E-07	7.0946	1.773E-07
4.4783	1.996E-07	2.0213	2.085E-07	2.5835	2.275E-07	3.7474	2.456E-07	5.3706	1.902E-07	7.4787	1.501E-07
4.7340	1.682E-07	2.1363	1.770E-07	2.7295	1.925E-07	3.9587	2.065E-07	5.6694	1.600E-07	7.8835	1.266E-07
5.0043	1.413E-07	2.2578	1.498E-07	2.8838	1.623E-07	4.1819	1.729E-07	5.9848	1.341E-07	8.3102	1.065E-07
5.2900	1.182E-07	2.3863	1.262E-07	3.0468	1.362E-07	4.4177	1.442E-07	6.3178	1.120E-07	8.7601	8.927E-08
5.5920	9.838E-08	2.5221	1.058E-07	3.2190	1.138E-07	4.6668	1.196E-07	6.6692	9.308E-08	9.2343	7.451E-08
5.9113	8.150E-08	2.6656	8.808E-08	3.4009	9.446E-08	4.9299	9.876E-08	7.0403	7.700E-08	9.7341	6.190E-08
6.2488	6.710E-08	2.8172	7.291E-08	3.5931	7.795E-08	5.2078	8.104E-08	7.4319	6.334E-08	10.2610	5.115E-08
6.6055	5.486E-08	2.9775	5.989E-08	3.7962	6.384E-08	5.5015	6.603E-08	7.8454	5.176E-08	10.8165	4.200E-08
6.9826	4.450E-08	3.1470	4.876E-08	4.0107	5.184E-08	5.8116	5.337E-08	8.2819	4.198E-08	11.4020	3.424E-08
7.3813	3.577E-08	3.3260	3.931E-08	4.2374	4.169E-08	6.1393	4.276E-08	8.7426	3.376E-08	12.0192	2.768E-08
7.8027	2.847E-08	3.5152	3.134E-08	4.4769	3.318E-08	6.4855	3.390E-08	9.2290	2.689E-08	12.6698	2.218E-08
8.2482	2.239E-08	3.7153	2.469E-08	4.7299	2.608E-08	6.8511	2.657E-08	9.7425	2.119E-08	13.3556	1.758E-08
8.7191	1.739E-08	3.9266	1.919E-08	4.9972	2.024E-08	7.2374	2.057E-08	10.2845	1.649E-08	14.0785	1.378E-08
9.2169	1.332E-08	4.1501	1.469E-08	5.2796	1.548E-08	7.6455	1.570E-08	10.8567	1.266E-08	14.8406	1.065E-08
9.7431	1.003E-08	4.3862	1.107E-08	5.5780	1.165E-08	8.0765	1.180E-08	11.4607	9.576E-09	15.6439	8.120E-09
10.2993	7.436E-09	4.6358	8.194E-09	5.8933	8.617E-09	8.5319	8.718E-09	12.0983	7.126E-09	16.4908	6.093E-09
10.8873	5.409E-09	4.8995	5.954E-09	6.2264	6.258E-09	9.0130	6.327E-09	12.7713	5.210E-09	17.3834	4.495E-09
11.5089	3.855E-09	5.1783	4.240E-09	6.5783	4.457E-09	9.5211	4.503E-09	13.4819	3.737E-09	18.3244	3.255E-09
12.1660	2.690E-09	5.4729	2.955E-09	6.9501	3.107E-09	10.0579	3.139E-09	14.2319	2.626E-09	19.3163	2.312E-09
12.8606	1.835E-09	5.7843	2.013E-09	7.3429	2.118E-09	10.6250	2.140E-09	15.0237	1.806E-09	20.3619	1.608E-09
13.5948	1.221E-09	6.1134	1.339E-09	7.7579	1.410E-09	11.2241	1.425E-09	15.8595	1.213E-09	21.4641	1.093E-09

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Table A-2a. Computed median and logarithmic standard deviation of the site amplification at frequencies of 0.5, 1.0, 2.5, 5.0, 10, 25, and 100 Hz for the single-corner seismological model

Frequency	0.5 Hz			1.0 Hz			2.5 Hz			5.0 Hz		
Motion Name	Input PSA [g]	Median	Log-SD	Input PSA [g]	Median	Log-SD	Input PSA [g]	Median	Log-SD	Input PSA [g]	Median	Log-SD
G001	7.04E-03	1.26E+00	2.04E-01	1.28E-02	1.19E+00	1.32E-01	2.05E-02	1.17E+00	1.50E-01	2.38E-02	1.10E+00	1.34E-01
G005	1.46E-02	1.26E+00	1.99E-01	3.05E-02	1.18E+00	1.29E-01	6.04E-02	1.16E+00	1.48E-01	8.86E-02	1.09E+00	1.36E-01
G010	2.03E-02	1.25E+00	1.97E-01	4.41E-02	1.18E+00	1.28E-01	9.27E-02	1.16E+00	1.47E-01	1.44E-01	1.09E+00	1.36E-01
G020	3.16E-02	1.25E+00	1.96E-01	7.05E-02	1.18E+00	1.28E-01	1.54E-01	1.16E+00	1.47E-01	2.47E-01	1.09E+00	1.36E-01
G030	4.09E-02	1.25E+00	1.95E-01	9.22E-02	1.18E+00	1.27E-01	2.04E-01	1.16E+00	1.46E-01	3.33E-01	1.09E+00	1.36E-01
G040	5.05E-02	1.25E+00	1.95E-01	1.15E-01	1.17E+00	1.27E-01	2.57E-01	1.16E+00	1.46E-01	4.24E-01	1.09E+00	1.36E-01
G050	5.88E-02	1.25E+00	1.95E-01	1.34E-01	1.17E+00	1.27E-01	3.03E-01	1.16E+00	1.46E-01	5.03E-01	1.09E+00	1.36E-01
G075	8.04E-02	1.25E+00	1.95E-01	1.85E-01	1.17E+00	1.27E-01	4.24E-01	1.16E+00	1.46E-01	7.10E-01	1.08E+00	1.36E-01
G100	1.00E-01	1.25E+00	1.95E-01	2.33E-01	1.17E+00	1.26E-01	5.35E-01	1.16E+00	1.45E-01	9.02E-01	1.08E+00	1.36E-01
G125	1.21E-01	1.25E+00	1.95E-01	2.82E-01	1.17E+00	1.26E-01	6.51E-01	1.16E+00	1.45E-01	1.10E+00	1.08E+00	1.36E-01
G150	1.41E-01	1.25E+00	1.95E-01	3.30E-01	1.17E+00	1.26E-01	7.65E-01	1.15E+00	1.45E-01	1.30E+00	1.08E+00	1.36E-01

Frequency	10 Hz			25 Hz			100 Hz		
Motion Name	Input PSA [g]	Median	Log-SD	Input PSA [g]	Median	Log-SD	Input PSA [g]	Median	Log-SD
G001	2.22E-02	1.02E+00	1.33E-01	1.32E-02	1.01E+00	1.05E-01	1.04E-02	1.08E+00	1.05E-01
G005	1.14E-01	9.92E-01	1.51E-01	1.01E-01	7.94E-01	2.13E-01	5.10E-02	9.31E-01	1.28E-01
G010	2.01E-01	9.86E-01	1.53E-01	2.08E-01	7.62E-01	2.42E-01	1.01E-01	8.50E-01	1.63E-01
G020	3.60E-01	9.83E-01	1.55E-01	4.08E-01	7.47E-01	2.57E-01	2.03E-01	7.85E-01	1.98E-01
G030	4.96E-01	9.82E-01	1.55E-01	5.84E-01	7.42E-01	2.62E-01	2.97E-01	7.53E-01	2.18E-01
G040	6.40E-01	9.81E-01	1.56E-01	7.74E-01	7.38E-01	2.66E-01	4.02E-01	7.31E-01	2.33E-01
G050	7.65E-01	9.80E-01	1.56E-01	9.39E-01	7.36E-01	2.68E-01	4.95E-01	7.16E-01	2.43E-01
G075	1.09E+00	9.79E-01	1.56E-01	1.38E+00	7.33E-01	2.71E-01	7.48E-01	6.92E-01	2.61E-01
G100	1.40E+00	9.78E-01	1.57E-01	1.79E+00	7.32E-01	2.73E-01	9.89E-01	6.78E-01	2.71E-01
G125	1.72E+00	9.78E-01	1.57E-01	2.22E+00	7.30E-01	2.74E-01	1.24E+00	6.68E-01	2.79E-01
G150	2.03E+00	9.78E-01	1.57E-01	2.65E+00	7.30E-01	2.75E-01	1.49E+00	6.61E-01	2.84E-01

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Table A-2b. Computed median and logarithmic standard deviation of the site amplification at frequencies of 0.5, 1.0, 2.5, 5.0, 10, 25, and 100 Hz for the double-corner seismological model

Frequency	0.5 Hz			1.0 Hz			2.5 Hz			5.0 Hz		
Motion Name	Input PSA [g]	Median	Log-SD	Input PSA [g]	Median	Log-SD	Input PSA [g]	Median	Log-SD	Input PSA [g]	Median	Log-SD
G001	2.26E-03	1.26E+00	2.05E-01	6.72E-03	1.18E+00	1.31E-01	2.00E-02	1.16E+00	1.51E-01	2.74E-02	1.09E+00	1.36E-01
G005	4.56E-03	1.26E+00	2.01E-01	1.53E-02	1.17E+00	1.29E-01	5.64E-02	1.16E+00	1.49E-01	9.82E-02	1.09E+00	1.37E-01
G010	6.16E-03	1.25E+00	1.99E-01	2.15E-02	1.17E+00	1.28E-01	8.45E-02	1.15E+00	1.48E-01	1.57E-01	1.08E+00	1.37E-01
G020	9.00E-03	1.25E+00	1.97E-01	3.22E-02	1.17E+00	1.27E-01	1.32E-01	1.15E+00	1.48E-01	2.56E-01	1.08E+00	1.37E-01
G030	1.17E-02	1.25E+00	1.97E-01	4.22E-02	1.16E+00	1.27E-01	1.76E-01	1.15E+00	1.47E-01	3.47E-01	1.08E+00	1.37E-01
G040	1.42E-02	1.25E+00	1.96E-01	5.17E-02	1.16E+00	1.27E-01	2.18E-01	1.15E+00	1.47E-01	4.35E-01	1.08E+00	1.37E-01
G050	1.64E-02	1.25E+00	1.96E-01	6.03E-02	1.16E+00	1.26E-01	2.56E-01	1.15E+00	1.47E-01	5.14E-01	1.08E+00	1.37E-01
G075	2.20E-02	1.25E+00	1.95E-01	8.15E-02	1.16E+00	1.26E-01	3.50E-01	1.15E+00	1.47E-01	7.12E-01	1.08E+00	1.37E-01
G100	2.74E-02	1.25E+00	1.94E-01	1.02E-01	1.16E+00	1.26E-01	4.41E-01	1.15E+00	1.46E-01	9.04E-01	1.08E+00	1.37E-01
G125	3.26E-02	1.24E+00	1.94E-01	1.22E-01	1.16E+00	1.26E-01	5.29E-01	1.15E+00	1.46E-01	1.09E+00	1.08E+00	1.37E-01
G150	3.81E-02	1.24E+00	1.94E-01	1.42E-01	1.16E+00	1.26E-01	6.22E-01	1.15E+00	1.46E-01	1.28E+00	1.08E+00	1.37E-01
Frequency	10 Hz			25 Hz			100 Hz					
Motion Name	Input PSA [g]	Median	Log-SD	Input PSA [g]	Median	Log-SD	Input PSA [g]	Median	Log-SD			
G001	2.54E-02	1.01E+00	1.43E-01	1.34E-02	9.86E-01	1.17E-01	1.05E-02	1.05E+00	1.12E-01			
G005	1.28E-01	9.86E-01	1.55E-01	1.04E-01	7.93E-01	2.18E-01	5.19E-02	9.31E-01	1.38E-01			
G010	2.26E-01	9.81E-01	1.58E-01	2.21E-01	7.58E-01	2.49E-01	1.03E-01	8.57E-01	1.69E-01			
G020	3.89E-01	9.77E-01	1.59E-01	4.27E-01	7.42E-01	2.65E-01	2.01E-01	7.91E-01	2.04E-01			
G030	5.40E-01	9.76E-01	1.60E-01	6.22E-01	7.36E-01	2.70E-01	3.00E-01	7.57E-01	2.24E-01			
G040	6.87E-01	9.75E-01	1.60E-01	8.15E-01	7.32E-01	2.74E-01	4.02E-01	7.33E-01	2.39E-01			
G050	8.20E-01	9.74E-01	1.60E-01	9.93E-01	7.30E-01	2.76E-01	4.97E-01	7.17E-01	2.50E-01			
G075	1.15E+00	9.73E-01	1.61E-01	1.44E+00	7.27E-01	2.80E-01	7.46E-01	6.90E-01	2.69E-01			
G100	1.48E+00	9.72E-01	1.61E-01	1.88E+00	7.25E-01	2.82E-01	9.96E-01	6.73E-01	2.82E-01			
G125	1.79E+00	9.72E-01	1.61E-01	2.31E+00	7.24E-01	2.83E-01	1.24E+00	6.62E-01	2.90E-01			
G150	2.12E+00	9.72E-01	1.61E-01	2.77E+00	7.23E-01	2.84E-01	1.50E+00	6.53E-01	2.97E-01			

Appendix B

Millstone Power Station Unit 2

IPEEE Adequacy Evaluation and IHS Development

Appendix B

Executive Summary

The 10 CFR 50.54(f) letter of March 2012 (Reference B7.10) requested all nuclear power plant licensees to conduct seismic hazard reevaluations using updated seismic hazard information and present-day methods for NRC Fukushima Near-Term Task Force (NTTF) recommendation 2.1. Millstone Power Station Unit 2 (MPS2) has developed the seismic hazard data (hazard curves and ground motion response spectrum or GMRS) using the guidance from the Electric Power Research Institute (EPRI) Report 1025287, *Seismic Evaluation Guidance: Screening, Prioritization, and Implementation Details (SPID) for Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic*) (Reference B7.9). MPS2 is performing a screening evaluation per the SPID guidance to determine whether risk based evaluations need to be performed. One method of screening out a plant from risk assessments is to show that the Individual Plant Examination of External Events (IPEEE) High Confidence of a Low Probability of Failure (HCLPF) spectrum, or IHS, envelops the GMRS in the 1 to 10 Hz range, provided the IPEEE is of sufficient quality. This appendix provides a comparison of the IHS and the GMRS and documents the IPEEE adequacy review performed for MPS2 following the guidance provided in Section 3.3.1 of the SPID.

MPS2 was a focused scope plant for the IPEEE, binned to 0.3g PGA (Reference B7.5). An EPRI seismic margin assessment (SMA) was performed in accordance with the EPRI NP-6041-SL Rev. 1, (Reference B7.4) methodology using the NUREG/CR-0098 (Reference B7.14) median rock spectrum per NUREG-1407 (Reference B7.5). The MPS2 IPEEE Summary Report (Reference B7.1) was provided to the NRC in December 1995. The NRC published a Staff Evaluation Report (SER) of the IPEEE Summary Report (Reference B7.2).

The IPEEE was performed using the NUREG/CR-0098 rock spectral shape and the plant capacity was determined to be 0.25g. The IHS has the same shape anchored to 0.25g. The IHS completely envelops the MPS2 GMRS in the 1 to 10 Hz range. The GMRS exceeds the IHS in the greater than 10 Hz frequency range.

To determine IPEEE adequacy, the SPID defines four categories - General Considerations, Prerequisites, Adequacy Demonstration, and Documentation - to be addressed in order to use the IHS for seismic hazard screening. The General Considerations require that focused scope submittals are enhanced to be in line with full scope assessments per NUREG-1407, which entails completion of a full evaluation of soil failures and review of relay chatter. A soil failures evaluation was performed and concludes that liquefaction, slope stability, and settlement are not a concern for MPS2. The full scope detailed review of relay chatter will be completed on the schedule identified in the NEI letter to NRC dated October 3, 2013 (Reference B7.11). The Prerequisites and the Adequacy Demonstration criteria were reviewed and were found to be met. Therefore, the MPS2 IPEEE results were determined to be adequate for screening and the risk insights from the IPEEE are still valid under the current plant configuration.

The NRC issued an SER, and forwarded a Technical Evaluation Report (TER) performed by Brookhaven National Laboratory, on the MPS2 IPEEE Summary Report. The SER and TER were positive and stated that the licensee's IPEEE process is capable of identifying potential

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vulnerabilities. No deficiencies in the IPEEE process conducted by MPS2 were identified in the SER or the TER.

Based on the comparison of IHS and GMRS in the 1 to 10 Hz range, and the results of the IPEEE adequacy review, MPS2 screens out from performance of a seismic risk assessment in accordance with the guidance in EPRI Report 1025287 (SPID).

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B1.0 INTRODUCTION

Following the accident at the Fukushima Daiichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the NRC Commission established a Near-Term Task Force (NTTF). The NTTF was tasked with conducting a systematic review of NRC processes and regulations 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 (Reference B7.16). Subsequently, the NRC issued a 10 CFR 50.54(f) letter requesting information to assure these recommendations would be addressed by all U.S. nuclear power plants (Reference B7.10). The 50.54(f) letter requests that operating nuclear plants reevaluate the seismic hazards at their sites using updated seismic hazard information and present-day regulatory guidance and methodologies. Depending on the outcome of the comparison between the reevaluated seismic hazard and the current design basis, performance of a seismic risk assessment may be necessary.

The guidance for developing the updated seismic hazard, performing the seismic hazard screening, and performing the subsequent seismic risk assessment work is provided in Electric Power Research Institute (EPRI) Report 1025287, *Seismic Evaluation Guidance: Screening, Prioritization, and Implementation Details (SPID) for Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic* (Reference B7.9). A ground motion response spectrum (GMRS) using up to date source characterization, updated ground motion model and site properties is developed for each site. The GMRS is compared to the site Individual Plant Examination of External Events (IPEEE) High Confidence of a Low Probability of Failure (HCLPF) spectrum (IHS) for screening in accordance with the SPID guidance. If the IHS exceeds the GMRS in the 1 to 10 Hz range and the IPEEE is demonstrated to be of adequate quality, per Section 3.3.1 of the SPID, a risk evaluation is not required.

The purpose of this appendix is to provide the IHS for comparison to the GMRS and the results of the IPEEE adequacy review for Millstone Power Station Unit 2 (MPS2).

The IPEEE adequacy review was conducted by Dominion, Sargent & Lundy, LLC (S&L), and Dr. R. P. Kennedy of RPK Structural Mechanics Consulting. A comprehensive summary of the reviews performed, and the results of the reviews, are provided in this appendix, including the summary report from Dr. R. P. Kennedy (Attachment B-1).

B2.0 Development of IHS and Comparison to GMRS

The MPS GMRS is provided in Section 2.4 and the MPS2 IHS is provided in Section 3.3.1 of this report.

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MPS2 performed the IPEEE using the EPRI - SMA methodology. The IHS has the same shape as the median-centered shape of NUREG/CR-0098 spectrum (rock founded structures) because this spectrum was used as the Review Level Earthquake (RLE) anchored at 0.3g for the MPS2 IPEEE SMA evaluations. The IHS is anchored at 0.25g peak ground acceleration, which is the lowest HCLPF capacity of any structure, system or component (SSC) determined during IPEEE. This 0.25g value was reported in the MPS2 IPEEE Summary Report (Reference B7.1) and is also stated in NUREG-1742 (Reference B7.26).

A comparison of the IHS and GMRS at 5% spectral damping is shown in Figure B2.0-1 below.

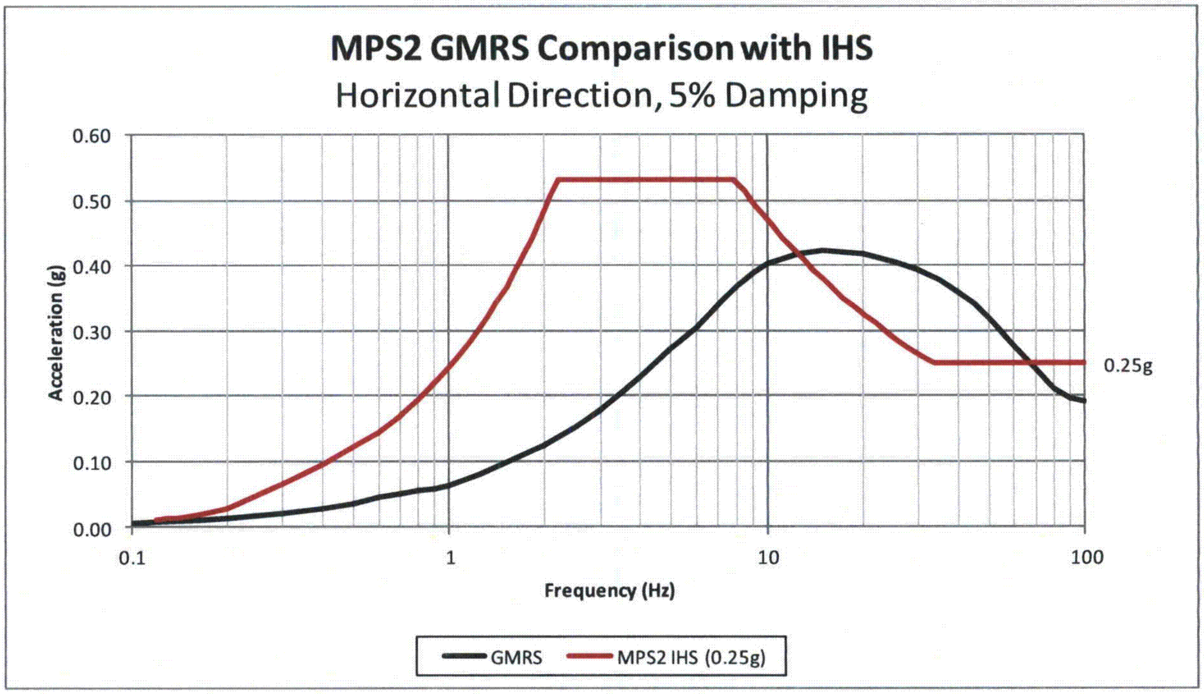

Figure B2.0-1 - MPS2 IHS Compared to GMRS

Based on the comparison shown above, the IHS exceeds the GMRS in the 1 to 10 Hz range. Therefore, an IPEEE adequacy review is performed, as discussed in the following sections, to support screening out of a risk evaluation for MPS2.

B3.0 GENERAL CONSIDERATIONS

MPS2 is a focused scope plant binned to 0.3g peak ground acceleration (PGA) NUREG/CR-0098 median rock spectrum per NUREG-1407 (Reference B7.5). The RLE is defined as the NUREG/CR-0098 median spectral shape for rock, anchored to 0.3g PGA.

The IPEEE seismic assessment was performed using an SMA per the EPRI NP-

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6041-SL (Reference B7.4) methodology. The IPEEE Summary Report for MPS2 was submitted to NRC on December 29, 1995. The NRC staff contracted with Brookhaven National Laboratory to conduct a screening review of the seismic portions of the MPS2 IPEEE summary report. The NRC staff sent a request for additional information (RAI) to MPS2 on February 24, 1998. Responses to the RAI were provided on May 1 (Reference B7.23), June 30 (Reference B7.24), and December 31, 1998 (Reference B7.6). Subsequent to receiving the initial RAI responses, the NRC staff concluded that additional information was needed to complete its review, and a second RAI was sent on June 15, 1999. A response to the second RAI was provided on September 29, 1999 (Reference B7.25).

The NRC issued a SER on MPS2's IPEEE summary report on January 12, 2001 (Reference B7.2). The SER also forwarded a TER performed on the seismic portion of the IPEEE by Brookhaven National Laboratory. The SER and the TER were reviewed. Excerpts from the TER are: "...the success paths are consistent with the requirements of NUREG 1407", "The walkdown approach appears reasonable", "Nonseismic failure is not an issue because of the availability of multiple success paths..." and "...the analysis for seismic induced fires/floods appears to be reasonable." The overall conclusions of the TER are: "The MP2 IPEEE submittal supplemented by the licensee's RAI responses with respect to the overall process, methods, and organization of the IPEEE are consistent with NUREG-1407" and "...the Licensee has satisfied the objectives outlined in the Generic Letter with respect to the IPEEE." Similarly, the SER's conclusions are: "..the staff concludes that the IPEEE results are reasonable given the design, operation and history" and "...the licensee's IPEEE process is capable of identifying the most likely severe accident vulnerabilities and therefore, the MP2 IPEEE has met the intent of Supplement 4 to Generic Letter 88-20."

The NRC January 12, 2001 letter that transmitted the SER and TER states that "...the licensee's process is capable of identifying potential vulnerabilities..." and "...the staff considers these issues resolved for MP2."

Therefore, NRC review of the IPEEE summary report was positive and no deficiencies in the IPEEE process conducted by MPS2 were identified.

The following sections summarize the results of the IPEEE adequacy evaluation according to the guidance of the SPID.

B3.1 RELAY CHATTER

The MPS2 relay evaluation for IPEEE was consistent with the requirements of a focused-scope evaluation, as described in NUREG-1407. 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 (Reference B7.11), the relay chatter review will be completed on the same schedule as the High Frequency Confirmation.

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B3.2 SOIL FAILURE EVALUATION

As stated in Section 3.3.1 of the SPID, any focused-scope plant intending to utilize an IPEEE submittal for screening purposes must bring the evaluation of soil failures in line with a full-scope assessment.

Per Table 3.1 of NUREG-1407, MPS2 is binned for 0.3g Focused Scope. Per Section 3.2.4.3 of NUREG-1407, a full-scope evaluation must consider soil liquefaction, foundation settlement, and slope instability (failure). These soil failure modes have been evaluated for a 0.3g full-scope scope RLE.

Per Section 3.2.2.2 of the IPEEE summary report (Reference B7.1), safety related systems and equipment are housed in the following structures. Hence these buildings are evaluated for soil failure issues.

- Containment
- Enclosure Building
- Auxiliary Building
- Warehouse
- Turbine Building
- Intake Structure

Per Section 7 of EPRI NP-6041, the soil failure evaluation of the above listed buildings has been performed using the following steps:

- Collection and review of pertinent documents: The documents containing static and seismic geotechnical data available in Sections 2.4, 2.5, and 2.7 of MPS2 FSAR (Reference B7.8) and available calculations/documents related to the soil failures have been collected, reviewed and used in performing the soil failures evaluation.
- Identifying the soil-related issues affecting the success path: Soil liquefaction, foundation settlements and slope instability affecting the buildings identified in Section 3.2.2.2 of the IPEEE summary report were evaluated.
- Screening of selected soil-related issues through a review: Soil-related issues (soil liquefaction, foundation settlement, and slope failure) were screened to eliminate the issues that do not require further detail evaluation.
- In case any soil related issue could not be screened out, calculations would be performed to evaluate the particular issue. (None were required).

Foundation Supporting Materials

Section 2.7.5.1 of the MPS2 FSAR describes the foundation supporting materials for the above listed structures. The Containment, Enclosure Building, Auxiliary Building, Turbine Building and Intake Structure are supported on unweathered rock. The Warehouse area of the Auxiliary Building Mat is supported on controlled select

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compacted fill. The compacted fill material was a select, processed, free draining, offsite borrow material. The fill material is a well graded fine to coarse sand with some gravel. All compacted fill supporting foundation slabs were compacted to at least 95% Standard Proctor which is approximately equal to 80% relative density.

Evaluation for Soil Liquefaction

The Containment and Enclosure Building mat, the Auxiliary Building mat (west of column line M-7), the Turbine Building, and the Intake Structure are supported on unweathered rock (Section 2.7.5.1 of MPS2 FSAR). The unweathered rock cannot liquefy by nature. Hence, these foundations are not susceptible to liquefaction effects during the RLE.

The Warehouse mat (area of Auxiliary Building Mat east of column line M-7) is supported on controlled select compacted fill. The fill has been evaluated for grain size distribution, uniformity, maximum grain size, and compaction percentage. The evaluation of these characteristics concluded that the controlled select compacted fill under the Warehouse is not liquefiable during the RLE.

Foundation Settlement

Section 2.7.5 of MPS2 FSAR discusses the foundations type, foundation supporting materials and foundation static contact pressures for settlement evaluation which represents conservative estimate of long term static loads, for MPS2 major structures. The Containment, Enclosure Building, Auxiliary Building, Turbine Building and Intake Structure are supported on unweathered rock (Section 2.7.5.2 of MPS2 FSAR) and are not subject to settlement.

The Warehouse portion of the Auxiliary Building (east of column line M-7) is supported on controlled select compacted fill over unweathered rock. Settlement analyses, based on the plate load triaxial test data, showed ultimate settlement would be less than one-half inch (Section 2.7.5.2 of MPS2 FSAR). Settlement joints between the warehouse portion and remainder of the auxiliary building were provided to accommodate this settlement. Based on the suggested allowable settlements used in Industry for safety class structures (Table 7.4 of Reference B7.21), the ultimate settlement of less than one-half inch is small and will have no adverse effects on safety systems.

Slope Instability

A review of the topography in the plant area shows that the MPS2 site is generally flat in the major plant area and there is no manmade slope or embankment in the plant area. Therefore, a slope instability review is not required for MPS2.

Appendix B

B4.0 PREREQUISITES

SPID Section 3.3.1 provides prerequisites that must be addressed in order to use the IPEEE analysis for screening purposes.

1. Confirmation that commitments made under the IPEEE have been met.

2. Confirmation that all of the modifications and other changes credited in the IPEEE analysis are in place.

3. Confirmation that any identified deficiencies or weaknesses to NUREG-1407 in the MPS2 IPEEE NRC SER are properly justified to ensure that the IPEEE conclusions remain valid.

4. Confirmation that major plant modifications since the completion of the IPEEE have not degraded/impacted the conclusion reached in the IPEEE.

Results of Prerequisites Review

Item 1

The results of the IPEEE program for MPS2 are provided in the MPS2 IPEEE summary report. Section 7.0 of the IPEEE Summary Report discusses outliers that were identified during performance of the IPEEE that required further investigation and resolution. Discussion of these items is provided in "Item 2" below.

Item 2

Table 7.1-1, Opportunities for Safety Enhancements, of the MPS2 IPEEE summary report provides the list of equipment outliers identified during walkdown evaluations for IPEEE review. There are 13 items specified as seismic outliers in this table. Three of these items are stated as "issue resolved" at the same table. An updated status of the remaining ten items was provided in a letter dated December 31, 1998 (Reference B7.6). Table 6-1 of Attachment 1 of the NTTF 2.3 Seismic Walkdown Summary Report (Reference B7.3) provides the current status of the seismic-related items as closed, indicating that the items specified in the IPEEE summary report are either determined to have adequate seismic capacity, are no longer in service, or have been modified to meet the IPEEE requirements. Additional closure details were provided in a letter to the NRC dated August 13, 2004 (Reference B7.7) (see Dominion Response to RAI 4).

Item 3

The NRC SER was provided in Reference B7.2 and does not identify any deficiencies in the MPS2 IPEEE report. Page 2 of the NRC SER letter states "On the basis of the IPEEE review, the staff concludes that the licensee's IPEEE process is capable of identifying the most likely severe accidents and severe accident vulnerabilities, and therefore, that the licensee has met the intent of Supplement 4 to GL 88-20 for MPS2."

Item 4

A review of major modifications that could affect IPEEE results was performed by reviewing plant SSCs for which a HCLPF capacity was calculated. These SSCs are included in Table 3.2-3 of the IPEEE Summary Report. A detailed review of modifications affecting these SSCs, since the IPEEE Summary Report submittal, was performed and the results are provided in Table B4.0-1.

Table B4.0-1 - Summary of Identified Modifications

Component / Structure	Description of Modification / Disposition
RSST Feeder Breaker 22S3-2-2	Modification removed breaker 22S3-2-2. The entire bus has been retired and new electrical feeds for Unit 3 are installed as Unit 3 assets. This component is no longer a consideration for impact to the IPEEE conclusions.
125VDC Distribution Panel D12	Modification mechanically connected panels VR11 and VR21 to adjacent panels D11&D12 and D21&D22, respectively to prevent seismic interaction, as a result of IPEEE findings. This modification has no adverse affect on the IPEEE conclusions.
Battery 201A, 201B	Modification addressed gaps at the anchor bolt locations by providing additional supports on the north battery racks as a result of IPEEE findings. The south battery racks were deemed acceptable by analysis. While this modification was performed to improve the HCLPF of the component, documentation of a revised HCLPF value for the racks was not located. There was no adverse effect on the IPEEE conclusions, as described in Section B5.6.
Emergency Diesel Generator	Modification installed Helicoil inserts to address worn bolt holes in the "A" Emergency Diesel H7A jacket water cooling jumper. Table 3.2-3 of Reference B7.1 identifies the controlling capacity of the EDGs to be expansion anchor shear. This modification has no adverse effect on the expansion anchor configuration, and therefore does not reduce the calculated HCLPF or affect the IPEEE conclusions.
Refueling Water Storage Tank	Clarification of safety function only. No modification is performed by this design change that would adversely affect the calculated HCLPF of the RWST. Therefore, the IPEEE is not affected.
Regulating Transformers UAC1 and UAC2	Modification replaced UAC1 and UAC2 with Uninterruptible Power Sources (UPSs) as back-up power for their respective 120V regulated instrument buses VR11 and VR21. Since the UPS (and formerly UAC1) only provide a back-up power source to the non-safety related regulated instrument bus, they are not required for IPEEE safe shutdown success path. Therefore, this modification does not affect the IPEEE conclusions.

The review summarized above gives reasonable assurance that plant modifications have not adversely affected the conclusions of the IPEEE.

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Prerequisites Review Conclusion

Based on the material presented above, the four IPEEE adequacy prerequisites from SPID Section 3.3.1 are considered to be met for MPS2.

B5.0 ADEQUACY DEMONSTRATION

B5.1 STRUCTURAL MODELS AND STRUCTURAL RESPONSE ANALYSIS

Methodology Used

As described in Section 3.2.2.2 of the IPEEE summary report, safety related systems and equipment are housed in the following structures and each was analyzed for IPEEE:

- Containment (Internal Structure)
- Enclosure Building
- Auxiliary Building
- Warehouse
- Intake Structure
- Turbine Building

Per Section 3.2.2.3 of IPEEE summary report, and Section 5.8.2.1 of the MPS2 FSAR, the above structures are founded on rock with the exception of the Warehouse, which is founded on compacted structural fill.

The structural response analysis for IPEEE used the existing models for the structures listed above with the exception of the Auxiliary Building and the Turbine Building, for which new models were developed for the IPEEE analyses. The Auxiliary Building is modeled using finite element methods. The other structural models used the lumped-mass stick model method with either single or multiple sticks. The following provides a brief description of the structural models:

- Two-dimensional models are used for the Containment Internal structure, Intake Structure, and Warehouse Building. The Warehouse Building model has a translational and a rotational spring attached to the building foundation to account for structural fill foundation. The other models are fixed-base (i.e. no foundation springs).
- A three-dimensional finite element model is used for the Auxiliary Building
- The Turbine Building analysis used a three-dimensional model with the displacement of the nodes in the vertical direction and the rotation of the nodes about one horizontal axis fixed.

The seismic structural models used 7% structural damping for response analysis. The peak horizontal ground acceleration input for the RLE was 0.3g and the input

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spectrum was NUREG/CR-0098 (Reference B7.14) median rock spectra shape, consistent with NUREG-1407.

The structural models and response analyses need to comply with the criteria and engineering practices at the time of the IPEEE, i.e., EPRI NP-6041-SL Rev.1. However, for the adequacy review, each of the structural models and response analyses were also evaluated against the seven criteria in the EPRI SPID Section 6.3.1. The seven criteria and corresponding assessments are summarized below.

Criterion 1

The structural models should be capable of capturing the overall structural responses for both horizontal and vertical components of ground motion.

Assessment for Criterion 1

Separate models were used for the various buildings. For buildings founded on rock, fixed-base structural seismic models are used. For the Warehouse, the structural seismic model includes translational and rotational springs attached to the building foundation to account for structural fill foundation. Per Table 2.3.2-1 of the report, the base case shear wave velocity of rock for MPS2 is 6500 ft/sec. Per SPID Section 6.3.3, it is appropriate to model a Rock-Founded structure as fixed base if the best estimate of shear wave velocity of the foundation is greater than about 5000 ft/sec. This is also consistent with the requirement of EPRI NP-6041, which only recommends that the effect of soil-structure interaction (SSI) be taken into account for major structures at all sites with a median soil stiffness at the slab foundation base slab interface corresponding to a shear wave velocity of 3500 ft/sec or lower. Therefore, use of rock ground input spectrum for the models is reasonable.

In the analyses for in-structure response spectra (ISRS), the reinforced section properties are uncracked section properties. Discussion on pages 4-19 and 4-20 of EPRI NP-6041 indicates that at seismic levels higher than design basis, the effect of using cracked sections properties needs to be addressed.

The actual concrete compressive strengths (without considering the aging effect) are generally significantly higher than the specified concrete compressive strengths. Furthermore, referring to Section 3.2.3.3 of the IPEEE Summary Report, a review of the design basis calculations found that the design of shear walls not only met the requirements of ACI 318-63, but was substantially more conservative. Therefore, considering that the actual concrete strength is substantially more than the specified concrete strength and that the shear walls in general have capacities substantially in excess of that required for design basis SSE, it is judged that the cracking of the concrete shear walls for RLE will not be wide spread and consideration of 10 to 15% frequency variation to obtain the maximum response from the response spectra as was done for the evaluation of equipment and components at MPS2 will adequately account for cracked concrete effects.

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Based on the above discussions, the existing models using uncracked section properties are found to be reasonable and consistent with EPRI NP-6041 guidelines.

Criterion 2

If there is significant coupling between the horizontal and the vertical responses, one combined structural model should be used for analyzing all three directions of the earthquake.

Assessment of Criterion 2

Significant coupling between horizontal and vertical responses does not occur for rock founded buildings because of the rigidity of vertical and horizontal elements reported in Section 5.8.3.2.2 of the MPS2 FSAR. For the Warehouse Building, the rotational mode frequency far exceeds the dominant horizontal mode frequency; therefore, no significant coupling of horizontal and vertical responses is expected.

Criterion 3

Structural mass (total structural, major components, and appropriate portion of live load) should be lumped so that the total mass, as well as the center of gravity, is preserved. Rotational inertia should be included if it affects response in the frequency range of interest

Assessment of Criterion 3

Lumped mass models appropriately include the masses at the level of floors, because that is where significant mass concentration occurs. Rotational inertia about any of the two horizontal axes is not expected to be significant because of rigidity of vertical elements. Therefore, not considering these inertias about horizontal axes is reasonable. However, when centers of mass and rigidity are not the same, effect of rotational inertia about vertical axis should be considered.

The Auxiliary Building is the building where a three-dimensional model is used and rotational inertia about vertical axis is included. Refer to the assessment of Criterion 5 below for demonstration of the insignificance of torsional coupling in this building, where the most eccentricity between the centers of mass and stiffness occurs. In other buildings, far less separation of centers of mass and rigidity occurs, justifying not using rotational inertia about vertical axis in these buildings.

Criterion 4

The number of nodal or dynamic degrees of freedom should be sufficient to represent significant structural modes. All modes up to structural natural frequencies of about 20 Hz in all directions should be included (vertical floor slab flexibility will generally not be considered because it is expected to have frequencies above 15 Hz, but this should be verified by the structural engineer). This will ensure that the *seismic responses and in-structure response spectra (ISRS) developed in the 1 to 10 Hz frequency range are reasonably accurate*

Assessment of Criterion 4

Based on considering the mass concentration at all floor levels in the models, appropriate translational degrees of freedom are included. As pointed out in assessment of Criterion 3 above, not considering rotational inertias about horizontal axes at floor levels is reasonable because of rigidity of vertical elements. In the critical case of the Auxiliary Building, where separation of centers of mass and rigidity and rotational inertia was modeled, an insignificant effect of coupling was noted. (See assessment of Criterion 5 below). Therefore, models account for significant degrees of freedom.

Also, extracted modal frequencies for reinforced concrete structures well cover the range from 1 to 20 Hz, except for the Turbine building, where frequencies are from 1.1 to 13.3 HZ because of steel frame structure. Therefore, the number of degrees of freedom is reasonably considered.

Criterion 5

Torsional effects resulting from eccentricities between the center of mass and the center of rigidity should be included. The center of mass and the center of rigidity may not be coincident at all levels, and the torsional rigidity should be computed

Assessment of Criterion 5

In order to evaluate the torsional effects due to eccentricities between the centers of mass and rigidity, a study was made on the Auxiliary Building which has the most eccentricity between the centers of mass and rigidity, as noted in the assessment of Criterion 3 above. For this reason, a three-dimensional model was constructed and used for this building in both USI A-46 and IPEEE programs. USI A-46 evaluations used SSE spectra, and IPEEE used applicable IPEEE spectra at the building foundation level at rock. Under the USI A-46 program, for one floor (floor at elevation 38'-6"), ISRS were generated at mass center and at the four corners of this floor for separate inputs in North-South and East-West directions. The comparison of spectral peaks for mass center and floor corner spectra shows 11% or less difference.

Based on the above worst case comparison, it is concluded that the torsional coupling effect is not significant enough to be included in the ISRS generation.

Criterion 6

The analyst should assess whether or not one-stick model sufficiently represents the structure. For example, two-stick models could be more appropriate for the analysis of internal and external structures of the containment founded on a common mat

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Assessment of Criterion 6

Separate models were used for various buildings. Single stick models were reviewed and found to be reasonable.

Criterion 7

The structural analyst should review whether in-plane floor flexibility (and subsequent amplified seismic response) has been captured appropriately for the purposes of developing accurate seismic response up to the 15 Hz frequency. Experience has shown that, for nuclear structures with floor diaphragms that have length to width ratios greater than about 1.5, the in-plane diaphragm flexibility may need to be included in the LMSM. The use of this 1.5 aspect ratio should be reviewed by the structural engineer since some structures are affected by the in-plane diaphragm flexibility by aspect ratios lower than the 1.5. As with all these recommendations, alternate approaches can be used when justified.

Assessment of Criterion 7

The in-plane floor flexibility of the floor panels has not been included in any of the building seismic models used for ISRS generation.

In order to study the effect of in-plane diaphragm flexibility on the structural response, the most extreme panel aspect ratio, which corresponds to a panel in the Auxiliary Building with a length to width ratio of about 3.5, was considered. The simple beam frequency of this panel, deforming in its own plane, is about 14.5 Hz. Considering other boundary conditions for this panel, will clearly yield frequency higher than 14.5 Hz for this panel.

Examination of ISRS generated for the above Auxiliary Building at its various floors, shows ISRS peak in the frequency range from 7 Hz to 8Hz, resulting from the lateral flexibility of the structure.

Comparing the above ISRS peak frequency to the conservative low frequency of the extremely long panel described leads to the conclusion that for this panel, not considering floor panel in-plane flexibility is acceptable.

Based on the extreme case discussed above, with length to width ratio of 3.5, it is concluded that not considering in-plane floor flexibility in the models used for ISRS generation is acceptable

Compliance with NUREG-1407

Based on the material presented above, the structural seismic models used for generation of ISRS for IPEEE evaluations meet the requirements of NUREG-1407 and EPRI NP-6041 and are adequate for screening purposes.

Adequate for Screening

Based on the material presented above, the structural seismic models used for generation of ISRS for are adequate for screening purposes.

B5.2 IN-STRUCTURE DEMANDS AND ISRS

Methodology Used

Per Table 3.2-1 of the IPEEE summary report, ISRS were generated for the Containment Interior Structure, the Intake Structure, the Warehouse Building and the Turbine Building. As previously noted, the Containment Interior Structure, the Intake Structure, and the Warehouse building used existing design basis stick models and new 3-D models were generated for the Auxiliary Building and the Turbine Building.

For all structures except the Auxiliary Building, the direct generation method was used to generate the IPEEE ISRS. The direct generation method for ISRS generation utilizing random vibration techniques and using modal properties of models and base input ground response spectrum is consistent with EPRI NP-6041. For IPEEE, the input spectrum was the NUREG/CR-0098 median rock spectra shape anchored to 0.3g.

The ISRS for the Auxiliary Building for IPEEE was generated by scaling the median centered ISRS for this building generated under the A-46 program using multiple time histories (Reference B7.1). The scaling factor used utilized the dominant horizontal mode frequency of the Auxiliary Building model for North-South and East-West excitations to compute the spectral amplitudes at 7% damping for SSE and IPEEE spectra. The ratio thus determined for each direction was used to convert the SSE ISRS of that direction to IPEEE ISRS for that direction. This scaling procedure is acceptable as noted on Page 4-34 of EPRI NP-6041.

Compliance with NUREG-1407

The in-structure demands and ISRS meet the requirements of NUREG-1407 and EPRI NP-6041.

Adequacy for Screening

Based on the discussion provided above, the methodology utilized for generation of in-structure demands and ISRS, and the results, are adequate for screening purposes.

B5.3 SELECTION OF SAFE SHUTDOWN EQUIPMENT LIST (SSEL)

Methodology Used

Section 3.2.2.4 of the MPS2 IPEEE summary report addresses the selection of the SSEL, and is supplemented by the response to the NRC request for additional information provided in Reference B7.6. MPS2 analyzed safe shutdown paths and required safe shutdown components in order to provide the following safe shutdown functions (as outlined in EPRI NP-6041): Reactor Reactivity Control, Reactor Coolant Pressure Control, Reactor Coolant Inventory Control, and Decay Heat Removal. Containment function is addressed in Table 3.2-4 of the MPS2 IPEEE summary report.

As discussed in Section 3.2.2.4 of the MPS2 IPEEE Summary Report, the SSEL is identified in the Millstone Nuclear Power Station, Unit No. 2 USI A-46 Walkdown Summary Report and Proposed Expansion of Licensing Basis for Verification of Equipment Seismic Adequacy dated January 1996 (Reference B7.17) and transmitted to the NRC on January 22, 1996. Per Section 2.0 of Reference B7.17, the selection of the safe shutdown path and SSEL components was done in accordance with the guidance in Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment (Reference B7.15). From the identified paths, the MPS2 P&IDs were reviewed to identify the components (both active and passive) in the paths that are required to support the safe shutdown function. To develop the IPEEE SSEL, the components (excluding the full set of contact pairs and relays) modeled in the Millstone Unit No. 2 Internal Events PRA were added to the SSEL from the A-46 Walkdown Summary Report, if not already included, in order to envelope safe shutdown paths to mitigate seismically-induced LOCAs (Reference B7.6). Piping systems, structures, and passive components were also added to the SSEL list from the A-46 Walkdown Summary Report.

Per Section 3.2.5.1 of NUREG-1407, it is desirable in the selection of alternative success paths to involve operational sequences, systems, piping runs, and components different from those used in the preferred path. For the MPS2 IPEEE, for a single item of equipment whose failure would prevent accomplishment of any of the four safe shutdown functions, an alternate path to safe shutdown was identified by use of a different train or different item of equipment (Reference B7.17). Therefore, this requirement was met for MPS2.

Compliance with NUREG-1407

The methodology used is in compliance with NUREG-1407, and the IPEEE seismic equipment selection results are adequate for screening purposes.

Adequacy for Screening

Based on the material presented above, the selection approach utilized for generating the SSEL is adequate for screening purposes.

B5.4 SCREENING OF COMPONENTS

Methodology Used

The MPS2 Seismic IPEEE was performed using the EPRI SMA option per the methodology of EPRI NP-6041. In accordance with Table 3.1 of NUREG-1407, for a focused scope IPEEE, a 0.30g PGA earthquake level was used for the RLE. The response spectra shape used was the NUREG/CR-0098 median shape applicable to a rock site.

In order to evaluate the demand on components mounted within the structures, the in-structure demand for the SME was determined. Per Section 3.2.1.2 of the IPEEE summary report, new median centered ISRS were generated for major civil structures at MPS2. The new ISRS provided the review level seismic demand on components located within structures. Section 4 of EPRI NP-6041 was used as a guide in developing the new ISRS and the new ISRS are considered adequate as discussed in Section B5.2 of this report.

Piping screening was performed by selecting some of the weaker piping runs, as determined by engineering judgment, and performing walkdowns. With the information gathered from walkdowns, small scale piping evaluations were performed. These confirmed the generally high capacity of the piping systems that exist at MPS2.

Per Section 3.2.2.2 of IPEEE summary report, safety related systems and equipment are housed in the following structures;

- Containment
- Enclosure Building
- Auxiliary Building
- Warehouse
- Intake Structure
- Turbine Building

Civil Structure Capacity Screening was performed by Jack Benjamin Associates as a subcontractor to Stevenson and Associates. Per Section 3.2.3.2 of the IPEEE summary report, from a review of the plant documentation and based on the original design, the structures mentioned above, except for the Turbine Building, were pre-screened based on the guidelines provided in Table 2-3 of EPRI Report NP-6041. The Class I structures met the intent of the first screening column in Table 2-3 (i.e., designed for a SSE of 0.17g).

A detailed review of the Turbine Building structure indicated that the east/west seismic capacity of the Turbine Building should be examined in detail as the East/West lateral loads at Turbine building are carried by a series of 11 moment resisting frames and these frames are not braced. Therefore, HCLPF capacity was calculated for this building. The Turbine Building HCLPF calculation is discussed in Section B5.6.

Per Section 3.2.4 of the IPEEE summary report, the component screening process

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followed the guidelines provided in Section 2 of EPRI NP-6041. The basis for these guidelines is discussed in Appendix A of EPRI NP-6041. The Seismic Review Team (SRT) was composed of W. Djordjevic and J.J. O'Sullivan of Stevenson and Associates (S&A) with typically at least one Engineer from Northeast Utilities (NU) participating as an SRT member during plant walkdowns. Follow-up walkdowns were conducted as needed by J.J. O'Sullivan and NU personnel. The USI A-46 walkdowns were conducted during the same time period and the efforts were coordinated with the IPEEE project. When appropriate, the USI A-46 walkdown results were used for both USI A-46 and SMA component screening. This is acceptable as indicated in Section 6.3.3.3 of NUREG-1407.

MPS2 components were evaluated against the 0.8g spectral acceleration column of Table 2-4 of EPRI NP-6041. This is consistent with the review level demand.

With the exception of piping and other in-line equipment, all equipment was subject to an anchorage screening evaluation. Anchorages were evaluated using the ISRS developed for the SMA (see Section 3.2.1.2 of IPEEE summary report) and the conservative, deterministic analysis techniques described in Appendix O of EPRI NP-6041 were used as the basis of evaluation. In many cases anchorage screening relied on the availability of evaluations performed for USI A-46. This is acceptable as Section 6.3.3.3 of the NUREG-1407 recommends using the GIP for both USI A-46 and IPEEE walkdowns.

Per Section 3.2.4.4 of NUREG-1407, spatial interaction evaluation, such as assessing the effects of flooding, as noted in EPRI NP-6041 must be performed. Section 3.2.4 of the IPEEE summary report states that "potential seismic interaction hazards were identified by the SRT and added to the list of-components designated for further review. In each case, components vulnerable to the interaction hazard were identified. The interaction hazard, such as a masonry block wall, was treated as an independent component and tracked." Based on this statement, the spatial interaction evaluation requirement given in Section 3.2.4.4 of NUREG-1407 is considered met.

Additional details regarding the screening per ERPI NP-6041 for various components are provided in Sections 3.2.4.1 through 3.2.4.16 of the IPEEE summary report. In addition, per Reference B7.2, screening of the components was found to be acceptable by the NRC and its contractor. Furthermore, per Section 2.5 of Reference B7.2, in response to NRC RAI, Northeast Utilities stated that the SRT walkdowns considered the potential effects of flooding if components or structures appeared to have low ruggedness which is consistent with the requirement provided in Section 3.2.4.4 of NUREG-1407.

Compliance with NUREG-1407

The component screening for MPS2 was performed in accordance with the requirements of NUREG-1407 and EPRI NP-6041.

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Adequacy for Screening

Based on the material presented above, the screening approach used and results are reasonable and adequate for screening purposes.

B5.5 WALKDOWNS

Methodology Used

NUREG-1407 guidance for walkdowns is provided in Sections 3.2.4.1 and 3.2.5.2. Per section 3.2.4.1 the walkdowns should be performed and documented in accordance with the recommendations contained in EPRI NP-6041.

Per Section 3.2.4 of the IPEEE summary report, SMA walkdowns were performed during 1994 and 1995. The SRT was composed of W. Djordjevic and J.J. O'Sullivan of Stevenson and Associates (S&A) with typically at least one Northeast Utilities Engineer participating as an SRT member during plant walkdowns. The SRT members were trained by EPRI in both USI A-46 walkdown requirements, and IPEEE add-on requirements.

Per Section 3.2.3.4 of the IPEEE summary report, construction drawings, analysis reports and design calculations were reviewed. A preliminary plant walkdown was conducted to familiarize the SRT with the layout and general structural details. Separations between structures were observed at several locations and found to be as indicated on the drawings.

Follow-up walkdowns were conducted as needed by J. J. O'Sullivan and NU personnel. The USI A-46 walkdowns were conducted during the same time period and the efforts were coordinated with the IPEEE project. When appropriate, the USI A-46 walkdown results were used for both USI A-46 and SMA component screening. This is acceptable as noted in Section 6.3.3.3 of NUREG-1407.

Potential seismic interaction hazards were identified by the SRT and added to the list of components designated for further review. In each case, components vulnerable to the interaction hazard were identified. Furthermore, Section 2.5 of Reference B7.2, in response to NRC RAI, Northeast Utilities stated that the SRT walkdowns considered the potential effects of flooding if components or structures appeared to have low ruggedness. Based on this statement, the spatial interaction evaluation as required in Section 3.2.4.4 of NUREG-1407 is adequately performed.

Per Section 3.2.2.6 of the IPEEE summary report, the MPS2 SMA took advantage of the overlapping requirements between the IPEEE and USI A-46 examination programs. The insights gained from USI A-46 walkdowns were transmitted to the IPEEE team. Additional walkdowns were performed by the seismic PRA team to cover systems, structures, and components not covered by USI A-46. Section 3.2.2.6 of the IPEEE summary report states that the SRT conducted the MPS2 seismic PRA walkdowns following the walkdown procedures detailed in EPRI NP-

6041.

Specific walkdowns were conducted to evaluate equipment. All equipment items were treated as if they were USI A-46 items, even if they were designated as IPEEE equipment items only. Safety-related piping, electrical raceways, and ductwork were walked down separately to assess fragility capabilities. Essential relays were evaluated based on circuit analyses and then seismic screening rules. In accordance with GIP rules, spot checks were made throughout during walkdowns to confirm type, location, and installation adequacy. Structural screening walkdowns were conducted by Dr. John Reed of Jack R. Benjamin & Associates to assess the primary site structures and determine building fragilities.

Section 3.2.4 of the IPEEE summary report states that Dr. Robert P. Kennedy of RPK Structural Mechanics and Dr. John D. Stevenson of S&A personally conducted two days of walkdowns with the SRTs and independently made determinations regarding completeness and correctness of the SMA and USI A-46 walkdown. Their conclusions were that the walkdowns were being conducted competently and the findings made were appropriate, even conservative, when compared to their own judgments. This conclusion is consistent with the NRC's SER conclusion which states that the walkdown approach appears reasonable (see Section 2.5 of Enclosure 2 of the NRC's SER).

Compliance with NUREG-1407

The IPEEE seismic walkdowns were found to be comprehensive and meet the requirements of NUREG-1407 and EPRI NP-6041.

Adequacy for Screening

Based on the above discussion, the IPEEE seismic walkdowns are adequate for screening purposes.

B5.6 FRAGILITY/HCLPF CAPACITY EVALUATIONS

Methodology Used

For the MPS2 IPEEE, HCLPF capacity calculations were performed for selected SSEL components and buildings that house the SSEL components. HCLPF capacities were calculated for equipment, equipment anchorage, and block walls adjacent to SSEL components as required based on the initial screening results.

The HCLPF evaluation of the structures and components at MPS2 was performed using the conservative deterministic failure margin (CDFM) approach per Section 3.2.4.6 of the NUREG-1407. Review of IPEEE HCLPF calculations was conducted by S&L and documented in Reference B7.18. Additionally, an adequacy review of IPEEE HCLPF calculations was performed by Dr. R.P. Kennedy of RPK Structural Mechanics Consulting and documented in Reference B7.20. The review conducted by S&L is summarized below. The review by Dr. R.P. Kennedy is included in Attachment B-1.

The following provides a summary of the review conducted by S&L.

A sample of HCLPF calculations were selected for adequacy review. The sample was chosen to represent a variety of component types, along with a focus on those components with potentially controlling HCLPF values. Since the overall MPS2 plant HCLPF is assumed to be limited by the Turbine Building, the HCLPF calculation of the Turbine Building was selected for review. Among heat exchangers, the Spent Fuel Pool Cooling Heat Exchangers have the lowest HCLPF capacity (0.26g) and this calculation selected for review. Among tanks, the Diesel Engine Fuel Oil Supply Day Tank and had the lowest HCLPF capacity (0.31g) and was chosen for review. Among other components the 125VDC Emergency Bus D02 has the lowest HCLPF capacity (0.26g) and was chosen. The sample of calculations selected covers all failure modes encountered during HCLPF capacity calculations.

The HCLPF capacity calculation associated with the MPS2 Turbine Building was found to be generally in accordance with EPRI NP-6041. It was noted that during the review that live loads were not considered in the HCLPF analysis, as prescribed on Page 6-7 of NP-6041 for PWRs. However, based on experience, the live loads constitute a small amount of the overall loads in nuclear power plant structures. Moreover, lack of consideration of live loads for the determination of HCLPF capacity is conservative as the live loads will reduce the tension in the anchor bolts at the base of the columns during the postulated seismic loading. Therefore, not considering the live loads will not adversely affect the HCLPF capacity of the dominating failure mode and is considered acceptable. A detailed description of the adequacy review is provided in Reference B7.18.

Review of the HCLPF capacity calculation of the MPS2 Spent Fuel Pool Heat Exchangers X20A and X20B concluded that the analysis was performed in accordance with EPRI NP-6041 and the GIP. The methodology employed and the calculated results were found to be reasonable and appropriate. A detailed description of the adequacy review is provided in Reference B7.18.

Review of the HCLPF capacity calculation of the MPS2 Diesel Generator Fuel Oil Supply Day Tank concluded that the analysis was appropriately prepared in accordance with Appendix H of the NP-6041. A detailed description of the adequacy review is provided in Reference B7.18.

The adequacy review performed for the 125VDC Emergency Bus D02 HCLPF capacity calculation concluded that the anchorage capacity analysis was performed correctly and the capacity for the functional failure mode was reasonably based on the generic equipment ruggedness spectrum (GERS) for this class of equipment.

The review of HCLPF capacity calculations performed by Dr. Robert P. Kennedy of

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RPK Structural Mechanics Consultants is summarized below. The scope and results of the review are documented in the RPK Structural Mechanics Consultants Report RPK-140211.1 (Reference B7.20).

This review included an assessment the HCLPF capacity calculations that were performed to support the IPEEE program for MPS2. This assessment also included low-HCLPF outlier items that were identified for improvement in the IPEEE Summary Report. The review concluded that the HCLPF calculations are of adequate quality to support the screening based on IPEEE results. The report also concludes that the HCLPF capacities computed in the calculations are reasonable and the calculations were developed consistent with the requirements in NUREG-1407, Section 3.1.

The assessment identified that documentation records of improved HCLPF capacities for two outlier items (Battery Racks DB1 and DB2 anchorage and Chilled Water Surge Tank anchorage) could not be located and further review and/or confirmation of modification was required. These items were reported as open items in the RPK Structural Mechanics Consultants Report since documentation could not be located prior to finalizing the review. Subsequently, field walkdowns and evaluation were performed to reconstitute the HCLPF calculations. It was concluded that the HCLPF capacity for each of these items remains greater than or equal to the plant HCLPF capacity of 0.25g through modifications previously performed and/or evaluation of the as-built configuration. The evaluation of these items is documented in Dominion Engineering Technical Evaluation ETE-CEM-2014-0001 (Reference B7.27).

Compliance with NUREG-1407

Based on the material presented above, the methodology used to perform HCLPF calculations is in compliance with NUREG-1407 and EPRI NP-6041. This conclusion is also consistent with the NRC's SER stating that the method used for the [HCLPF capacity] evaluation appears to be reasonable per Section 2.6.1 of Enclosure 2 of Reference B7.2.

Adequate for Screening

The lowest HCLPF capacity remains as 0.25g, which is the same value reported in the IPEEE Summary Report and listed in NUREG-1742. The IPEEE HCLPF calculations are considered adequate for screening purposes.

B5.7 <u>SYSTEM MODELING</u>

Methodology Used

Section 3.2.2.4 of the MPS2 IPEEE summary report addresses system information, and further system information is presented in response to an NRC RAI (Reference B7.6). The preferred and alternate safe shutdown paths (considering both transients with the RCS intact and transients with a small break LOCA) for MPS2 were selected to provide the following safe shutdown functions: Reactor Reactivity Control, Reactor Coolant Pressure Control, Reactor Coolant Inventory Control, and Decay Heat Removal. Redundancies and alternate paths are considered to accomplish the safe shutdown functions. Containment penetrations and isolation valves are identified and listed in Table 3.2-4 of the MPS2 IPEEE summary report.

Per Section 3.2.5.8 of NUREG-1407, treatment of non-seismic failures and human actions need to be identified. For safe shutdown paths associated with transients not involving a breach of the RCS, required operator actions are discussed and clearly identified for each safe shutdown function in Attachment 2 of the response to the RAI (Reference B7.6). An alternate path by a different train or a different item of equipment is considered for single failure of equipment that would prevent accomplishment of any of the four essential safe shutdown functions. Single failures due to both seismic loads and non-seismic random active failures are considered.

For safe shutdown paths associated with a seismically-induced small break LOCA, no operator actions are required if the success path follows the sequence that relies on automatic high pressure safety injection (HPSI) (shown on the event tree in Attachment 1 of Reference B7.6). The only exception to this would be if both motor driven Auxiliary Feedwater pumps were to fail and the turbine driven Auxiliary Feedwater Pump had to be manually started. These human actions are well practiced and proceduralized. If the HPSI fails, the success path (also shown on the event tree in Attachment 1 of Reference B7.6) would require operator actions to rapidly depressurize to allow the use of the low pressure safety injection (LPSI) system. These paths are considered optional due to the redundancy and independence of equipment in the success path that relies on automatic HPSI operation. The response to the RAI states that there are no non-seismic-related single random failures that would tend to mask the importance of outliers identified during the seismic review.

Based on the guidance found in EPRI NP-6041, a small break LOCA initiator event tree was developed. In addition, logic diagrams have been developed for each of the four safe shutdown functions for transients wherein the reactor coolant system (RCS) pressure boundary is intact. The event tree and logic diagrams are provided in Attachments 1 and 2 of the response to the RAI, respectively.

Compliance with NUREG-1407

NUREG-1407, Section 3.2.5.1, states that for IPEEE purposes, it is desirable that to the maximum extent possible, the alternate path involve operational sequences, systems, piping runs and components different from those used in the preferred path. As indicated above, this requirement was met based on the design of MPS2.

The treatment of non-seismic failures and human actions in the MPS2 IPEEE meets the requirements of Section 3.2.5.8 of NUREG-1407.

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Adequacy for Screening

The methodology used is in compliance with NUREG-1407, and the IPEEE system modeling results are adequate for screening purposes.

B5.8 CONTAINMENT PERFORMANCE

Methodology Used

Section 3.2.6 of the MPS2 IPEEE summary report addresses containment performance. Per NUREG-1407, the evaluation of containment performance during a seismic event should address containment integrity, containment isolation, prevention of bypass functions, and specific systems that maintain containment integrity.

Per Section 3.2.6.3 of Reference B7.1, seismic evaluation of the containment structure was performed by John Reed who concluded the structure had adequate strength to be screened out. The method used for seismic evaluation of the containment structure for gross failure included review of drawings, reports and calculations along with expert walkdowns of the containment to identify interaction effects and anchorage of major structures that might interact with containment boundary.

MPS2 analyzed the Containment Air Recirculation Fan (CARF) System, Containment Spray (CS) system, and containment isolation failure (bypass failure and isolation function failure) to address containment isolation, bypass, and integrity.

Equipment of the CARF and CS systems are identified in the Millstone Nuclear Power Station, Unit 2 Safe Shutdown Equipment List Report transmitted to the NRC on January 22, 1996 (Reference B7.17). Per Section 2.0 of this report the selection of the safe shutdown path and safe shutdown equipment list (SSEL) components was done in accordance with the guidance in Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment.

Relay chatter evaluations of penetrations for containment bypass failure and isolation function failure were performed. Each containment penetration was identified and listed in Table 3.2-4 of the MPS2 IPEEE summary report. The table lists the isolation valves and the status of each penetration using the screening criteria of Section 3.2.6.4 of the MPS2 IPEEE Summary Report. Containment isolation penetrations that met the following plant-specific criteria screened out from further evaluation:

- Valves and penetrations that belong to a closed system (A closed system, for the purpose of this investigation, was a system such as the Charging system that does not directly communicate with the Containment environment). Penetrations of closed piping systems were not considered as significant vulnerabilities because a radiological release would require the simultaneous failure of the isolation valves and a system integrity failure, such as a pipe break or other means. The probability of this occurring was assumed to be negligibly small.

- Penetrations with piping of < 2". Penetrations with pipes with diameters 2 inches or less are not considered important to containment bypass failures since aerosol plugging is likely to reduce the amount of leakage which could occur through these pipes. Further, a breach through a 2 inch line, if it were to occur, would have relatively small consequences.
- Penetration piping with locked closed valves. Penetration piping with locked closed valves, manual valves and components without relays are not important to relay chatter since these components are not actuated by relays.
- Penetrations with manual valves and components with no associated relays. Penetrations that belong to normally operating or normally open plant systems are not important to relay chatter failure and can be screened out since, closure or chatter of these valves might impact the performance of the system but does not impact bypass failure or isolation function of Containment.

The containment evaluation meets the intent of Section 3.2.6 of NUREG-1407, which requires evaluation of the containment integrity, isolation, and bypass functions to identify vulnerabilities that involve early failure of the containment functions.

The NRC SER states that "The licensee's containment performance analyses for seismic and fire events appear to have considered important containment performance issues and are consistent with the intent of Supplement 4 to Generic Letter 88-20 (see enclosure 1 of the Reference B7.2)." Additionally, Section 2.9 of the Enclosure 2 of the NRC's SER states that "the method used [for containment performance evaluation] appears adequate and the analyses performed are reasonable. The results of the containment performance evaluation were discussed in sufficient detail, and no safety related concerns were found."

The methodology used is in compliance with NUREG-1407, and the IPEEE containment performance results are adequate for screening purposes.

Compliance with NUREG-1407

The methodology used is in compliance with NUREG-1407.

Adequacy for Screening

The IPEEE containment performance results are adequate for screening purposes.

B5.9 PEER REVIEW

Methodology Used

Per Section 3.2.4 of the IPEEE summary report, SMA walkdowns were performed during 1994 and 1995. The SRT was composed of W. Djordjevic and J.J. O'Sullivan of Stevenson and Associates (S&A) with typically at least one Northeast Utilities

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Engineer participating as an SRT member during plant walkdowns. Follow-up walkdowns were conducted as needed by J. J. O'Sullivan and NU personnel. The USI A-46 walkdowns were conducted during the same time period and the efforts were coordinated with the IPEEE project.

Per Section 3.2.2.6 of the IPEEE summary report, a peer review was performed by Dr. R. P. Kennedy of RPK Structural Mechanics and Dr. J. D. Stevenson of Stevenson & Associates. They personally conducted two days of walkdowns with the SRT and independently made determinations regarding completeness and correctness of the SMA walkdown. Their conclusions were that the walkdowns were being conducted competently and that the findings were appropriate. The identified concerns were tracked by initially screening in relevant components (See Reference B7.19).

Additionally, Section 6.2 of the IPEEE summary report states that several different teams were involved in performing the review of assumptions and methodology related to seismic margins evaluations. It is also stated that the building response models, in-structure demand assumptions and the interaction analysis between the Turbine and Auxiliary Buildings were performed primarily by Stevenson and Associates with review performed by Northeast Utilities personnel.

Per Section 6.4 of the IPEEE Summary Report, the comments raised by the independent reviews were responded to by the project engineer and the MPS2 IPEEE team.

The peer review was conducted by qualified personnel who were not associated with the initial evaluations and their findings/concerns were tracked and addressed. Also, as indicated above, the Northeast Utility personnel were involved in several aspects of the peer review.

The IPEEE Summary Report does not explicitly discuss peer reviews in every area. However, the IPEEE adequacy review herein found the IPEEE to be technically adequate and the conclusions to be acceptable.

Compliance with NUREG-1407

The peer review requirements are outlined in Section 7 of the NUREG-1407. As stated in this section, the purpose of the peer review is twofold. The first purpose is to provide quality control and quality assurance to the IPEEE process. The second purpose relates to the importance of having utility personnel cognizant of the IPEEE. Section 7 also recommends peer review be conducted by individuals who are not associated with the initial evaluation, and that the peer review team have combined experience in the areas of system engineering and specific external events. Based on the material presented above, the IPEEE peer review meets the requirements of NUREG-1407 and EPRI NP-6041.

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Adequacy for Screening

The IPEEE peer review meets the requirements of NUREG-1407 and EPRI NP-6041 and is adequate for screening purposes.

B6.0 CONCLUSION

The MPS2 IPEEE was a focused scope EPRI seismic margin assessment submittal. Based on a comparison of the spectra, the IHS exceeds the GMRS in the 1 to 10 Hz range. In order to complete the screening process in accordance with the guidance in EPRI 1025287 (SPID), the MPS2 IPEEE was subjected to an adequacy review and concluded that the IPEEE is of sufficient quality for screening purposes and the risk insights gained from the IPEEE remain valid under the current plant configuration.

A soil failure analysis has been completed with satisfactory results. The full scope detailed review of relay chatter required in SPID Section 3.3.1 has not been completed. The detailed relay chatter review will be completed on the same schedule as the high frequency confirmation, consistent with the schedule identified in the NEI letter to NRC dated October 3, 2013 (Reference B7.11).

Based on the IPEEE adequacy review performed and documented herein, and the comparison of IHS and GMRS, MPS2 screens out from performing a risk assessment consistent with the guidance contained in the SPID.

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B7.0 REFERENCES

B7.1 Northeast Utilities Letter to NRC Document Control Desk, "Generic Letter 88-20, Supplements 4 & 5, Individual Plant Examination of External Events - Summary Report," Serial No. B15481, dated December 29, 1995.

B7.2 Jacob I. Zimmerman, NRC Letter to R. G. Lizotte, Northeast Nuclear Energy Company, "Millstone Nuclear Power Station Unit No. 2 – Individual Plant Examination of External Events (IPEEE) (TAC NO. M83642)," dated January 12, 2001.

B7.3 Dominion Nuclear Connecticut, Inc. Letter to U. S. NRC Document Control Desk, "Millstone Power Station Units 2 and 3, Report in Response to March 12, 2012 Information Request Regarding Seismic Aspects of Recommendation 2.3," Serial No. 12-205H, dated November 27, 2012.

B7.4 Electric Power Research Institute (EPRI) Report NP-6041-SL, "A Methodology for Assessment of Nuclear Plant Seismic Margin (Revision 1)," August 1991.

B7.5 NRC NUREG-1407, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities," June 1991.

B7.6 Northeast Nuclear Energy Letter to NRC Document Control Desk, "Millstone Unit No. 2 Response to Request for Additional Information Relating to the Individual Plant Examination of External Events (IPEEE)," Serial No. B17558, December 31, 1998.

B7.7 Dominion Nuclear Connecticut, Inc. Letter to U. S. NRC Document Control Desk, "Millstone Power Station Units 2 and 3 Response to Request for Additional Information License Renewal Applications," Serial No. 04-398, August 13, 2004.

B7.8 Millstone Power Station Unit 2 Final Safety Analysis Report (FSAR), Revision 28.

B7.9 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," February 28, 2013.

B7.10 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.

B7.11 Kimberly A. Keithline, NEI letter to David L. Skeen, NRC, "Relay Chatter Reviews for Seismic Hazard Screening," Document No. ML13281A308, October 3, 2013.

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B7.12 Anthony R. Pietrangelo, NEI letter to David L. Skeen, NRC, "Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations," Document No. ML13101A379, April 9, 2013.

B7.13 Eric J. Leeds, NRC letter to Joseph E. Pollock, NEI, "Electric Power Research Institute Final Draft Report XXXXXX, "Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic," as an Acceptable Alternative to the March 12, 2012, Information Request for Seismic Reevaluations," dated May 7, 2013.

B7.14 NUREG/CR-0098, "Development of Criteria for Seismic Review of Selected Nuclear Power Plants," May 1978.

B7.15 Seismic Qualification Utility Group (SQUG), "Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment," Revision 2A, March 1993.

B7.16 NRC Report, "Recommendations for Enhancing Reactor Safety in the 21st Century-The Near Term Task Force Review of Insights From the Fukushima Dai-Ichi Accident," July 12, 2011 (ML111861807).

B7.17 Northeast Utilities Services Company Letter to NRC Document Control Desk, "Millstone Nuclear Power Station, Unit No. 2 USI A-46 Walkdown Summary Report and Proposed Expansion of Licensing Basis for Verification of Equipment Seismic Adequacy," Serial No. B15469, January 22, 1996.

B7.18 Sargent & Lundy, LLC Report SL-012305, "Millstone Unit 2 IPEEE Adequacy Evaluation," March 2014.

B7.19 Stevenson & Associates Letter to S. W. Wainio, Northeast Utilities Services Company, "Millstone, Unit 2 Peer Review," November 3, 1994.

B7.20 RPK Structural Mechanics Consulting (Dr. R. P. Kennedy) Report RPK-140211.1, "Adequacy Review Millstone Unit 2 HCLPF Capacity Calculations," dated February 18, 2014. (Attached)

B7.21 Editing Board and Task Groups of the Committee on Nuclear Structures and Materials of the Structural Division of the American Society of Civil Engineers, "Structural Analysis and Design of Nuclear Plant Facilities"

B7.22 NRC Regulatory Guide 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion," March 2007.

B7.23 Letter from John P. McElwain to U.S. Nuclear Regulatory Commission, "Millstone Unit No. 2, Response to Request for Additional Information Relating to the Individual Plant Examination of External Events (IPEEE)," dated May 1, 1998.

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B7.24 Letter B17325 from Martin L. Bowling to U.S. Nuclear Regulatory Commission, "Millstone Unit No. 2, Response to Request for Additional Information Relating to the Individual Plant Examination of External Events (IPEEE)," dated June 30, 1998.

B7.25 Letter B17873 from Raymond P. Necci and David A. Smith to U.S. Nuclear Regulatory Commission, "Millstone Nuclear Power Station, Unit No. 2 Individual Plant Examination of External Events (IPEEE) Response to Supplemental Request of Additional Information (TAC No. M83642)," dated September 29, 1999.

B7.26 NUREG-1742, "Perspectives Gained from the Individual Plant Examination of External Events (IPEEE) Program," April 2002.

B7.27 Engineering Technical Evaluation ETE-CEM-2014-0001, Rev. 0, "Development of Guidance and Information for NRC's Fukushima Near-term Task Force Recommendation 2.1 – Seismic"

B8.0 ATTACHMENT

B-1 RPK Structural Mechanics Consulting Report RPK-140211.1, "Adequacy Review – Millstone Unit 2 HCLPF Capacity Calculations" dated February 18, 2014 – 8 pages

Adequacy Review
Millstone Unit 2 HCLPF Capacity Calculations

Robert P. Kennedy
February 18, 2014

1. Introduction

I have performed an adequacy review of the Millstone Unit 2 HCLPF capacity calculations as requested in Section 3.3.1 "IPEEE Adequacy" of Ref. 1. The purpose of this review was to assess the adequacy of IPEEE submitted HCLPF capacities for use in screening against the current estimated GMRS for Millstone Unit 2.

In conducting my review, I have reviewed all of the documentation listed on the attached document review list entitled *Unit 2 BDB MPS IPEEE Adequacy Review*. My reference to these documents are in terms of the Document Number (Doc #) in the first column of this list.

Doc #1 and 4 are NRC letters with regard to the Safety Evaluation for Unresolved Safety Issue A-46. Doc #5 is a similar NRC letter correspondence with regard to the Individual Plant Examination of External Events (IPEEE). Doc #5 states that "the staff concluded that the aspects of seismic events, fires, and HFO were adequately addressed." Doc #3 is a Millstone Unit 2 USI A-46 Seismic Walkdown Summary Report. Docs #1, 3, 4, and 5 were only briefly reviewed for generally background information purposes since detailed HCLPF capacity calculations information is not presented in any of these documents.

Doc #2 summarizes the HCLPF seismic margin assessment performed for structures and components at Millstone Unit 2. These assessments were performed by Stevenson and Associates (S&A) in 1995. They were performed as part of the Individual Plant Examinations for External Events (IPEEE) program requested by the NRC. The HCLPF seismic margin assessment was performed in accordance with the EPRI Conservative Deterministic Failure Margin (CDFM) approach recommended in EPRI NP-6041 (Ref. 2). I performed a detailed review of Doc #2.

All structures except the Turbine Building were screened out from further review at a HCLPF PGA capacity of 0.30g in accordance with the Screening Tables in Ref. 2. Doc #6 documents the S&A seismic evaluation of the Turbine Building. The Turbine Building HCLPF capacity was estimated to be 0.25g PGA. I performed a review of Doc #6.

Doc #7 develops a seismic model for computing the horizontal seismic response of the Turbine Building. I reviewed Doc #7. Docs #8-10 address some peripheral seismic issues associated with the Turbine Building. I only performed a brief overview of Docs #8-10.

28625 Mountain Meadow Road, Escondido, CA 92026
(760)751-3510 • (760) 751-3537 (Fax)
email: bob@rpkstruct.com

Docs #11-13 deal with the development of in-structure response spectra (ISRS) within the structures to be used as the seismic input demands for components mounted in these structures. For all structures except the Auxiliary Building S&A developed new structures models and computed ISRS for a 0.3g NUREG CR-0098 median rock input ground motion. An existing USI-A46 seismic analysis was used for the Auxiliary Building. This analysis was for a 0.17g SSE response spectrum. S&A scaled these existing ISRS by a scale factor of 2.1 in order to approximate ISRS from a 0.30g NUREG CR-0098 median rock input ground motion. This approximation is slightly conservative since the ratio between input spectra ranges between 1.76 and 2.1 over the frequency range of 1.0 Hz and 10 Hz.

I reviewed and I concur with the approach used by S&A to generate the 0.30g NUREG CR-0098 median rock spectrum ISRS.

Docs #14-24 provide the HCLPF calculations for various components. I reviewed all of these calculations.

2. **Overall Findings**

The Millstone Unit 2 HCLPF capacity calculations are consistent with the state of practice used for computing HCLPF capacities in accordance with the recommendations of EPRI NP-6041 (Ref. 2)

Doc #2 provides a very good overall summary of the HCLPF capacity calculations performed. Details are provided in the various calculation packages. Several hundreds of detailed calculation pages exist. I reviewed the sample defined in the attached documentation list.

Based on my sample review, it is my judgement that Millstone Unit 2 has retained the HCLPF calculations used in the 1995 IPEEE submittal. In my judgement, the HCLPF calculations are of adequate quality to support the use of the Doc #2 HCLPF capacities in a Fukushima Near-Term 2.1 Screening Evaluation in accordance with Ref. 1.

All but two of the HCLPF capacities reported in Table 3.2-3 of Doc #2 appear to have a reasonable calculation basis. I could not find the calculation basis for two components with HCLPF capacities reported in Table 3.2-3. For these two components, the reported HCLPF capacities are substantially larger than the HCLPF values computed in the S&A calculations. These two components are discussed in Section 3.

All of the HCLPF capacities computed in the S&A HCLPF calculations are reasonable in my judgement. These calculations have been developed consistent with the methodology and requirements provided in NUREG-1407, Section 3.1 and are determined to be adequate for GMRS screening purposes using the IPEEE HCLPF spectrum.

All HCLPF capacity results are defined in terms of the Peak Ground Acceleration (PGA). All of these HCLPF capacities are defined by NUREG CR-0098 median rock response spectrum shape anchored at the reported HCLPF PGA capacity values.

Six components are reported in Table 3.2-3 of Doc #2 with HCLPF capacities less than 0.25g. The HCLPF capacities reported for these six components are summarized herein in Table 1. This table also shows the HCLPF capacities computed by S&A calculations which I reviewed. These six components are further discussed in Section 4.

3. Apparent Discrepancy Between Table 3.2-3 Reported HCLPF Values and S&A HCLPF Calculation

Table 1 shows substantial difference between the HCLPF capacity reported in Table 3.2-3 of Doc #2 and in the S&A HCLPF calculation for the Battery Racks and the Chilled Water Surge Tank.

The low HCLPF capacity in the S&A calculation for the Battery Racks is based on an anchorage detail that results in a gap that causes significant bending moment to develop in the anchor. However, these battery racks have been subsequently modified so that neither reported HCLPF capacity is any longer relevant. No HCLPF capacity calculation has been located for the modified racks. However, the HCLPF capacity of the modified racks is likely to be high. I have not further pursued the difference between the reported HCLPF capacity of the unmodified battery rack anchorage.

I concur with the methodology used in the S&A HCLPF calculation C-015 for the Chilled Water Surge Tank. However, some of the input may be too conservative. To assess this issue, I reviewed the USI-A46 SEWS anchorage calculation for this tank. This calculation was also performed by S&A and has a November 30, 1995 signing date which is a few days later than the November 22, 1995 signing date on the S&A HCLPF calculation C-015. Both calculations evaluate the same anchorage failure mode. The SEWS calculation was generated by a computer analysis and insufficient details are presented to enable me to understand the calculation. However, the results are consistent with the 0.22g capacity reported in Table 3.2-3 of Doc #2.

I noted that calculation C-015 and the SEWS calculation had different input. Both start with the USI-A46 computed ISRS. However, the C-015 spectral acceleration for the USI-A46 ISRS is about 20% higher than that used in the SEWS calculation. Also, the SEWS calculation is based on a 5/8-inch Hilti Kwik-Bolt anchor whereas C-015 uses a smaller 7/16-inch Wegit Wedge anchor. This difference will make a significant difference in the computed capacity.

At this stage, I recommend that the exact anchorage of the Chilled Water Storage Tanks be determined and a new HCLPF calculation should be performed. This new calculation should follow the methodology used in the S&A HCLPF calculation C-015, but with better documented input data.

4. Resolution of Low HCLPF Capacities

Table 2 herein presents the resolution of low HCLPF capacities for the six components with HCLPF values less than 0.25g. I have reviewed each of the documents listed in Table 2 except Calculation 96-ENG-1380 MZ for the modified Battery Racks. This calculation does not provide a HCLPF capacity for the modified racks.

I concur with the resolutions presented in the Notes column of Table 2. A critical part of these resolutions is to calculate current HCLPF capacity estimates for the modified Battery Racks, and the Chilled Water Surge Tank. Once Dominion has satisfactorily completed the actions identified in the Notes column of Table 2 for these two components, the plant IPEEE HCLPF Spectrum (IHS) can be considered to be the NUREG/CR-0098 rock spectral shape anchored at 0.25g.

References

1. EPRI 1025287, *Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1-Seismic*, 2013

2. EPRI NP-6041-SL, *A Methodology for Assessment of Nuclear Power Plant Seismic Margin (Revision 1)*, August 1991

Table 1
Component HCLPF Capacities Less Than 0.25g

Component	HCLPF PGA (g)	
	Table 3.2-3 Doc #2	S&A Calculation
22S3-2-2 RSST Feeder Breaker	0.19	0.19
Block Wall 7.8 Inverter No. 5	0.051	0.051
Battery Racks DB1 and DB2	0.13	0.061
120VAC Panel VR11 and VR21	0.17	0.17
Chilled Water Surge Tank	0.22	0.136

Table 2: Low HCLPF Item Resolution

Low HCLPF Item	Discussed In Document	Modification	Calculation	Notes
22S3-2-2 RSST Feeder Breaker	Letter 12-205H; MPS Seismic Walkdown Report Submittal, Table 6-1	MP2-10-01106	N/A	As stated in the letter 12-205H Seismic Walkdown Report submittal, "As a result of a plant modification related to the RSST, breaker 22S3-2-2 enclosure is no longer in service. Therefore, the enclosure anchorage is no longer considered an IPEEE outlier." Design Change Package MP2-10-01106 eliminated the RSST Feeder Breaker (22S3-2-2) and enclosure. Therefore, failure of the breaker enclosure does not affect plant HCLPF.

Low HCLPF Item	Discussed In Document	Modification	Calculation	Notes
Block Wall 7.8 Inverter No. 5	Letter B17558; RAI Response 12/31/98; Letter 12-205H; MPS Seismic Walkdown Report Submittal, Table 6-1	None	N/A	The block wall was not considered Safety Related and therefore was assumed to be unreinforced during the IPEEE walkdown and HCLPF = 0.051g. Inverter No. 5 (INV-5) is in the fall zone and assumed to fail due to interaction with the wall, and assigned 0.051g HCLPF. The INV-5 is a non-safety-related alternate power supply to 120vac bus and is powered from the non-safety-related Turbine Battery bus. RAI response letter B17558, Seismic Question 1d describes that the Turbine Battery and bus were removed from the SSEL since it is not important to the safe shutdown paths. INV-5 is also not risk significant and, by extension, is not important to the safe shutdown paths, and likewise should not be on the SSEL. Therefore, failure of the block wall or inverter do not affect plant HCLPF.

Low HCLPF Item	Discussed In Document	Modification	Calculation	Notes
Battery Racks DB1 and DB2	Letter B17558; RAI Response 12/31/98, Att 8 (#6);	MMOD M2-96568	S&A Calc C007 96-ENG-1380 M2	S&A Calculation concludes a HCLPF of 0.061g but 0.13g was reported in IPEEE submittal. Calculation states that the North DB1 and DB2 require additional anchorage to satisfy SQUG/A-46. Racks modified by MMOD M2-96568. Calc 96-ENG-1380 M2 evaluated modified rack but no revised HCLPF is derived. Dominion will locate an existing HCLPF calculation or reconstitute a calculation to confirm that the HCLPF capacity is >0.25g for the modified battery racks.
120VAC Panel VR11 and VR21	Letter B17558; RAI Response 12/31/98, Att 8 (#7)	MMOD M2-96570	96-ENG-1502M2	Panels modified by MMOD M2-96570. Calculation shows improved HCLPF value from 0.167g to 0.29g.
Chilled Water Surge Tank	Letter B17558; RAI Response 12/31/98, Att 8 (#9) Letter 04-398; RAI Response 8/13/2004 (License Renewal)	None	S&A Calc C015	S&A Calculation concludes a HCLPF of 0.14g but 0.22g was reported in IPEEE submittal. According to letter 04-398 RAI response 4a, the tank was evaluated using SQUG criteria and found to be acceptable based on the SEWS forms provided in the A-46 submittal. No improved HCLPF was provided. Dominion will locate an existing HCLPF calculation or reconstitute a calculation to confirm that the HCLPF capacity is >0.25g for the Chilled Water Surge Tank.

Unit 2 BDB MPS IPEEE Adequacy Review

	Document #	eRoom Doc Filename	Title
1	NRC Letter to S.E. Scace Dated July 19, 2000	MP2 A46 SER Suppl	MILLSTONE NUCLEAR POWER STATION, UNIT NO. 2 - SUPPLEMENTAL SAFETY EVALUATION FOR UNRESOLVED SAFETY ISSUE (USI) A-46 PROGRAM IMPLEMENTATION (TAC NO. MA6421)
2	B15481	MP2 IPEEE Report	Response to Gen Letter 88-20 Supplements 4 & 5 IPEEE- Summary Report
3	NRC Letter 15469 Dated Jan 22, 1996	MP2 USI A-46 Submittal B15469	Millstone Unit 2 USI A-46 Walkdown Summary Report and Proposed Expansion of Licensing Basis for Verification of Equipment Seismic Adequacy
4	NRC Letter to R.P.Necci Dated June 30, 1999	MP2 A46 SER	PLANT-SPECIFIC SAFETY EVALUATION REPORT FOR USI A-46 PROGRAM IMPLEMENTATION AT MILLSTONE NUCLEAR POWER STATION, UNIT NO. 2 (TAC NO. M69459)
5	NRC Letter to R.G.Lizotte Dated Jan 12, 2001	MP2 IPEEE SER TAC M83642	MILLSTONE NUCLEAR POWER STATION, UNIT NO. 2 - INDIVIDUAL PLANT EXAMINATION OF EXTERNAL EVENTS (IPEEE) (TAC NO. M83642)
6	S&A Transmittal Letter 93C2799-DCS-021	S&A Transmittal Letter 93C2799-DCS-021	Transmittal of S&A Analysis Report Millstone Point Unit 2 Turbine Building Seismic Evaluation 93C2799-AR001
7	S&A 93C2799-C001 Attachment 1	S&A 93C2799-C001 Attachment 1	MP2 Turbine Building Horizontal Model
8	S&A 93C2799-C002 Attachment 2	S&A 93C2799-C002 Attachment 2	MP2 Turbine Pedestal Seismic Capacity
9	S&A 93C2799-C003 Attachment 3	S&A 93C2799-C003 Attachment 3	MP2 Turbine Pedestal Seismic Analysis
10	S&A Calc C-017	S&A Calc C-017	Millstone Unit 2 Auxiliary Building/Turbine Building Interaction Displacement Issue
11	93C2799-C-004	S&A 93C2799-C-004	MP2 Building Models
12	93C2799-C-005	S&A 93C2799-C-005	MP2 In-Structure RS for Seismic Margin Assessment
13	93C2799-C-006	S&A 93C2799-C-006	Calculation C-006 Millstone Unit 2 Auxiliary Building/Turbine Building Interaction
14	93C2799-C-007	S&A 93C2799-C-007	Seismic Capacity of DB1 Battery Rack
15	93C2799-C-008	S&A 93C2799-C-008	Seismic Capacity of the RWST
16	93C2799-C-009	S&A 93C2799-C-009	Seismic Capacity of the DG Day Tank
17	93C2799-C-010	S&A 93C2799-C-010	Seismic Capacity of the Boric Acid Tanks
18	93C2799-C-011	S&A 93C2799-C-011	Seismic Capacity of Selected Block Walls
19	93C2799-C-012	S&A 93C2799-C-012	Seismic Capacity of Service Water Pump
20	93C2799-C-014	S&A 93C2799-C-014	Anchorage Evaluation of Misc Cabinets
21	93C2799-C-015	S&A 93C2799-C-015	Miscellaneuos Seismic Capacity Calculations
22	93C2799-C-016	S&A 93C2799-C-016	High Confidence Low Probability Failure Capacity of Spent Fuel Heat ExchangerX20A & X20B
23	93C2799-C-018	S&A 93C2799-C-018	Seismic Capacity of the RBCCW Heat Exchangers
24	93C2799-C-019	S&A 93C2799-C-019	High Confidence Low Probability Failure Capacity of Shutdownl Heat ExchangerX23A & X23B

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Millstone Power Station Unit 3

IPEEE Adequacy Evaluation and IHS Development

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Executive Summary

The 10 CFR 50.54(f) letter of March 2012 (Reference C7.1) requested all nuclear power plant licensees to conduct seismic hazard reevaluations using updated seismic hazard information and present-day methods for NRC Fukushima near-term task force (NTTF) recommendation 2.1. Millstone Power Station Unit 3 (MPS3) has developed the seismic hazard data (hazard curves and ground motion response spectrum or GMRS) using the guidance from the Electric Power Research Institute (EPRI) Report 1025287, *Seismic Evaluation Guidance: Screening, Prioritization, and Implementation Details (SPID) for Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic* (Reference C7.2). MPS3 is performing a screening evaluation per the SPID guidance to determine whether risk based evaluations need to be performed. One screening method compares the Individual Plant Examination of External Events (IPEEE) High Confidence of a Low Probability of Failure (HCLPF) spectrum, or IHS, to the GMRS in the 1 to 10 Hz range, and requires a review to determine that the IPEEE submittal was of sufficient quality. This appendix provides a comparison of the IHS and the GMRS and documents the IPEEE adequacy review performed for MPS3 following the guidance provided in Section 3.3.1 of the SPID.

MPS3 was defined as a focused scope plant for IPEEE in NUREG-1407 (Reference C7.3). The MPS3 IPEEE submittal was provided to NRC on December 23, 1991 (Reference C7.13). The IPEEE submittal provided a previously performed Seismic Probabilistic Safety Study (PSS) (also referred to as a Seismic Probabilistic Risk Assessment (SPRA)). The NRC conducted a review and issued a Staff Evaluation Report (SER) of the IPEEE summary report on May 26, 1998 (Reference C7.17).

The PSS was performed using a site-specific response spectrum curve. The plant HCLPF capacity was determined to be 0.26g as a minimum, but could be judged to be 0.3g. The IHS has the same shape as the site specific curve and was conservatively anchored to 0.26g. The IHS completely envelops the MPS3 GMRS in the 1 to 10 Hz range. The GMRS exceeds the IHS in the greater than 10 Hz frequency range.

To determine IPEEE adequacy, the SPID defines four categories - General Considerations, Prerequisites, Adequacy Demonstration, and Documentation - to be addressed in order to use the IHS for seismic hazard screening. The General Considerations require that focused scope submittals are enhanced to be in line with full scope assessments per NUREG-1407, which entails completion of a full evaluation of soil failures and review of relay chatter. A soil failures evaluation was performed and concludes that liquefaction, slope stability, and settlement are not a concern for MPS3. The full scope detailed review of relay chatter will be completed on the schedule identified in the NEI letter to NRC dated October 3, 2013 (Reference B7.11). The Prerequisites and the Adequacy Demonstration criteria were reviewed and were found to be met. Therefore, the MPS3 IPEEE results were determined to be adequate for screening and the risk insights from the IPEEE are still valid under the current plant configuration.

The NRC issued an SER on the MPS3 IPEEE Summary Report. The NRC staff considered the seismic PSS to be detailed enough to meet the objectives in GL 88-20, Supplement 4 and

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considered potential concerns resolved.

Based on the comparison of IHS and GMRS in the 1 to 10 Hz range and the results of the IPEEE adequacy review, MPS3 screens out from performance of a seismic risk assessment in accordance with the guidance in EPRI Report 1025287 (SPID).

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C1.0 INTRODUCTION

Following the accident at the Fukushima Daiichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the NRC Commission established a Near Term Task Force (NTTF). The NTTF was tasked with conducting a systematic review of NRC processes and regulations 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 (Reference C7.8). Subsequently, the NRC issued a 10 CFR 50.54(f) letter requesting information to assure these recommendations would be addressed by all U.S. nuclear power plants (Reference C7.1). The 50.54(f) letter requests that licensees and holders of construction permits under Title10 Code of Federal Regulations Part 50 reevaluate the seismic hazards at their sites using updated seismic hazard information and present-day regulatory guidance and methodologies. Depending on the outcome of the comparison between the reevaluated seismic hazard and the current design basis, performance of a seismic risk assessment may be necessary.

The guidance for developing the updated seismic hazard, performing the seismic hazard screening, and performing the subsequent seismic risk assessment work is provided in 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*" (Reference C7.2). A ground motion response spectrum (GMRS) using up to date seismic hazard data and source characterization is developed for each site. The GMRS is compared to the site Individual Plant Examination of External Events (IPEEE) High Confidence of a Low Probability of Failure (HCLPF) spectrum (IHS) for screening in accordance with the SPID guidance. If the IHS exceeds the GMRS in the 1 to 10 Hz range and the IPEEE is demonstrated to be of adequate quality, per Section 3.3.1 of the SPID, a risk evaluation is not required.

Millstone Power Station Unit 3 (MPS3) was defined as a focused scope plant for IPEEE in NUREG-1407 (Reference C7.3). The MPS3 IPEEE submittal was provided to NRC in response to NRC Generic Letter (GL) 88-20, Supplement 4 on December 23, 1991 (Reference C7.13). In providing the submittal, Northeast Nuclear Energy Company (NNECO) informed NRC that the evaluation of External Events at MPS3 was performed as part of the Individual Plant Examination (IPE), which utilized a previously performed seismic Probabilistic Safety Study (PSS) (or, Seismic Probabilistic Risk Assessment (SPRA)). The MPS3 PSS formed the basis of the IPE submittal (Reference C7.14) that was provided to the NRC on August 31, 1990. The MPS3 PSS was prepared in accordance with NUREG/CR-2300 and NUREG/CR-2815. NRC requested additional information in a letter dated April 6, 1994

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(Reference C7.15) and the response to the request was submitted to NRC on June 6, 1994 (Reference C7.16). The NRC conducted a review and issued a SER of the IPEEE Summary Report on May 26, 1998 (Reference C7.17).

The purpose of this appendix is to provide the IHS for comparison to the GMRS and to provide the results of the IPEEE adequacy review for MPS3.

The IPEEE adequacy review was conducted by Dominion, Sargent & Lundy, LLC (S&L), and Dr. R. P. Kennedy of RPK Structural Mechanics Consulting. A comprehensive summary of the reviews performed, and the results of the reviews, are provided in this appendix, including the summary report from Dr. R. P. Kennedy (Attachment C-1).

C2.0 DEVELOPMENT OF IHS AND COMPARISON TO GMRS

Per the SPID (Reference C7.2), a comparison of the GMRS with the IHS can be performed for screening. The response spectrum curve used for the MPS3 PSS was a site-specific shape based on amplification factors generated in Reference C7.10. These amplification factors were defined at discreet frequencies and multiplied by the site PGA (0.17g) to generate the site-specific curve used. The IHS for screening is the site-specific curve anchored to the plant HCLPF capacity. The plant HCLPF for MPS3 is reported in Reference C7.11 to be 0.26g, which is the lowest plant damage state HCLPF capacity. As described in RPK Structural Mechanics Consulting Report RPK-140208.1 (Reference C7.9), the IHS could be anchored at a PGA HCLPF value of 0.3g based on a review of the controlling damage state and the improvements made, prior to IPEEE submittal to NRC, to one of the key HCLPF components in that logic sequence.

The MPS GMRS is provided in Section 2.4 and the MPS3 IHS (anchored to 0.26g) is provided in Section 3.3.2 of this report. A comparison of the IHS to the GMRS for MPS3 is shown in Figure C3.0-1. The figure also includes a plot of the IHS anchored to 0.30g.

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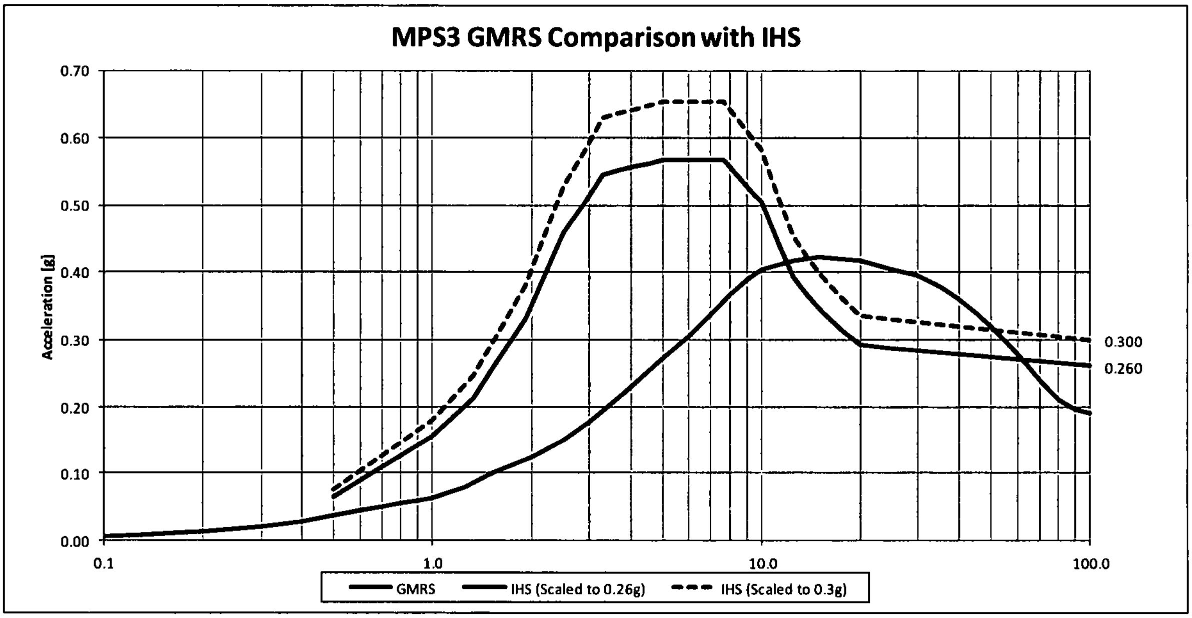

Figure C3.0-1 – Comparison of MPS3 IHS and GMRS

Based on the comparison shown above, the IHS (anchored to 0.26g) exceeds the GMRS in the 1 to 10 Hz range. Therefore, an IPEEE adequacy review is performed, as discussed in the following sections, to support screening out of the performance of a risk evaluation for MPS3.

C3.0 GENERAL CONSIDERATIONS

The PSS performed for MPS3 formed the basis of the seismic portion of the IPEEE submittal (Reference C7.13). As stated in Appendix 1 of the response to an RAI to NRC (Reference C7.16), the MPS3 IPEEE was prepared substantially prior to receiving the draft NUREG-1407 (Reference C7.3), and was submitted in August 1990 prior to the publication of the final NUREG-1407 report (June 1991). As such, the submittal did not use NUREG-1407 as a guidance document.

The NRC issued an SER on the MPS3 IPEEE summary report on May 26, 1998 (Reference C7.17). The SER contains Appendix 1 on the seismic and other portions of the IPEEE. The seismic portions of the SER and Appendix 1 were reviewed. Appendix 1 to the SER discusses the results of the Level III PSS that was submitted by MPS3 for IPEEE. Per Appendix 1, the original PSS and its revisions, which were conducted prior to the IPEEE initiation date, were extensively reviewed by the NRC staff and by Brookhaven National Laboratory (Reference C7.24) and Lawrence Livermore National Laboratory (LLNL) (Reference C7.23). In the area of hazard selection, though the 1989 LLNL hazard curves exceeded the 1983 Dames and

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Moore hazard curves that were used in the PSS, MPS3 stated that the use of LLNL hazard curves would not have led to conclusions or vulnerability insights different from those obtained using the Dames and Moore hazard curves. Further, the revised LLNL curves results are comparable to those obtained using the Dames and Moore curves. The NRC staff generally agreed with MPS3 assessment that additional sensitivity studies addressing the 1989 and 1993 LLNL hazard curves were not needed. The NRC staff also agreed that the walkdown, relay chatter, soil liquefaction and HCLPF calculations were adequate and met the intent of GL 88-20 Supplement 4. On Containment performance, the SER states that there is adequate ruggedness for the containment heat removal function. Independent of the MPS3 PSS, the NRC staff performed its own risk evaluation (NUREG-1152, Reference C7.22) for MPS3. The NRC staff estimated the mean CDF due to earthquakes to be about 6E-6 using the PSS hazard curves and concluded that this is very close to the estimation of 9.1E-6 made by MPS3 in its PSS.

The NRC staff considered the PSS to be detailed enough to meet the objectives in GL 88-20, Supplement 4 and considered potential concerns resolved.

Therefore, NRC's review of the IPEEE Summary Report was positive and no deficiencies in the IPEEE process conducted by MPS3 were identified.

C3.1 RELAY CHATTER

The MPS3 relay evaluation for IPEEE was consistent with the requirements of a focused-scope evaluation, as described in NUREG-1407 (Reference C7.3). 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 (Reference C7.5), the relay chatter review will be completed on the same schedule as the High Frequency Confirmation.

C3.2 SOIL FAILURE EVALUATION

Per Table 3.1 of NUREG-1407 (Reference C7.3), Millstone plant site is binned for 0.3g Focused Scope. Per Section 2.5.2.6 of the MPS3 FSAR (Reference C7.19), MPS3 is designed for a SSE of 0.17g. Per Section 3.2.4.3 of NUREG-1407 (Reference C7.3), the following soil failures need to be addressed for full-scope plant sites:

- Soil Liquefaction
- Foundation Settlement
- Slope Instability (failure)

For purposes of the IPEEE adequacy requirements of the SPID, the above soil failures are evaluated for a full-scope review level earthquake (RLE) based on the NUREG/CR-0098 median rock spectra shape anchored to 0.3g. The evaluation was

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performed by S&L and documented in S&L Report SL-012306 (Reference C7.12).

Per Section 1 of Reference C7.26, the following buildings house safety related equipment and components, and therefore need to be evaluated for IPEEE adequacy of MPS3 for soil failure issues.

- Reactor Containment Building and Concrete Internal Structures
- Engineered Safety Features Building
- Auxiliary Building
- Control Building
- Emergency Generator Enclosure
- Service Water Pumphouse

Per Section 7 of EPRI NP-6041-SL (Reference C7.4), the soil failure evaluation of above listed buildings has been performed using following steps:

- Collection and review of pertinent documents: The documents containing static and seismic geotechnical data available in MPS3 FSAR Sections 2.4, 2.5, and 3.7 and available calculations/documents related to the soil failures have been collected, reviewed and used in performing the soil failures evaluation. These documents are referenced where used within the body of this report.
- Identifying the soil-related issues affecting the safety related equipment and components: Soil liquefaction, foundation settlements and slope instability affecting the buildings identified in Section 1 of Reference C7.26 (listed above) are evaluated.
- Screening of selected soil-related issues through a review: Soil-related issues (soil liquefaction, foundation settlement, slope failure) were screened to eliminate the issues that do not require further detail evaluation.
- In case any soil related issue could not be screened out, an evaluation would be performed to address that particular issue. None were required.

Foundation Supporting Materials

Section 3.7B.1.4 of MPS3 FSAR (Reference C7.19) describes the supporting media for Category I structures. The founding material for major plant structures are listed in Table 2.5.4-14 of MPS3 FSAR (Reference C7.19). The above listed structures are founded on bedrock, with the exception of the Control Building and Emergency Diesel Generator Building. The Control Building is founded on 1 to 4 feet of compacted structural backfill overlying basal till of thickness between 1 foot on the east side and 15 feet on the west. Per Section 2.5.4.5.2 of MPS3 FSAR (Reference C7.19), all structural backfill was compacted to 95 percent of the maximum dry density determined from the Modified Proctor Test, ASTM D1557, Method D. Moisture content was maintained within 4 percent of optimum. This compaction criterion will yield a relative density higher than 75 percent. The Emergency

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Generator Enclosure is founded on basal till varying in thickness from less than 10 feet to 30 feet overlying bedrock.

Evaluation for Soil Liquefaction

EPRI NP-6041-SL provides the following general definition of soil liquefaction: The pore water pressures in a saturated soil can increase under earthquake loading conditions. This increase in pore water pressure can lead to a condition of liquefaction, whereby the excess pore water pressure becomes equal to the effective confining pressure. Even if the excess pore water pressure is less than the effective confining pressure, the shear strength of the soil can reduce to a value which could result in soil failure.

The potential for soil to liquefy depends on soil classification (grain size distribution), its compaction level (relative density), groundwater level and the intensity of the earthquake. The following are some of the soil characteristics from various documents, which provide the screening of non-liquefiable soil (soil profile which does not liquefy under any level of earthquake intensity).

Liquefaction Potential of Soil Supporting Various Buildings

Among the buildings that are within the scope of this study, Reactor Containment Building and Concrete Internal Structure, Engineered Safety Features Building, Auxiliary Building, and Service Water Pumphouse are founded on rock (Table 2.5.4-14 and Section 3.7B.1.4 of MPS3 FSAR) which cannot liquefy during RLE by nature. The Control Building and the Emergency Generator Enclosure Building required additional review for liquefaction potential. Reference C7.12 provides the detailed review and concludes that soil liquefaction is not a concern for any of the buildings that contain SSEL components. This conclusion is consistent with Section 2.5 of the Appendix 1 of the NRC's SER (Reference C7.17) which states that "the staff agrees with the licensee statement and concludes that no further analysis of soil liquefaction is required for Millstone 3 IPEEE."

Foundation Settlement

Section 2.5.4.10.2 of MPS3 FSAR discusses the settlement of structures. Per Section, 2.5.4.10.2 of MPS3 FSAR, rock and soil supported Seismic Category I structures experience only elastic displacements under the design loads. Hence per Section 7 of EPRI NP-6041-SL, the settlements for RLE (0.3g) can be estimated by the settlement due to SSE (0.17g) multiplied by a scale factor of 1.76 (0.3g/0.17g). Predicted static settlements for various structures are provided in Table 2.5.4-14 of MPS3 FSAR. The FSAR does not provide any information regarding the allowable settlements and also does not provide settlements including the SSE load (only the maximum static settlements are provided). It states that the settlements are very small. As compared to the suggested allowable settlements used in Industry for safety class structures (Table 7.4 of Reference C7.29), the settlements of MPS3 structures are very small. The suggested allowable settlements provided in Reference C7.29 are differential settlements. Thus the total allowable settlement will be larger than the differential settlements, i.e., comparison of the total settlement with the suggested allowable differential settlement provided in Reference C7.29 is a conservative comparison. Since major parts of the settlements will be due to the dead loads, inclusion of the RLE effects will cause only small increases in the total settlements. The foundation settlements of the Reactor Containment Building, Engineered Safety Features Building, Auxiliary Building, Service Water Pumphouse, Control Building, and Emergency Generator Enclosure were evaluated individually in Reference C7.12 and found to be acceptable.

Slope Instability

Section 2.5.5 of MPS3 FSAR (Reference C7.19) discusses the stability of slopes at the site. The topography in the plant area is generally flat in the major plant area.

A plan of the shoreline in the vicinity of the MPS3 Service Water Pumphouse is shown on Figure 2.5.4-41 of MPS3 FSAR. To the east of the Service Water Pumphouse, a reinforced concrete seawall with post-tensioned rock anchors has been built between the Service Water Pumphouse and the MPS2 Intake Structure to retain the earth and protect the structures from wave action. On the west side of the Service Water Pumphouse, extending in a northerly direction is a reinforced concrete retaining wall keyed into rock. The purpose of this wall is to protect the circulating and service water lines from being undermined due to wave action on the adjoining slope. To the west of the Service Water Pumphouse, a variable slope has been cut in the beach and outwash sand to provide for a transition from the offshore intake channel at El. -32 feet to the Service Water Pumphouse area site grade at El. +14 feet. The slope varies from five horizontal to one vertical immediately adjacent to the Service Water Pumphouse, to ten horizontal to one vertical near Bay Point, the western extent of the beach. Compacted backfill was placed in areas where additional fill was required to meet these grade requirements.

Detailed analyses were performed to determine static and dynamic stability of two man-made slopes at the site. The analyses of beach and outwash sand and armor stone slope at the shoreline, adjacent to the Service Water Pumphouse, showed that the slope was safe under an average amplified seismic loading of 0.25g (amplified from 0.17g base SSE) and under static conditions. The analyses showed low factor of safety for slope failure. For RLE condition, the factor of safety may be lower than 1.0. As discussed in Section 2.5.5.2.1 of MPS3 FSAR, due to the low factor of safety obtained, an analysis was performed to estimate the deformations which could theoretically occur along the postulated failure surface during the earthquake loading. The results showed maximum cumulative slope movements less than 0.1 inch, which is negligible. For RLE of 0.30g, the movement will be more than 0.1 inch, but still be negligible and would have no adverse effect to any safety related system component or structures.

The vertical rock cut excavated for the containment structure, was previously analyzed by assuming failure planes developed along fully continuous joint and foliation surfaces for both static and dynamic loading conditions. It was determined that the stability of these slopes was inadequate to maintain isolation of the containment structure walls from the external load applied by the rock wedges. As a result, a continuous reinforced concrete structural hoop or ring beam was constructed in the annular space between the containment walls and the rock face. The purpose of this ring beam is to transfer any rock loading from the less stable areas where potential failure wedges may form to the more stable areas elsewhere around the containment, maintaining isolation of the rock loads from the containment exterior walls. Section 3.8.1.1 of MPS3 FSAR discusses the details of the ring beam design. The ring is analyzed as a laterally loaded and supporting ring, in which only inward unrestrained deflection is possible (the rock itself resists lateral outward movement. The lateral displacements of the ring beam are calculated to be 0.2 inch, which is negligible with respect to the 4 inches of compressible material which is provided to isolate the containment shell from any lateral loads above the mat. For RLE of 0.3 g, the lateral displacement of the ring beam is estimated to be about 0.35 inch, which is negligible. The ring girder is a seismic Category I structure and is designed for all applicable loadings. It can be categorized as Category I concrete frame structure. For structural strength point of view, the ring beam is screened out per Table 2-3 of EPRI NP-6041-SL (Reference C7.4).

C4.0 PREREQUISITES

In accordance with the requirements noted in Section 3.3.1 of the SPID (Reference C7.2), the following prerequisites must be addressed in order to use the IPEEE analysis for seismic hazard screening purposes and to demonstrate that the IPEEE results can be used for comparison with the GMRS:

1. Confirm that commitments made under the IPEEE have been met. If not, address and close those commitments.
2. Confirm whether all of the modifications and other changes credited in the IPEEE analysis are in place.
3. Confirm that any identified deficiencies or weaknesses to NUREG-1407 in the plant specific NRC's SER are properly justified to ensure that the IPEEE conclusions remain valid.
4. Confirm that major plant modifications since the completion of the IPEEE have not degraded/impacted the conclusion reached in the IPEEE.

<u>Prerequisite 1</u>

The results of the IPEEE program for MPS3 are provided in the MPS3 IPE Report

(Reference C7.14). There are no specific seismic commitments outlined in the MPS3 IPE Report.

Prerequisite 2

Per Section 6 of the Attachment 2 of the NTTF 2.3 Seismic Walkdown Summary Report (Reference C7.18), "although not identified as IPEEE vulnerabilities or outliers, the MPS3 IPE Report (Reference C7.14), Table 6-2, Addressment of Significant PRA Findings, provides the seismic-related findings along with a description of how the items were addressed. The seismic related items are complete as indicated in Table 6-2 of the IPE Report."

There are no other specific seismic modifications and other changes credited in the MPS3 IPE Report.

Prerequisite 3

The NRC's IPEEE SER has been provided in Reference C7.17. It does not specify any deficiencies in the MPS3 IPE report. The NRC letter provided in Reference C7.17 states "Based on a review of the information contained in the submittal and associated responses to requests for additional information, the staff concludes that NNECO's process is capable of identifying the most likely severe accidents and severe accident vulnerabilities and therefore, NNECO has met the intent of Supplement 4 to GL 88-20."

Prerequisite 4

A review of major modifications that could affect IPEEE results was performed by reviewing plant SSCs for which a fragility calculation was performed. A listing of fragilities for key structures and equipment is provided in Table 2-1 of NTS/SMA 20601.02-R2, "A Program to Determine the Capability of the Millstone 3 Nuclear Power Plant to Withstand Seismic Excitation Above the Design SSE" (Reference C7.11). A detailed review of modifications affecting these SSCs, since the IPEEE Summary Report submittal, was performed and the results are provided in Table C4.0-1.

Table C4.0-1 – Summary of Modifications Identified

Component / Structure	Description of Modification/ Disposition
Containment Recirculation System Pumps	Shaft seal tubing modification to prevent leakage of process fluid to the atmosphere post-LOCA. Modifications performed by this design change would not adversely affect the calculated fragility for these components.

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Table C4.0-1 – Summary of Modifications Identified

Component / Structure	Description of Modification/ Disposition
Component Cooling Water System Pumps	Modification performs a rerate of portions of the Component Cooling Water System. The pumps were re-rated by this modification to 160 degrees F. No physical changes to the Component Cooling Water System Pumps were performed by this modification. Therefore the fragility calculated for these components remains unaffected by this modification.
Power Operated Relief Valves	Modification develops a comprehensive list of active valves at MPS3 and reconciles the list with related controlled documents. No modification was identified for the PORVs during this review; therefore there is no change to the calculated fragility due to this modification.
	Modification to replace existing connectors with Litton/Veam connectors associated a PORV. No modification to the PORV was performed; therefore the fragility calculated for the PORVs remains unaffected by this modification.
480V MCCs	Modification to eliminate "hot shorts" associated with spurious opening of the Charging pump suction valve during a fire. This modification has no impact on the seismic qualification of the MCCs.
Reactor Coolant Pumps	Modification to replace "A" pump internals, including turning vane and associated bolting, seal cartridge assembly, turning vane locking cups, diffuser adapter bolts, and the No.1 O-ring. The fragility calculated for these components remains unaffected by this modification.
	Modification to replace "B" pump internals, including turning vane and associated bolting, seal cartridge assembly, turning vane locking cups, diffuser adapter bolts, and the No.1 O-ring. The fragility calculated for these components remains unaffected by this modification.
	Modification to replace "C" pump internals, including turning vane and associated bolting, seal cartridge assembly, turning vane locking cups, diffuser adapter bolts, and the No.1 O-ring. The fragility calculated for these components remains unaffected by this modification.

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Table C4.0-1 – Summary of Modifications Identified

Component / Structure	Description of Modification/ Disposition
RCP Component Cooling Water Heat Exchangers	Modification performs a rerate of portions of the Component Cooling Water System. Heat exchangers were re-rated by this modification to 160 degrees F. No physical changes to the RCP Component Cooling Water Heat Exchangers were performed by this modification. Therefore the fragility calculated for these components remains unaffected by this modification.

Distributed systems (such as piping, conduits, and cable trays) were not considered in this review because these components tend to have sufficiently high capacities.

The fragility associated with loss of offsite power due to ceramic insulator failure is derived from earthquake experience and generically applied. Since there is no site-specific configuration associated with the calculation of ceramic insulator failure, station modifications performed since IPEEE would not affect the fragility assigned to these components.

Fragilities were calculated for the following structures. The dominant failure modes for the structures include sliding, shear wall failure, diaphragm failure, and base mat shear wall failure. It is reasonable to assume that no modifications have been performed that would adversely affect fragilities based on these failure modes.

- Control Building
- Service Water Pumphouse
- Emergency Generator Enclosure
- Auxiliary Building
- Engineered Safeguard Features Building
- Containment Crane Wall

The review summarized above gives reasonable assurance that plant modifications have not adversely affected the conclusions of the IPEEE.

Prerequisites Review Conclusion

Based on the material presented above, the four IPEEE adequacy prerequisites from the EPRI SPID (Reference C7.2) are met for MPS3.

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C5.0 ADEQUACY DEMONSTRATION

C5.1 STRUCTURAL MODELS AND STRUCTURAL RESPONSE ANALYSIS

Methodology Used

Safety related systems and equipment are housed in the following structures and each was analyzed for the seismic PRA.

- Reactor Containment Building and Concrete Internal Structures
- Engineered Safety Features Building
- Auxiliary Building
- Control Building
- Emergency Generator Enclosure
- Service Water Pumphouse

The structural models and response analysis for these structures were reviewed for consistency with NUREG-1407 and EPRI NP-6041 guidance.

The structures are founded on bedrock, with the exception of the control building and emergency generator enclosure building. The control building is founded on 1 to 4 feet of compacted structural backfill overlying basal till of thickness between 1 foot on the east side and 15 feet on the west. The Emergency Generator Enclosure is founded on basal till varying in thickness from less than 10 feet to 30 feet overlying bedrock.

The structural response analysis for the seismic PRA used the existing models for the structures. The following is a brief description of the structural models:

- For the emergency generator enclosure building that is founded on shallow soil, a finite element soil-structure interaction analysis was performed. A two dimensional model with three degrees-of-freedom (one rotational, one horizontal and one vertical) per mass node for each excitation direction was used.
- For the control building, the original fixed-base design model with six degrees of freedom was used; three translation, two rocking, and one torsional.
- All other Seismic Category I structures were analyzed considering six degrees-of-freedom; three translation, two rocking, and one torsional.
- In the seismic models, the floors are treated as rigid diaphragms that transfer the earthquake inertia forces to frames and shearwalls, which in turn transfer the loads to the foundation mat and the sub-grade. Beam theory, combining the effects of shear, flexure, torsion, and axial deformation, is used to establish the stiffness characteristics of the frame-wall systems. Eccentricities between the centers of mass and centers of rigidity are considered.
- The Containment shell and the internal structures, which are founded on a common mat, are modeled as two separate sticks. The other structures are

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modeled as single stick models.

The structural models and response analyses need to comply with the criteria and engineering practices at the time of the IPEEE, i.e., EPRI NP-6041 SL Rev.1. However, for the adequacy review, each of the structural models and response analyses were also evaluated against the seven criteria in EPRI SPID Section 6.3.1. The seven criteria and corresponding assessments are as follows.

Criterion 1

The structural models should be capable of capturing the overall structural responses for both horizontal and vertical components of ground motion.

Assessment for Criterion 1

In the analyses to obtain ISRS, uncracked reinforced properties were utilized with the exception of the Containment Building and Containment Internal Structures. Discussion on pages 4-19 and 4-20 of EPRI NP-6041 indicates that at seismic levels higher than design basis, the effect of using cracked section properties needs to be addressed. The actual concrete strength based on cylinder test data is significantly higher than the specified strength for the buildings at MPS3. The minimum average concrete compressive strength for the structures is 4200 psi which corresponds to the Engineered Safety Features Building. This is 40% higher than the specified strength of 3000 psi for MPS3 structures. Since the actual concrete strength is substantially more than the specified concrete strength, it is judged that the cracking of the concrete shear walls for beyond design basis earthquakes will not be wide spread and the consideration of ±15% broadening of the response spectra for generating MPS3 floor response spectra will adequately account for cracked concrete effects.

Based on the above, the existing models using uncracked section properties are reasonable and in agreement with EPRI NP-6041 guidelines.

Criterion 2

If there is significant coupling between the horizontal and the vertical responses, one combined structural model should be used for analyzing all three directions of the earthquake.

Assessment of Criterion 2

In the original structural design models used for MPS3, eccentricities between the centers of mass (CM) and centers of rigidity (CR) were considered (See Section 3.7B.2.3 of MPS3 FSAR). With the exception of the auxiliary building, the structural design forces were developed from the absolute sum of the accelerations in one direction due to the simultaneous responses from all three directions of input. For the auxiliary building, the dynamic forces of the members were computed by the square-root-of-the-sum-of-the-squares (SRSS) method. Therefore, for the IPEEE evaluation of the structures, the coupling between the horizontal and vertical responses has been adequately considered.

Criterion 3

Structural mass (total structural, major components, and appropriate portion of live load) should be lumped so that the total mass, as well as the center of gravity, is preserved. Rotational inertia should be included if it affects response in the frequency range of interest

Assessment of Criterion 3

Per Page 3.7B-6 of FSAR, masses are concentrated at floor levels, and eccentricities of centers of mass and rigidity are included in the models. Review of the seismic design calculations shows that the live loads were not considered in calculation of the masses. However, the weight of miscellaneous equipment and major components are properly accounted for in all the models. Since the live loads are not significant in operating power plants compared to the self (dead) weight of the structure and the weight of major components and equipment, lack of consideration of the live loads is considered acceptable.

Of the six buildings that house necessary equipment, four buildings that are founded on rock and the control building models use three-dimensional models and therefore, consider the torsional effects. The emergency generator enclosure building model is a two dimensional model and therefore, torsional effects cannot be considered in it. However, as stated in Section 3.7B.2.11 of MPS3 FSAR, the emergency generator enclosure building is basically symmetrical. Therefore, torsional coupling is negligible.

Criterion 4

The number of nodal or dynamic degrees of freedom should be sufficient to represent significant structural modes. All modes up to structural natural frequencies of about 20 Hz in all directions should be included (vertical floor slab flexibility will generally not be considered because it is expected to have frequencies above 15 Hz, but this should be verified by the structural engineer). This will ensure that the seismic responses and in-structure response spectra (ISRS) developed in the 1 to 10 Hz frequency range are reasonably accurate.

Assessment of Criterion 4

Based on considering the mass concentration at all floor levels in the models, appropriate translational degrees and rotational degrees of freedom are considered for buildings founded on rock as well as the control building. Also as discussed under item 3, not considering torsional degrees of freedom due to horizontal excitations for the emergency generator enclosure building is judged to be reasonable based on symmetry in the emergency generator enclosure building.

Therefore, seismic models account for significant degrees of freedom

Criterion 5

Torsional effects resulting from eccentricities between the center of mass and the center of rigidity should be included. The center of mass and the center of rigidity may not be coincident at all levels, and the torsional rigidity should be computed

Assessment of Criterion 5

As discussed under criteria 3 and 4 above, the effect of torsional coupling due to horizontal inputs is either considered (for the four buildings that are founded on rock as well as the control building), or it is judged to be insignificant (for the emergency generator enclosure building).

Criterion 6

The analyst should assess whether or not one-stick model sufficiently represents the structure. For example, two-stick models could be more appropriate for the analysis of internal and external structures of the containment founded on a common mat

Assessment of Item 6

Review of the dynamic model of the containment building and internal structures shows that the containment shell and the internal structures which are founded on a common mat are modeled as two separate sticks (See Figure 3.7B-9 of MPS3 FSAR). For other structures, single stick models were used. These models are considered appropriate.

Criterion 7

The structural analyst should review whether in-plane floor flexibility (and subsequent amplified seismic response) has been captured appropriately for the purposes of developing accurate seismic response up to the 15 Hz frequency. Experience has shown that, for nuclear structures with floor diaphragms that have length to width ratios greater than about 1.5, the in-plane diaphragm flexibility may need to be included in the LMSM. The use of this 1.5 aspect ratio should be reviewed by the structural engineer since some structures are affected by the in-plane diaphragm flexibility by aspect ratios lower than the 1.5. As with all these recommendations, alternate approaches can be used when justified.

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Assessment of Criterion 7

The in-plane floor flexibility of the floor panels has typically not been included in the building seismic models used in MPS3.

In order to study the effect of in-plane diaphragm flexibility on the structural response, the most extreme panel aspect ratio, which corresponds to a panel in the Auxiliary Building with a length to width ratio of about 4.2 at EL. 28'-6" was considered. The simple beam frequency of this panel, deforming in its own plane, is about 13 Hz. Considering more realistic boundary conditions due to walls supporting the slab will clearly yield frequency higher than 15 Hz for this panel.

Additionally, examination of all ISRS generated for the Auxiliary Building at its various floors, shows all horizontal ISRS peak at frequency about 8Hz, resulting from the lateral flexibility of the structure. Comparing the above ISRS peak frequency to the conservative low frequency of 13 Hz for the extremely long panel described leads to the conclusion that for this panel, not considering floor panel in-plane flexibility is acceptable.

Based on the extreme case discussed above with length to width ratio of 4.2, it is concluded that not considering in-plane floor flexibility in the models used for ISRS generation is acceptable

Compliance with NUREG-1407

Based on the material presented above, the structural seismic models used for generation of ISRS meet the requirements of NUREG-1407 and EPRI NP-6041 and are adequate for screening purposes.

Adequacy for Screening

Based on the material presented above, the structural seismic models used for generation of ISRS for are adequate for screening purposes.

C5.2 IN-STRUCTURE DEMANDS AND ISRS

Methodology Used

Consistent with FSAR Section 3.7B.2.9, the criteria utilized in generating MPS3 ISRS was to broaden the peak resonant value by plus and minus 15%. Beyond this resonant range, the actual amplified response spectra are utilized.

Appropriate adjustment factors were used to develop site-specific median-centered ground motion response spectra for developing ISRS and the models used for the generation of ISRS are adequate as discussed in Section 5.1, therefore the use of design basis SSE spectra for the generation of ISRS is acceptable and consistent with the SSE scaling guidelines outlined on Pages 4-12 and 4-13 of EPRI NP-6041.

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The ISRS are generated at the mass centers for each floor, and do not consider the effects of torsion on ISRS amplification at locations far from the mass center. These effects can be noticeable at distances far from the mass center. However, the input motion incoherence, which generally tends to reduce the responses, was not considered in the generation of ISRS. The review documented in Reference C7.12 concludes that, based on the observation that not all components are located far from the mass center and the fact that the ISRS do not consider reduction of the response due to incoherence, the generated ISRS are judged to be reasonable.

Compliance with NUREG-1407

Based on the results of the review above, the in-structure demands and ISRS meet the requirements of NUREG-1407 and EPRI NP-6041.

Adequacy for Screening

The in-structure demands and ISRS are adequate for screening purposes.

C5.3 SELECTION OF SEISMIC EQUIPMENT LIST (SEL)/SAFE SHUTDOWN EQUIPMENT LIST (SSEL)

Methodology Used

The MPS3 PSS was developed in accordance with NUREG/CR-2300 and NUREG/CR-2815. As discussed in Section C1.0, the MPS3 PSS formed the basis of the MPS3 IPE, which was submitted to NRC to satisfy the requirements of the IPEEE, including seismic. As part of the PSS, a list of systems was developed based on the required safety functions from the event tree (reactor trip, reactor coolant system inventory control, core cooling, containment cooling, and radioactivity scrubbing). Information on each system, including a component list, is provided in Section 2.3.3 of the MPS3 PSS. Section 2.5.1 of the MPS3 PSS contains the seismic risk analysis. MPS3 divided plant structures and equipment into two groups: (1) structures and equipment important to safety that are essential to prevent a core melt and (2) items whose failure could adversely affect safety-related structures or equipment. These component lists comprised the SSEL.

Section 3.2.5.1 of NUREG-1407 states that 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. As MPS3 IPEEE was developed using a seismic PRA, multiple paths were analyzed; this meets the intent of Section 3.2.5.1.

Compliance with NUREG-1407

The methodology used is in compliance with NUREG-1407.

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Adequacy for Screening

The IPEEE seismic equipment selection results are adequate for screening purposes

C5.4 SCREENING OF COMPONENTS

Methodology Used

Section 3.1.2 of the NUREG-1407 does not provide specific guidance for screening when an existing SPRA is used for IPEEE. The MPS3 IPE submittal does not directly address the screening procedure used for the structures, components and equipment.

According to Section 1.1 of the MPS3 IPE submittal (Reference C7.14), the MPS3 Level III PRA formed the basis to address Generic Letter 88-20. The results of the PRA study are provided in the MPS3 PSS report. The external events included in the PSS are earthquakes, fires, external flooding, internal flooding, extreme winds, aircraft accidents, hazardous materials, and turbine missiles. Of these events, the fire and seismic events were found to be important to risk. Sections 1.2, 2.5 and Appendix 1-B of the PSS report provide details of the external event analysis for MPS3. Sections 2.5.1.1 and appendices 2-I and 2-J of the MPS3 PSS address the seismic fragility analysis of structures and equipment that are necessary to mitigate the consequences of accidents caused by an earthquake.

Per Section 2.1.3 of Reference C7.26, no safety related component are located within non-Category I buildings. The non-Category I structures are separated from Category I structures. Other than the turbine building which was evaluated for failure modes deemed likely to damage adjacent important structures, no other non-Category I structures were analyzed since failure in these structures were judged to have no effect on any Category I building.

Based on the above, the method of screening for civil structures is considered sound and appropriate.

During the plant walkdown, no items of non-seismic Category I equipment were identified whose failure is likely to cause damage to safety-related equipment.

Per Section 2.5.1.1.1 of the PSS report, results of the Stone & Webster (Reference C7.27) fragility evaluation of safety related components were utilized as screening values for selection of equipment for HCLPF evaluation. As described in Section 5 of Reference C7.26, a cursory review of approach and methodology used in the preliminary equipment evaluation indicated that the results of Stone & Webster (Reference C7.27) evaluation are generally conservative. Consequently, it was judged that components exhibiting a median ground acceleration capacity of 1.5g or greater in the Stone & Webster evaluation will have negligible impact upon risk associated with the MPS3 plant operation. Therefore, detailed evaluation of fragilities and HCLPF capacity was done only on components that exhibited a calculated acceleration capacity less than 1.5g. Because of the extremely severe consequence of a steam generator U-Tube bundle failure, a reevaluation of the U-Tubes was also conducted even though the reported median capacity of this component was predicted to be greater than 2.0g in Reference C7.27.

Based on the above, and considering the fact that the selection of the equipment for fragility evaluation was based on a conservative initial evaluation of all safety related equipment, the adequacy review performed in Reference C7.12 concluded that the methodology used for equipment screening is considered sound and reasonable.

Compliance with NUREG-1407

Based on the material presented above, the screening of components meets the intent of NUREG-1407 and EPRI NP-6041.

Adequacy for Screening

Based on the material presented above, the screening of components is acceptable for screening purposes.

C5.5 WALKDOWNS

Methodology Used

The MPS3 IPE submittal did not provide a summary of walkdown findings nor a concise description of the walkdown team and the procedures used as requested in Section C.2.1 of Appendix C, NUREG-1407. According to Reference C7.16, the seismic walkdowns were performed during the late 1983/early 1984 time period. The team that performed the walkdown of the structures was led by D. A. Wesley of Structural Mechanics Associates. The team that performed the walkdown of the electrical and mechanical components was led by R. D. Campbell of Structural Mechanics Associates. From Northeast Utilities, three individuals participated in the seismic walkdowns.

As stated in Section 1.2 of the IPE submittal (Reference C7.14), when the MPS3 PRA was being performed, Northeast Utilities and contractor personnel performed plant walkdowns of virtually all major systems and plant areas. Since the plant was under construction at the time the PRA was performed, the personnel had access to many systems and areas which are not as easily accessible in an operating plant, including reactor containment and lower cavity.

After the seismic PRA report was submitted, NRC contracted Dr. John Reed of Jack Benjamin Associates to perform a walkdown for the purpose of an Independent Review of seismic fragility, wind, and external flooding.

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Appendix 1 of the NRC's SER (Reference C7.17) states "the staff concludes that walkdowns conducted during the PSS development satisfy the intent of GL 88-20, Supplement 4."

Compliance with NUREG-1407

Based on the material presented above, the seismic walkdowns are consistent with NUREG-1407 and EPRI NP-6041 walkdown guidance.

Adequacy for Screening

The seismic walkdown results are adequate for screening purposes.

C5.6 FRAGILITY EVALUATIONS

Methodology Used

The HCLPF evaluation of the structures and components at MPS3 was performed using the fragility analysis (FA) approach per Section 3.2.4.6 of the NUREG-1407 (Reference C7.3). The following presents the results of the evaluation of fragilities for selected structural components and equipments for compliance with the requirements listed in NUREG-1407 (Reference C7.3) and EPRI NP-6041 (Reference C7.4).

The MPS3 seismic fragilities were computed using the Separation of Variables approach. Review of a sample of fragility calculations was conducted by S&L and documented in Reference C7.12. An additional review was performed by Dr. R. P. Kennedy of Structural Mechanics Consulting and documented in Reference C7.9. The review conducted by S&L is summarized below. The review by Dr. R. P. Kennedy is included in Attachment C-1.

A sample of fragility calculations was chosen for adequacy review in Reference C7.12. As discussed in Section 3.5.1.1 of the MPS3 IPE submittal (Reference C7.14), the information provided by Structural Mechanics Associates was used in the seismic fragility analysis. Reference C7.11 provided the HCLPF calculation results to NRC. Per Section 3.3 of Reference C7.11, it was found that the core melt expression for the plant is essentially that given by damage state TE (Transient [caused by loss of offsite power] with failure of onsite emergency power of RCS heat removal) expression. Table 3-2 of Reference C7.11 lists the HCLPF capacity of TE damage state as 0.26g. The components involved in the TE damage state are identified in Equation 3-1, with the identification correlated with equipment name given in Table 2-1. These components can be categorized as:

- Structures
- Tanks
- Miscellaneous components such as pumps, generators, cable trays

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Among the "Structures" involved in TE damage state, the Emergency Generator Enclosure (EGE) Building has the lowest HCLPF capacity (0.3g). Therefore, this structure was selected for further overview of its fragility calculation.

Among the Tanks involved in TE damage state, the Refueling Water Storage Tank has the lowest HCLPF capacity (0.3g). Therefore, this tank was selected for further overview of its fragility calculation.

Among the miscellaneous components, the HCLPF capacity of the ceramic insulators for the loss of offsite power scenario was based on engineering judgment and earthquake experience rather than an explicit fragility calculation. The next component involved in the TE damage state with the least HCLPF capacity is the Emergency Diesel Generator, which was selected for review of its fragility calculation.

The fragility calculation associated with the MPS3 EGE Building was found to be consistent with EPRI NP-6041-SL. Analyses performed considered failures associated with sliding including consideration of attached piping, diaphragm failure, shear wall failure, and wall footing failure. It was noted during the review that live loads were not considered in the fragility analysis, as prescribed on page 6-7 of EPRI NP-6041-SL, for PWRs. However, based on experience, the live loads constitute only a small amount of the overall loads in operating nuclear power plant structures. Moreover, lack of consideration of live loads for the calculation of fragility is conservative; for sliding capacity and structural capacity of the embedded members resisting the soil pressures, the lack of live loads will decrease the resisting friction force. Moreover, for vertical shear walls, neglecting the vertical loads in calculating the shear and moment capacity of the wall, as is the case in the EGE shear wall evaluations, will result in reduction of the structural shear and moment capacity, and is therefore conservative. The review noted that the capacity of the EGE is controlled by the bending capacity of the wall footings. Review of the applicable factors used to compute the median acceleration capacity showed that these factors are properly considered in the evaluation of fragility. Therefore, the fragility evaluation and the resulting HCLPF capacity are considered reasonable for the EGE Building.

The RWST is a vertical flat bottom fluid storage tank. It was noted that the capacity of the tank has been evaluated generally in a manner consistent with the EPRI NP-6041-SL Appendix H (Reference C7.4) guidelines with two deviations. First, a median damping of 7% was assumed for the evaluation of seismic impulsive response of the tank, which is not consistent with the recommended damping ratio of 5% in Appendix H of EPRI NP-6041-SL (Reference C7.4). The second deviation was that the equation used to calculate the buckling capacity of the tank shell is not consistent with elephant foot buckling approach recommended in Appendix H of EPRI NP-6041. These deviations were further reviewed by Dominion and discussed with Dr. R. P. Kennedy. It was concluded that a reduction in capacity resulting from these deviations was offset by the high uncertainties assigned in the fragility calculation of the RWST such that its HCLPF capacity would not change appreciably (Reference C7.30).

The fragility calculation for the emergency diesel generator is based on data provided in the original vendor's seismic qualification report, which identified the most critically stressed item of the emergency diesel generator system to be the Lube Oil Cooler's anchor bolts. Therefore, the fragility of these anchor bolts is calculated and reported as the fragility of the emergency diesel generator system. Adjustment factors were calculated to estimate the median acceleration capacity. Factors were considered for strength, ductility, equipment qualification, spectral shape, damping, modeling, mode combination, earthquake component combination, structural response, and soil-structure interaction. The applicable factors used to compute the median acceleration capacity of the emergency diesel generator are properly considered in the evaluation of fragility. In response to the NRC's recommendations in the Risk Evaluation Report (Reference C7.22), MPS3 replaced the anchor bolts of the diesel generator oil coolers with higher strength bolts.

An additional review of the fragility analyses prepared in support of the MPS3 IPEEE was performed by Dr. R.P. Kennedy of RPK Structural Mechanics Consulting (Reference C7.9). This review concluded that the fragility calculations were consistent with the accepted methodology used during the time the analyses were performed. This review noted that the fragility calculations are of sufficient quality to be used for screening purposes. The HCLPF capacities reported were stated to have reasonable basis. This review also found that the fragility results also seem reasonable and have been developed consistent with the methodology and requirements provided in NUREG-1407. Dr. Kennedy did not identify any open issues in the fragility calculations. The full report documenting this review (Reference C7.9) is provided as Attachment C-1 to this appendix.

Compliance with NUREG-1407

Based on the material presented above, the methodology used to perform fragility calculations is generally consistent with NUREG-1407 and EPRI NP-6041.

Adequacy for Screening

The fragility calculations methodology and results are adequate for screening purposes.

C5.7 SYSTEM MODELING

Methodology Used

As described in Section C1.0, the MPS3 PSS formed the basis of the MPS3 IPE

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(Reference C7.14) and subsequent IPEEE. A plant functional event tree was developed in the MPS3 IPE as described in Section 3.1.2 of the MPS3 IPE. A support state event tree was developed based on the support state methodology (Section 3.1.4, MPS3 IPE). A list of systems was developed based on the required safety functions from the event tree (reactor trip, reactor coolant system inventory control, core cooling, containment cooling, and radioactivity scrubbing). Fault trees were developed for each support state modeled in the event trees. Random failures, test and maintenance outages, human errors, and common cause failures were analyzed to determine unavailabilities for each plant system.

Section 2.5.1 of the MPS3 PSS contains the seismic risk analysis. The modeling of accident sequences in the seismic risk analysis was accomplished by using internal initiating events already identified and determining their applicability as seismic-induced initiators following an earthquake. This effort, in addition to an analysis of seismic-induced initiators, identified four categories of seismic initiators: large break LOCA, small break LOCA, loss of offsite power (LOOP) transient, and LOCA with containment bypass. The seismic initiators yielded 19 discrete plant damage states. Core melt fault trees were developed for the 19 plant damage states, with input taken from the plant level event trees for internal initiators.

According to Section 2.5.1.2 of the MPS3 PSS, non-seismic random failures were also considered to occur as the result of an earthquake. Unlike the seismic failures, the probabilities of the non-seismic random failures were kept constant with increasing g level. Human actions are addressed in Section 3.3 of the MPS3 IPE. Additional information on human actions is included in Appendix D to the IPE, and in Section 2.2.3.2 and Appendix 2D of the MPS3 PSS (Reference C7.25).

The treatment of non-seismic failures and human actions in the Plant IPEEE is consistent with Section 3.1.2, Part 4, of NUREG-1407.

Section 3.2.5.1 of NUREG-1407 states that 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. As MPS3 IPEEE was developed using a seismic PRA, multiple paths were analyzed; this meets the intent of Section 3.2.5.1.

Compliance with NUREG-1407

Based on the review above, the system modeling is consistent with NUREG-1407.

Adequacy for Screening

The PSS system modeling results are adequate for screening purposes.

C5.8 CONTAINMENT PERFORMANCE

Methodology Used

As described in Section C1.0, the MPS3 PSS formed the basis of the MPS3 IPE (Reference C7.14) and subsequent IPEEE. Sections 4.4 through 4.6 of the MPS3 IPE address containment performance. Per NUREG-1407, Section 3.1.2, the use of an existing seismic PRA to address the seismic IPEEE is acceptable provided the PRA reflects the current as-built and as-operated condition of the plant and that some of the deficiencies of past PRAs such as containment performance are addressed. The section then goes on to state that licensees should ensure that the performance of containment and containment systems are addressed in accordance with NUREG-1407, Section 3.2.6. Per Section 3.2.6 of NUREG-1407, the evaluation of containment performance during a seismic event should address containment integrity, containment isolation, prevention of bypass functions, and specific systems that maintain containment integrity.

A full structural analysis of MPS3 containment was performed to identify containment failure modes and failure pressure. The analysis considered containment shell, basemat, major penetrations, containment equipment hatch, and personnel air lock. Variability in material properties, analysis methods, and construction were also accounted for.

In a NRC RAI, MPS3 was requested to provide a discussion of the containment performance deficiencies of past PRAs per NUREG-1407, Section 3.1.2. MPS3 provided a response to the RAI on June 6, 1994 (Reference C7.16) providing the results of their review and concluding that the seismic PRA did not uncover any other seismically unique containment performance vulnerabilities.

Section 4.6 of the MPS3 IPE indicates that the containment recirculation spray and quench spray systems are required, in general, to ensure containment integrity. MPS3 analyzed the containment recirculation spray system, quench system, and containment isolation failure (bypass failure and isolation function failure).

The fault tree analysis of the quench spray system is discussed in Section 2.3.3.9 of the MPS3 PSS. The fault tree analysis of the containment recirculation system is discussed in Section 2.3.3.14 of the MPS3 PSS. In addition, a containment response analysis is described in detail in Section 4.4 of the MPS3 PSS.

As discussed in Section 4.6 of the MPS3 IPE, containment isolation failure was analyzed and concluded to be an unlikely failure mode.

The NRC SER (Reference C7.17) was reviewed. No deficiencies were identified in the SER. The NRC SER states that "the licensee's containment performance analyses for seismic and internal fire events appear to have considered important severe phenomena and are consistent with the intent of Supplement 4 to Generic

Letter 88-20." Furthermore, Section 2.5 of the Appendix 1 of the NRC's SER states that "the staff agrees that there is adequate seismic ruggedness for the containment heat removal function, and that the containment systems and structures possess adequate strength so that no seismically unique vulnerabilities exist."

The containment evaluation meets the requirements of Section 3.2.6 of NUREG-1407 (as specified in Section 3.1.2, Part 6) to evaluate the containment integrity, isolation, and bypass functions to identify vulnerabilities that involve early failure of the containment functions.

Compliance with NUREG-1407

The methodology used to address Containment performance is in compliance with NUREG-1407.

Adequacy for Screening

The Containment performance results are adequate for screening purposes.

C5.9 PEER REVIEW

Methodology Used

The peer review requirements are outlined in Section 7 of NUREG-1407, which recommends that the peer review be conducted by individuals who are not associated with the initial evaluation, and that the peer review team have combined experience in the areas of system engineering and specific external events.

As stated in Section C5.5, the structural plant walkdowns were led by D. A. Wesley of Structural Mechanics Associates. The team that performed the walkdown of the electrical and mechanical components was led by R. D. Campbell of Structural Mechanics Associates. From Northeast Utilities, three individuals participated in the seismic walkdowns. After the SPRA report was submitted, NRC contracted Dr. John Reed of Jack Benjamin Associates to perform a walkdown for the purpose of an Independent Review.

Additionally, per IPE submittal letter (Reference C7.14), the MPS3 PSS was subjected to four independent expert reviews. They were: 1) expert panel review, 2) NRC review (Reference C7.22), 3) LLNL review (Reference C7.23), and 4) BNL review (Reference C7.24).

Based on the above, the peer review was conducted by qualified personnel who were not associated with the initial evaluations, and had the necessary combined experience in the areas of system engineering and specific external events. Therefore, the reviews are consistent with the requirements of NUREG-1407.

Appendix C

Compliance with NUREG-1407

Based on the material presented above, the peer review meets the requirements of NUREG-1407.

Adequacy for Screening

The peer review is adequate for screening purposes.

C6.0 CONCLUSION

MPS3 was defined as a focused scope plant for IPEEE in NUREG-1407 (Reference C7.3). The IPEEE submittal provided a previously performed Seismic Probabilistic Safety Study (PSS) (Seismic Probabilistic Risk Assessment (SPRA)).

Based on a comparison of the spectra, the IHS (anchored to 0.26g) exceeds the GMRS in the 1 to 10 Hz range. In order to complete the screening process in accordance with the guidance in EPRI 1025287 (SPID), the MPS3 IPEEE was subjected to an adequacy review and concluded that the IPEEE is of sufficient quality for screening purposes and the risk insights gained from the IPEEE remain valid under the current plant configuration.

A soil failure analysis has been completed with satisfactory results. The full scope detailed review of relay chatter required in SPID Section 3.3.1 has not been completed. The detailed relay chatter review will be completed on the same schedule as the high frequency confirmation, consistent with the schedule identified in the NEI letter to NRC dated October 3, 2013 (Reference C7.5).

Based on the IPEEE adequacy review performed and documented herein, and the comparison of IHS and GMRS, MPS3 screens out from performing a risk assessment consistent with the guidance contained in the SPID.

Appendix C

C7.0 REFERENCES

C7.1. U. S. Nuclear Regulatory Commission (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.

C7.2. Electric Power Research Institute (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," February 28, 2013.

C7.3. NRC NUREG-1407, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities," June 1991.

C7.4. EPRI Report NP-6041-SL, "A Methodology for Assessment of Nuclear Plant Seismic Margin (Revision 1)," August 1991.

C7.5. Kimberly A. Keithline, NEI letter to David L. Skeen, NRC, "Relay Chatter Reviews for Seismic Hazard Screening," Document No. ML13281A308, October 3, 2013.

C7.6. Anthony R. Pietrangelo, NEI letter to David L. Skeen, NRC, "Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations," Document No. ML13101A379, April 9, 2013.

C7.7. Eric J. Leeds, NRC letter to Joseph E. Pollock, NEI, "Electric Power Research Institute Final Draft Report XXXXXX, "Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic," as an Acceptable Alternative to the March 12, 2012, Information Request for Seismic Reevaluations," dated May 7, 2013.

C7.8. NRC Report, "Recommendations for Enhancing Reactor Safety in the 21st Century-The Near Term Task Force Review of Insights From the Fukushima Dai-Ichi Accident," July 12, 2011 (ML111861807).

C7.9. RPK Structural Mechanics Consulting (Dr. R. P. Kennedy) Report RPK-140208.1, "Adequacy Review Millstone Unit 2 HCLPF Capacity Calculations," dated February 8, 2014. (Attachment C-1)

C7.10. Structural Mechanics Associates Millstone Unit 3 PRA Calculation, "Development of Spectral Shape Factors" (Doc #10 in Reference C7.9).

C7.11. Structural Mechanics Associates Report NTS/SMA 20601.01-R2, "A Program to Determine the Capability of the Millstone 3 Nuclear Power Plant to Withstand Seismic Excitation Above the Design SSE" dated November, 1984.

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C7.12. Sargent & Lundy, LLC Report SL-012306, "Millstone Unit 3 IPEEE Adequacy Evaluation," March 2014.

C7.13. Letter A09683, J.F. Opeka to NRC Control Desk, *Response to Generic Letter 88-20, Supplement 4; Revised Response to Generic Letter 88-20, Supplement 1, Individual Plane Examination (IPE) for Severe Accident Vulnerabilities*, dated December 23, 1991.

C7.14. Letter B13596, E.J. Mroczka to NRC Document Control Desk, *Response to Generic Letter 88-20, Individual Plant Examination for Severe Accident Vulnerabilities Summary Report*, dated August 31, 1990.

C7.15. V.L. Rooney, NRC letter to J.F. Opeka, NNECO "Request for Additional Information Concerning Review of IPEEE for External Events (TAC No. M83643)," dated April 6, 1994.

C7.16. Opeka, J. F. letter to the U.S. Nuclear Regulatory Commission, "Letter No. B14863, Millstone Nuclear Power Station, Unit No. 3 Response to Request for Additional Information Concerning the Review of the Individual Plant Examination for External Events {TAC No. M83643}," June 6, 1994.

C7.17. NRC letter to Martin L. Bowling, JR, "Millstone Nuclear Power Station Unit No. 3 – Individual Plant Examination of External Events (IPEEE) (TAC NO. M83643)," May 26, 1998.

C7.18. Dominion Nuclear Connecticut, Inc. Letter to U. S. NRC Document Control Desk, "Millstone Power Station Units 2 and 3, Report in Response to March 12, 2012 Information Request Regarding Seismic Aspects of Recommendation 2.3," Serial No. 12-205H, dated November 27, 2012.

C7.19. Millstone Unit 3 Final Safety Analysis Report (FSAR) Rev.17.5.

C7.20. NUREG/CR-0098, "Development of Criteria for Seismic Review of Selected Nuclear Power Plants," May 1978.

C7.21. Not Used.

C7.22. U. S. Nuclear Regulatory Commission, "Millstone 3 Risk Evaluation Report," NUREG-1152, August 1985.

C7.23. A. A. Garcia et. Al, "A Review of the Millstone 3 Probabilistic Safety Study," NUREG/CR-4142, April 1986.

C7.24. M. Khatib-Rahbar, et al, "Review and Evaluation of the Millstone Unit 3 Probabilistic Safety Study: Containment Failure Modes, Radiological Source – Terms and Offsite Consequences," NUREG/CR-4143, September 1985.

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C7.25. "Millstone Unit 3 Probabilistic Safety Study," August 1983.

C7.26. Report No. SMA 20601.01-R1-0, "Seismic Fragilities of Structures and Components at the Millstone 3 Nuclear Power Station" Amendment 2, Structural Mechanics Associates, April 2, 1984.

C7.27. "Seismic Fragility Evaluation of Millstone Unit 3 Structures and Components," Stone and Webster Corporation, May 1983.

C7.28. EPRI Report TR-103959, "Methodology for Developing Seismic Fragilities," Final Report, Jack Benjamin and Associates and RPK Structural Mechanics Consulting for Electric Power Research Institute, June 1994.

C7.29. Editing Board and Task Groups of the Committee on Nuclear Structures and Materials of the Structural Division of the American Society of Civil Engineers, "Structural Analysis and Design of Nuclear Plant Facilities"

C7.30. Engineering Technical Evaluation ETE-CEM-2014-0001, Rev. 0, "Development of Guidance and Information for NRC's Fukushima Near-term Task Force Recommendation 2.1 – Seismic"

C8.0 ATTACHMENT

C-1 RPK Structural Mechanics Consulting Report RPK-140208.1, "Adequacy Review – Millstone Unit 3 Fragility Calculations" dated February 8, 2014 – 9 pages

Adequacy Review
Millstone Unit 3 Fragility Calculations

Robert P. Kennedy
February 8, 2014

1. Introduction

I have performed an adequacy review of the Millstone Unit 3 fragility calculations as requested in Section 3.3.1 "IPEEE Adequacy" of Ref. 1. The purpose of this review was to assess the adequacy of IPEEE submitted fragilities and HCLPF capacities for use in screening against the current estimated GMRS for Millstone Unit 3.

In conducting my review, I have reviewed all of the documentation listed on the attached document review list entitled *Unit 3 BDB MPS IPEEE Adequacy Review*. My reference to these documents are in terms of the Document Number (Doc #) in the first column of this list.

Doc #1 summarizes the seismic fragility calculation performed for structures and components at Millstone Unit 3. These calculations were performed by Structural Mechanics Associates (SMA) in 1983 through March 1984. They were performed as a part of a Probabilistic Seismic Risk Assessment (PSRA) requested by the NRC and the Advisory Committee on Reactor Safety (ACRS) in support of the licensing of Millstone Unit 3. These results were presented to both NRC and ACRS at that time.

Doc #2 converts the fragility median and logarithmic standard deviation estimates into High-Confidence-Low-Probability-of-Failure (HCLPF) Seismic Margin Estimates for each Structure, System, and Component (SSC) considered. Doc #2 also uses the Boolean expressions derived from fault trees given in the Unit 3 PSRA for the dominant four seismic initiated accident sequences to determine Plant Damage State HCLPF seismic margin capacities. It was mutually agreed with the NRC staff to define the HCLPF seismic margin capacities at approximately 95% confidence of less than about 5% probability of failure. This initial usage of the HCLPF seismic margin capacity definition for Millstone Unit 3 (together with its use for Limerick at the same time) became the basis for the now common usage of the HCLPF seismic margin. The results of Doc #2 were also presented to both the NRC and ACRS in 1984 as part of licensing hearings.

Subsequently, the results presented in Docs # 1 and 2 were submitted in 1990 in Doc #3 to the NRC to satisfy the IPEEE seismic review requirements. Doc #4 responds to the NRC request for additional information on the Millstone Unit 3 IPEEE submittal. Doc #5 provides the NRC Staff Evaluation Report of the Millstone Unit 3 IPEEE submittal. A very positive evaluation was received. The staff concluded "that the licensee's IPEEE

28625 Mountain Meadow Road, Escondido, CA 92026
(760)751-3510 • (760) 751-3537 (Fax)
email: bob@rpkstruct.com

process is capable of identifying the most likely severe accidents and severe accident vulnerabilities."

Docs #6 and 7 did not materially add to my understanding of the seismic fragilities computed for Millstone Unit 3 and were therefore only briefly reviewed.

The Millstone Unit 3 seismic fragilities were computed following the Separation of Variables approach which was subsequently extensively documented in the EPRI Methodology for Developing Seismic Fragilities report (Ref. 2). In fact, the Millstone Unit 3 seismic fragilities study was one of the more than a dozen PSRA studies used to develop the seismic fragility Separation of Variability methodology documented in Ref. 2. In this methodology, median factors of conservatism, and estimates of logarithmic standard deviation β are made for each of the important parameters used in the existing seismic evaluations. These median factors and logarithmic standard deviation β estimates are then combined in accordance with the Separation of Variability methodology to obtain median and variability fragility estimates. For use in the Millstone Unit 3 PSRA, this methodology is summarized in Doc. 1.

Doc #8 through 15 provide the computation of the various median factors of conservatism estimates and logarithmic standard deviation β estimates used in the computation of the individual component fragilities. Docs # 16 through 41 then use these factors to compute the fragility estimates for individual components. Doc #16 through 41 only represent the sample of component fragility calculations which I reviewed. However, this sample includes all of the reported dominant contributors to seismic risk documented in Doc #2.

In addition to reviewing the 41 documents listed in the attached document list, I reviewed the SMA fragility calculations for the following structures:

- Auxiliary Building
- Emergency Generator Building
- Control Building

Fragilities for the lowest capacity structure failure modes are summarized in Tables 4-7 through 4-18 of Doc #1. I carefully reviewed structure failure mode fragilities with reported median capacities of 1.2g and lower. I spot checked the fragility calculations for higher capacity failure modes for the above three buildings.

2. Overall Findings

The Millstone Unit 3 computed seismic fragilities are consistent with the state of practice used for computing seismic fragilities on over a dozen nuclear power plants during the 1980 through 1986 time frame. During this time period, seismic fragilities were generally estimated by scaling existing seismic evaluation results. Only a limited number of new calculations were performed. The emphasis was on estimating median factors of conservatism and variabilities (logarithmic standard deviations β) associated with each of the important parameters used in the existing seismic evaluations. Many of the estimates depended heavily on the expertise and judgement of the fragility analyst.

Doc #1 provides a very good overall summary of the seismic fragility analyses performed. Details are provided in the various fragility calculation packages. Several hundreds of detailed calculation pages exist. I reviewed the sample defined in the attached documentation list.

Based on my sample review, it is my judgement that Millstone Unit 3 has retained the fragility analysis calculations used in the 1984 PSRA. In some cases, these calculations are somewhat deficient in cross-referencing of data between individual calculation packages. However, with sufficient review effort, all of the necessary information for review of a calculation can be found. Therefore, in my judgement, the fragility calculations are of adequate quality to support the use of the Doc #1 fragilities and Doc #2 HCLPF capacities in a Fukushima Near-Term 2.1 Screening Evaluation.

All of the HCLPF capacities reported in Doc #2 appear to have a reasonable calculation basis. All of the fragility results are reasonable in my judgement. These calculations have been developed consistent with the methodology and requirements provided in NUREG-1407, Section 3.1 and are determined to be adequate for GMRS screening purposes using the IPEEE HCLPF spectrum.

Detailed comments on the use of the Plant Damage State HCLPF capacities reported in Table 3-2 of Doc #2 are presented in the following two sections.

3. Comment on Plant Damage State HCLPF Capacity for Millstone Unit 3

Individual component HCLPF capacities for key structures and components are reported in Table 2-1 of Doc #2. These individual component fragilities are combined using the Boolean expressions presented in Section 3.1.1 of Doc #2 to obtain Plant Damage State fragilities for four seismic induced plant damage states. Plant Damage State fragilities and HCLPF capacities are reported in Table 3-2 of Doc #2.

The lowest Plant Damage State HCLPF capacity reported in Table 3-2 is for Damage State TE: Transient (loss of offsite power) with Early Core Melt. This reported HCLPF capacity is 0.26g. The other three Damage States have much higher HCLPF capacities.

The reported HCLPF capacity of 0.26g for Damage State TE results from either (1) the wall footing failure of the Emergency Generator Enclosure Building which is assumed to result in failure of power cables passing through the stem of this footing, or (2) failure of the oil cooler anchor bolts anchoring the oil cooler to the Emergency Diesel Generator. Both of these components have individual HCLPF capacities of 0.30g. However, because of the Boolean expression 'OR' combination of these two independent failure modes, the TE Damage State HCLPF is driven down to 0.26g which is less than the 0.30g HCLPF computed for either component alone.

If either of these two component failure modes are eliminated, the HCLPF capacity becomes 0.30g for the controlling TE Damage State because the next lowest HCLPF capacity leading to Damage State TE is the Control Building Diaphram failure with a HCLPF capacity of 0.39g which is too high to reduce the TE Damage State HCLPF below that of the remaining single component with the 0.30g HCLPF.

In accordance with Plant Design Change Request MP3-86-126, Millstone Unit 3 replaced the low strength anchor bolts anchoring the oil cooler to the Emergency Diesel Generator with high strength anchor bolts. This change was made as a result of the seismic risk study presented in Doc #2 and raises the Emergency Diesel Generator HCLPF capacity sufficiently high that it no longer contributes to the Plant Damage State HCLPF.

Based on the above paragraph, my judgement is that the HCLPF capacity for Millstone Unit 3 should be reported to be:

$$HCLPF = 0.30g \qquad (1)$$

4. HCLPF Screening Response Spectrum

The HCLPF capacity discussed in the previous section is reported in terms of the Peak Ground Acceleration (PGA). However, for screening purposes, one must compare the HCLPF response spectrum with the GMRS response spectrum.

Section 3.3.1 of Doc #1 reports that seismic fragility estimates were based on a site-specific response spectrum defined at 10% damping in Figure 3-1 of Doc #1. However, since the GMRS response spectrum is defined at 5% damping, the HCLPF response spectrum should also be defined at 5% damping for comparison purposes.

Doc #15 shows both the 10% and 5% site specific response spectra used in the fragility assessment on Pages 8 and 9 of Doc #15. The plotted site specific response spectra are anchored to the Millstone Unit 3 PGA of 0.17g.

The 5% damped HCLPF response spectrum can be computed from:

$$SA_{5\%,f} = AF_{5\%,f} * PGA_{HCLPF} \qquad (2)$$

where $AF_{5\%,f}$ is the ratio of the 5% damped spectral acceleration $SA_{5\%,f}$ at frequency f to the PGA. A Methodology calculation Page M-15 attached as the next to last page of Doc #10 *Development of Spectral Shape Factor* reports the AF values used in the seismic fragility analyses for 5%, 7%, and 10% damping. I have confirmed that the reported AF values shown on calculation Page M-15 are consistent with the site specific spectra plots shown in Doc #15. Table 1 herein tabulates the 5% damped $AF_{5\%,f}$ values shown on Methodology Calculation Page M-15. Table 1 also shows the site specific spectral accelerations computed by myself from these AF values for PGA values of 0.17g, 0.26g, and 0.30g. Log-Log interpolation can be used to obtain spectral accelerations at intermediate frequencies.

I recommend the use of the spectral acceleration values shown in Table 1 for a HCLPF PGA of 0.30g be used for HCLPF/GMRS Screening purposes.

References

1. EPRI 1025287, *Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1-Seismic*, 2013

2. EPRI TR-103959, *Methodology for Developing Seismic Fragilities,* July 1994

Table 1
5% Damped Site Specific Spectral Accelerations

Frequency f (Hz)	$AF_{5\%}$	Spectral Accelerations (g)		
		PGA=0.17g	PGA=0.26g	PGA=0.30g
0.5	0.25	0.042	0.065	0.075
1.0	0.60	0.102	0.156	0.180
1.33	0.82	0.139	0.213	0.246
2.5	1.76	0.299	0.458	0.528
3.3	2.10	0.357	0.546	0.630
5.0	2.18	0.371	0.567	0.654
7.7	2.18	0.371	0.567	0.654
10.0	1.94	0.330	0.504	0.582
12.5	1.51	0.257	0.393	0.453
15.3	1.31	0.223	0.341	0.393
20.0	1.12	0.190	0.291	0.336
25.0	1.10	0.187	0.286	0.330
100.0	1.00	0.170	0.260	0.300

Unit 3 BDB MPS IPEEE Adequacy Review

	Document #	eRoom Doc Filename	Title
1	SMA 20601.01 R1-0	MP3 Seismic Fragilities Report	Seismic Fragilities of Structures and Components at the Millstone 3 Nuclear Power Station
2	NTS/SMA 20601.01-R2	NTS-SMA 20601.01-R2 MP3 Seismic Excitation Above Design SSE	A Program to Determine the Capability of the Millstone 3 Nuclear Power Plant to Withstand Seismic Excitation above the Design SSE
3	B13596, Dated 7/31/90	MP3 B13596 Response to GL 88-20 Summary Report Submittal 8-31-90	Millstone Nuclear Power Station Unit # 3 Response to Generic Letter 88-20 Individual Plant Examination for Severe Accident Vulnerabilities Summary Report Submittal
4	B14863 Dated 6/6/1994	MP3 B14863 Respnse to IPEEE RAI_ 6-6-94	Response to Request for Additional Information Concerning the Review of the IPEEE for External Events
5	A13809 Dated 5/26/1998	MP3 IPEEE SER_A13809	Individual Plant Examination of External Events (TAC # M83643)
6	Safe Shutdown Path Summary Table Draft B	Safe Shutdown Path Summary Table Draft B	Preferred Safe Shutdown Paths for Millstone 3
7	Seismic FragilitiesFor Selected M3 Structures & Equip	Seismic FragilitiesFor Selected M3 Structures & Equip	Seismic FragilitiesFor Selected M3 Structures & Equip (Draft) (Structural Mechanics Associates)
8	MP3 PRA Ductility Factors	MP3 PRA Ductility Factors	Development of Ductility Factors (Structural Mechanics Associates)
9	MP3 PRA Seismic Qaulification Method Factors	MP3 PRA Seismic Qaulification Method Factors	Development of Qualification Method Factors (Structural Mechanics Associates)
10	MP3 PRA Spectral Shape Factors	MP3 PRA Spectral Shape Factors	Development of Spectral Shape Factors (Structural Mechanics Associates)
11	MP3 PRA Modeling Error Factors	MP3 PRA Modeling Error Factors	Development of Modeling Error Factors (Structural Mechanics Associates)
12	MP3 PRA Mode Combination Factors	MP3 PRA Mode Combination Factors	Development of Mode Combination Factors (Structural Mechanics Associates)
13	MP3 PRA Earthquake Component Combination Factors	MP3 PRA Earthquake Component Combination Factors	Development of Earthquake Component Combination Factors (Structural Mechanics Associates)
14	MP3 PRA Damping Factors	MP3 PRA Damping Factors	Development of Damping Factors (Structural Mechanics Associates)
15	MP3 PRA Structural Response Factors	MP3 PRA Structural Response Factors	Development of Structural Response Factors (Structural Mechanics Associates)
16	MP3 PRA West. Supplied Equip (Reactor Internals)	MP3 PRA West. Supplied Equip (Reactor Internals)	Evaluation of Westinghouse Supplied Equipment (Reactor Internals) (Structural Mechanics Associates)
17	MP3 PRA West. Supplied Equip (Control Rod Drive)	MP3 PRA West. Supplied Equip (Control Rod Drive)	Evaluation of Westinghouse Supplied Equipment (Control Rod Drive) (Structural Mechanics Associates)

18	**MP3 PRA West. Supplied Equip (Reactor Incore Instrumentation)**	**MP3 PRA West. Supplied Equip (Reactor Incore Instrumentation)**	Evaluation of Westinghouse Supplied Equipment (Reactor Incore Instrumentation) (Structural Mechanics Associates)
19	**MP3 PRA West. Supplied Equip (Pressurizer Relief Tank)**	**MP3 PRA West. Supplied Equip (Pressurizer Relief Tank)**	Evaluation of Westinghouse Supplied Equipment (Pressurizer Relief Tank) (Structural Mechanics Associates)
20	**MP3 PRA West. Supplied Equip (Residual Heat Removal Pump)**	**MP3 PRA West. Supplied Equip (Residual Heat Removal Pump)**	Evaluation of Westinghouse Supplied Equipment (Residual Heat Removal Pump) (Structural Mechanics Associates)
21	**MP3 PRA West. Supplied Equip (Residual Heat Removal Heat Exchangers)**	**MP3 PRA West. Supplied Equip (Residual Heat Removal Heat Exchangers)**	Evaluation of Westinghouse Supplied Equipment (Residual Heat Removal Heat Exchangers) (Structural Mechanics Associates)
22	**MP3 PRA West. Supplied Equip (Reactor Trip Switchgear)**	**MP3 PRA West. Supplied Equip (Reactor Trip Switchgear)**	Evaluation of Westinghouse Supplied Equipment (Reactor Trip Switchgear) (Structural Mechanics Associates)
23	**MP3 PRA BOP Equip (Containment Recirculation Coolers)**	**MP3 PRA BOP Equip (Containment Recirculation Coolers)**	Evaluation of Balance of Plant Equipment (Containment Recirculation Coolers) (Structural Mechanics Associates)
24	**MP3 PRA BOP Equip (BOP Piping)**	**MP3 PRA BOP Equip (BOP Piping)**	Evaluation of Balance of Plant Equipment (BOP Piping) (Structural Mechanics Associates)
25	**MP3 PRA BOP Equip (Quench Spray Pump)**	**MP3 PRA BOP Equip (Quench Spray Pump)**	Evaluation of Balance of Plant Equipment (Quench Spray Pump) (Structural Mechanics Associates)
26	**MP3 PRA BOP Equip (Component Cooling Water Pump**	**MP3 PRA BOP Equip (Component Cooling Water Pump**	Evaluation of Balance of Plant Equipment (Component Cooling Water Pump) (Structural Mechanics Associates)
27	**MP3 PRA BOP Equip (Reactor Plant Component Cooling Surge Tank)**	**MP3 PRA BOP Equip (Reactor Plant Component Cooling Surge Tank)**	Evaluation of Balance of Plant Equipment (Reactor Plant Component Cooling Surge Tank) (Structural Mechanics Associates)
28	**MP3 PRA BOP Equip (Motor Driven Aux Feedwater Pump)**	**MP3 PRA BOP Equip (Motor Driven Aux Feedwater Pump)**	Evaluation of Balance of Plant Equipment (Motor Driven Aux Feedwater Pump) (Structural Mechanics Associates)
29	**MP3 PRA BOP Equip (ESF Logic Panel)**	**MP3 PRA BOP Equip (ESF Logic Panel)**	Evaluation of Balance of Plant Equipment (ESF Logic Panel) (Structural Mechanics Associates)
30	**MP3 PRA BOP Equip (Sequencer)**	**MP3 PRA BOP Equip (Sequencer)**	Evaluation of Balance of Plant Equipment (Sequencer) (Structural Mechanics Associates)
31	**MP3 PRA BOP Equip (4160 Volt Switchgear)**	**MP3 PRA BOP Equip (4160 Volt Switchgear)**	Evaluation of Balance of Plant Equipment (4160 Volt Switchgear) (Structural Mechanics Associates)
32	**MP3 PRA BOP Equip (Emergency Diesel Generator)**	**MP3 PRA BOP Equip (Emergency Diesel Generator)**	Evaluation of Balance of Plant Equipment (Emergency Diesel Generator) (Structural Mechanics Associates)

33	**MP3 PRA BOP Equip (125VDC Batteries)**	**MP3 PRA BOP Equip (125VDC Batteries)**	Evaluation of Balance of Plant Equipment (125VDC Batteries) (Structural Mechanics Associates)
34	**MP3 PRA BOP Equip (125VDC Distribution Switchgear)**	**MP3 PRA BOP Equip (125VDC Distribution Switchgear)**	Evaluation of Balance of Plant Equipment (125VDC Distribution Switchgear) (Structural Mechanics Associates)
35	**MP3 PRA BOP Equip (120VAC Converters)**	**MP3 PRA BOP Equip (120VAC Converters)**	Evaluation of Balance of Plant Equipment (120VAC Converters) (Structural Mechanics Associates)
36	**MP3 PRA BOP Equip (480VAC Motor Control Centers)**	**MP3 PRA BOP Equip (480VAC Motor Control Centers)**	Evaluation of Balance of Plant Equipment (480VAC Motor Control Centers) (Structural Mechanics Associates)
37	**MP3 PRA BOP Equip (RHR Pumps)**	**MP3 PRA BOP Equip (RHR Pumps)**	Evaluation of Balance of Plant Equipment (RHR Pumps) (Structural Mechanics Associates)
38	**MP3 PRA BOP Equip (Steam Generator)**	**MP3 PRA BOP Equip (Steam Generator)**	Evaluation of Balance of Plant Equipment (Steam Generator) (Structural Mechanics Associates)
39	**MP3 PRA BOP Equip (RHR Heat Exchangers)**	**MP3 PRA BOP Equip (RHR Heat Exchangers)**	Evaluation of Balance of Plant Equipment (RHR Heat Exchangers) (Structural Mechanics Associates)
40	**MP3 PRA BOP Equip (Containment Recirculation Coolers)**	**MP3 PRA BOP Equip (Containment Recirculation Coolers)**	Evaluation of Balance of Plant Equipment (Containment Recirculation Coolers) (Structural Mechanics Associates)
41	**RWST Seis Frag Calc**	**RWST Seis Frag Calc**	RWST Seis Frag Calc