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REF 10 CFR 50.54(f)

March 27, 2014

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

SUBJECT: Comanche Peak Nuclear Power Plant, Docket Nos. 50-445 AND 50-446, Seismic Hazard and Screening Report (CEUS Sites), Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident

REFERENCES:

1. NRC Letter, Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, dated March 12, 2012
2. NEI Letter, Proposed Path Forward for NTTF Recommendation 2.1: Seismic Re-evaluations, dated April 9, 2013, ADAMS Accession No. ML13101A379
3. NRC Letter, Electric Power Research Institute Final Draft Report, "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, ADAMS Accession No. ML13106A331
4. EPRI Report 1025287, Seismic Evaluation Guidance, Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic, ADAMS Accession No. ML12333A170
5. NRC Letter, Endorsement of EPRI Final Draft Report 1025287, "Seismic Evaluation Guidance," dated February 15, 2013, ADAMS Accession No. ML12319A074
6. Luminant Power's Letter TXX-13138, Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Seismic Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident - 1.5 Year Response for CEUS Sites, dated September 12, 2013

Dear Sir or Madam:

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

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In Reference 2, the Nuclear Energy Institute (NEI) requested NRC agreement to delay submittal of the final CEUS Seismic Hazard Evaluation and Screening Reports so that an update to the Electric Power Research Institute (EPRI) ground motion attenuation model could be completed and used to develop that information. NEI proposed that descriptions of subsurface materials and properties and base case velocity profiles be submitted to the NRC by September 12, 2013 (Reference 6), with the remaining seismic hazard and screening information submitted by March 31, 2014. NRC agreed with that proposed path forward in Reference 3.

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

The attached Seismic Hazard and Screening Report for Comanche Peak Nuclear Power Plant (CPNPP) provides the information described in Section 4 of Reference 4 in accordance with the schedule identified in Reference 2. Based on the results of CPNPP's Seismic Hazard and Screening Report, no further evaluations or interim actions are required or will be performed.

This letter contains no new regulatory commitments.

If you have any questions regarding this report, please contact Carl B. Corbin at (254) 897-0121 or carl.corbin@luminant.com.

I state under penalty of perjury that the foregoing is true and correct.

Executed on March 27, 2014.

Sincerely,

Luminant Generation Company LLC

Rafael Flores

By: Fred W. Madden
Fred W. Madden
Director, External Affairs

Attachment Comanche Peak Nuclear Power Plant Seismic Hazard and Screening Report

c - Eric J. Leeds, Director, Office of Nuclear Reactor Regulation
Marc L. Dapas, Region IV
Jessica A. Kratchman, NRR/JLD/PMB
Balwant K. Singal, NRR
Resident Inspectors, Comanche Peak

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 Nuclear Regulatory Commission (NRC) established a Near Term Task Force (NTTF) to conduct a systematic review of NRC processes and regulations and to determine if the agency should make additional improvements to its regulatory system. The NTTF developed a set of recommendations intended to clarify and strengthen the regulatory framework for protection against natural phenomena. Subsequently, the NRC issued a 50.54(f) letter that requests information to assure that these recommendations are addressed by all U.S. nuclear power plants. The 50.54(f) letter requests that licensees and holders of construction permits under 10 CFR Part 50 reevaluate the seismic hazards at their sites against present-day NRC requirements. Depending on the comparison between the reevaluated seismic hazard and the current design basis, the result is either no further risk evaluation or the performance of a seismic risk assessment. Risk assessment approaches acceptable to the staff include a seismic probabilistic risk assessment (SPRA), or a seismic margin assessment (SMA). Based upon 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 50.54(f) letter pertaining to NTTF Recommendation 2.1 for the Comanche Peak Nuclear Power Plant (CPNPP) located in Somervell County, Texas. In providing this information, Luminant Generation Company LLC (Luminant Power) followed the guidance provided in the *Seismic Evaluation Guidance: Screening, Prioritization, and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic* [2].

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

In response to the 50.54(f) letter and following the guidance provided in the SPID [2], a seismic hazard reevaluation for CPNPP was performed. For screening purposes, a Ground Motion Response Spectrum (GMRS) was developed. Based on the results of the screening evaluation, no further evaluations will be performed.

2.0 Seismic Hazard Reevaluation

Located in Somervell County in North Central Texas, CPNPP is about 65 miles southwest of the Dallas-Fort Worth Metropolitan Area. In addition, the Squaw Creek Reservoir, the stations ultimate heat sink, extends northward into Hood County [7.g]. CPNPP is located on the Comanche plateau, a subdivision of the Central Texas section of the Great Plains physiographic province. Gently dipping Lower Cretaceous limestone and sandstone directly underlie the site. Structurally, the site is located on the southern flank of the Fort Worth Basin, a sedimentary depositional trough formed in mid-Pennsylvanian times [7.a].

There is no evidence of historical or modern earthquakes causing earthquake-induced geologic failure within the site region [8.a]. The site region is part of a tectonically stable continental margin. The Great Plains region, in general, and the CPNPP site, in particular, is characterized by very low rates of background seismicity [8.a]. The Holocene Meers fault scarp, is the only fault with tectonic geomorphic evidence of earthquake-induced geologic failure within the site region [8.b]. Luminant Power determined that the maximum potential earthquake would be an intensity VII (Modified Mercalli Scale) event. Historical records suggest that the resulting ground accelerations at the site would be less than or equal to 0.10g [7.b]. Conservatively, the SSE was selected to have a Peak Ground Acceleration (PGA) of 0.12g at what was originally characterized to be the top of bedrock [7.c].

2.1 Regional and Local Geology

The site region (200-mile radius) for CPNPP encompasses an area that is transected by the Laurentian cratonic edge, which formed by the breakup of the preexisting continental mass known as Rodinia in the Late Proterozoic Era and Early Cambrian Period [8.e], [8.f]. This basic structure forms a template that has affected the subsequent tectonic, stratigraphic, and structural development and associated geophysical expression for the region [8.e]. The later phases of Laurentian Margin development are characterized by stable margin, drift-related deposition [8.f].

The history of geologic events in the site area subsequent to the development of an erosional surface on the Precambrian basement is one of crustal downwarping, alternate marine invasion and retreat, and related accumulation and erosion of sediments. Throughout Paleozoic time, marine submergence alternated within periods of land uplift and emergence. During these pulsations, sedimentation in the site region varied from deep-water marine limestones and shales to sandstones and shales carried into shallower seas from emergent sourcelands. Cycles of deposition alternated with periods of erosion and partial removal of these materials. Major interruptions in the depositional history can be identified by significant unconformities at the contact zones between the Cambro- Ordovician limestone and Mississipian shales and limestones, and between the Pennsylvanian shales/sandstones and the lower Cretaceous formations immediately underlying the site [7.h].

2.2 Probabilistic Seismic Hazard Analysis

2.2.1 Probabilistic Seismic Hazard Analysis Results

In accordance with the 50.54(f) letter and following the guidance in the SPID [2], a probabilistic seismic hazard analysis (PSHA) was completed using the recently developed Central and Eastern United States Seismic Source Characterization (CEUS-SSC) for Nuclear Facilities [1] together with the updated EPRI Ground-Motion Model (GMM) for the CEUS [3]. For the PSHA, a lower-bound moment magnitude of 5.0 was used, as specified in the 50.54(f) letter.

For the PSHA, the CEUS-SSC background seismic sources out to a distance of 400 miles (640 km) around CPNPP were included. This distance exceeds the 200 mile (320 km) recommendation contained in USNRC Regulatory Guide 1.208 [6] and was chosen for completeness. Background sources included in this site analysis are the following:

1. Extended Continental Crust—Gulf Coast (ECC_GC)
2. Gulf Highly Extended Crust (GHEX)
3. Mesozoic and younger extended prior – narrow (MESE-N)
4. Mesozoic and younger extended prior – wide (MESE-W)
5. Midcontinent-Craton alternative A (MIDC_A)
6. Midcontinent-Craton alternative B (MIDC_B)

7. Midcontinent-Craton alternative C (MIDC_C)
8. Midcontinent-Craton alternative D (MIDC_D)
9. Non-Mesozoic and younger extended prior – narrow (NMESE-N)
10. Non-Mesozoic and younger extended prior – wide (NMESE-W)
11. Oklahoma Aulacogen (OKA)
12. Reelfoot Rift (RR)
13. Reelfoot Rift including the Rough Creek Graben (RR-RCG)
14. Study region (STUDY_R)

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

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

The CPNPP site is located within the mid-continent region of the CEUS approximately 96 km away from the Gulf region border. For each of the above background sources, the mid-continent version of the updated CEUS EPRI GMM was used to model the travel path of seismic waves. For the Cheraw, Meers, and Commerce RLMEs, the mid-continent version of the updated CEUS EPRI GMM was used to model the travel path of seismic waves. For the NMFS RLME source, a combination of Gulf (50%) and mid-continent (50%) versions of the updated CEUS EPRI GMM were created based on the relative travel paths from all alternative fault geometries of NMFS to the Comanche site. For the ERM-N, ERM-S, and Marianna RLMEs, a combination of Gulf (84%) and mid-continent (16%) versions of the updated CEUS EPRI GMM were used. These percentages represent conservative estimates of the relative fraction of the seismic wave travel path through these regions from source to site.

2.2.2 Base Rock Seismic Hazard Curves

Consistent with the SPID [2], base rock seismic hazard curves are not provided as the site amplification approach referred to as Method 3 has been used. Seismic hazard curves are shown below in Section 3 at the Safe Shutdown Earthquake (SSE) control point elevation.

2.3 Site Response Evaluation

Following the guidance contained in Seismic Enclosure 1 of the 3/12/2012 50.54(f) Request for Information and in the SPID [2] for nuclear power plant sites that are not founded on hard rock (defined as 2.83 km/sec), a site response analysis was performed for CPNPP.

2.3.1 Description of Subsurface Material

The CPNPP site is located on the southern flank of the Fort Worth Basin in Somervell County, Texas. The plant is about 65 miles southwest of the Dallas-Fort Worth Metropolitan Area [7.g]. The plant is founded on firm sedimentary rock (limestone) of the early Cretaceous Glen Rose Formation. As indicated in Table 2.3.1-1, the SSE Control Point is defined at the surface. Reference rock is at a depth of 5,300 ft (1,615 m) below the control point.

Table 2.3.1-1
Summary of Geotechnical Profile Data for CPNPP

Depth Range (feet)	Soil / Rock Description	Density (pcf)	Shear Wave Velocity (fps)	Compression Wave Velocity (fps)	Poisson's Ratio
0	SSE control point (at surface)	---	---	---	---
0-65	Early Cretaceous limestone	155	5,685	11,324	0.33
65-68	Early Cretaceous shale	135	3,019	8,312	0.42
68-92	Early Cretaceous limestone	155	4,943	10,486	0.36
92-126	Early Cretaceous limestone	155	6,880	13,164	0.31
126-160	Early Cretaceous limestone	150	4,042	9,255	0.38
160-189	Early Cretaceous limestone with interbedded shales, sand	130	3,061	7,927	0.41
189-269	Early Cretaceous sandstone	135	3,290	7,593	0.38
269-331	Early Cretaceous shale	140	3,429	8,188	0.39
331-393	Early Cretaceous sandstone	145	3,092	7,686	0.40
393-2,595	Pennsylvanian shales with sandstone and limestone beds	150	5,546	10,627	0.32
2,595-~4,500	Pennsylvanian Atoka Group sands	150	7,642	13,921	0.28
~4,500-~5,000	Mississippian and Pennsylvanian limestone (Marble Falls)	150	10,520	19,740	0.30
~5,000-~5,300	Mississippian Barnett Shale	150	7,783	12,858	0.21
~5,300->8,300	Late Cambrian to Early Ordovian limestone and dolomite (Ellenburger)	150	10,906	20,382	0.30
25' to 200' thick	Late Cambrian to Early Ordovian limestone, clastic, conglomerate and siltstone	---	---	---	---
175' to 500' thick	Late Cambrian to Ordovian limestone, sandstone, shale and siltstone	---	---	---	---
~9,000	Precambrian undifferentiated Grenville crystalline basement	---	---	---	---

NOTES:

1.) Definition of the SSE at the top of the bedrock (i.e., control point) is per Reference [7.c] and [7.f].
2.) Geotechnical profile data was obtained from References [8.c] and [8.d].

2.3.2 Development of Base Case Profiles and Nonlinear Material Properties

Table 2.3.1-1 shows the recommended shear-wave velocities and unit weights along with depths and corresponding stratigraphy. From Table 2.3.1-1 the SSE control point is at the surface on top of early Cretaceous limestone, sandstone, and shale. Measured velocities listed in Table 2.3.1-1 are for results obtained from the CPNPP Units 3 & 4 FSAR [8.c], [8.d]. The measurement methods used were in accordance with Regulatory Guides 1.132 and 1.138 as described in the CPNPP Units 3 & 4 FSAR [8.g]. CPNPP Units 1 & 2 are collocated on the same Comanche plateau with Units 3 & 4, and are separated by only about 3,000 ft. Based on the close proximity of the two sites and the modern methods used to establish the measured velocities, the data from the CPNPP Units 3 & 4 FSAR was judged to be appropriate for use. Velocity measurement extends to a depth below the SSE control point of about 393 ft (120m). Beneath this depth the velocities have been assumed. The mean base-case profile (P1) was based on the specified shear-wave velocities in Table 2.3.1-1 with reference rock assumed at a depth of 5,300 ft (1,615m). Lower (P2)- and upper (P3)- range profiles were developed with scale factors of 1.25 reflecting uncertainty in measured velocities to a depth of 393 ft (120m) and 1.57 below to reflect increased epistemic uncertainty for assumed shear-wave velocities. The scale factors of 1.25 and 1.57 reflect a $\sigma_{\mu ln}$ of about 0.2 and about 0.35 respectively based on the SPID [2] 10th and 90th fractiles which implies a scale factor of 1.28 on $\sigma_{\mu ln}$. Depth to reference basement was taken at 5,300 ft (1,615m) randomized ± 1,590 ft (485m). Profile P3, the stiffest profile, encountered hard rock shear-wave velocities (9,285 ft/s, 2,890m/s) at a depth below the SSE control point of about 2,595 ft (791m). The three shear-wave velocity profiles are shown in Figure 2.3.2-1 and listed in Table 2.3.2-1.

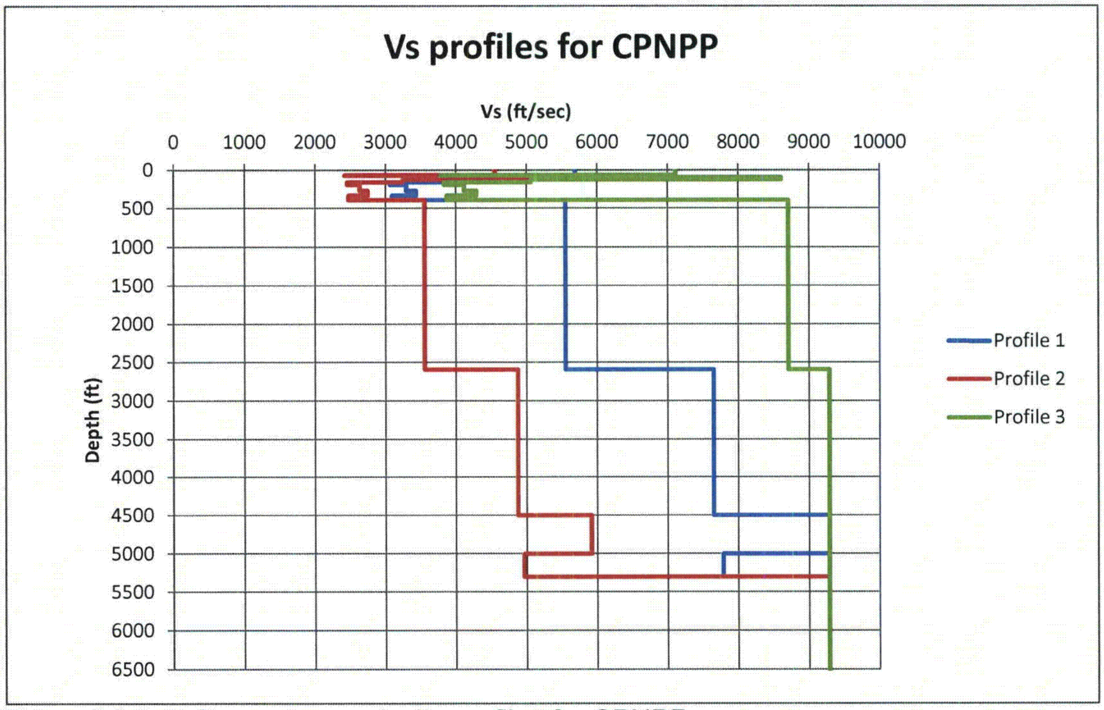


Figure 2.3.2-1: Shear-wave velocity profiles for CPNPP

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

Profile 1			Profile 2			Profile 3		
thickness(ft)	depth (ft)	Vs(ft/s)	thickness(ft)	depth (ft)	Vs(ft/s)	thickness(ft)	depth (ft)	Vs(ft/s)
	0	5685		0	4548		0	7106
5.0	5.0	5685	5.0	5.0	4548	5.0	5.0	7106
5.0	10.0	5685	5.0	10.0	4548	5.0	10.0	7106
5.0	15.0	5685	5.0	15.0	4548	5.0	15.0	7106
5.0	20.0	5685	5.0	20.0	4548	5.0	20.0	7106
5.0	25.0	5685	5.0	25.0	4548	5.0	25.0	7106
5.0	30.0	5685	5.0	30.0	4548	5.0	30.0	7106
5.0	35.0	5685	5.0	35.0	4548	5.0	35.0	7106
5.0	40.0	5685	5.0	40.0	4548	5.0	40.0	7106
5.0	45.0	5685	5.0	45.0	4548	5.0	45.0	7106
5.0	50.0	5685	5.0	50.0	4548	5.0	50.0	7106
5.0	55.0	5685	5.0	55.0	4548	5.0	55.0	7106
5.0	60.0	5685	5.0	60.0	4548	5.0	60.0	7106
5.0	65.0	5685	5.0	65.0	4548	5.0	65.0	7106
3.0	68.0	3019	3.0	68.0	2415	3.0	68.0	3774
6.0	74.0	4943	6.0	74.0	3954	6.0	74.0	6178
6.0	80.0	4943	6.0	80.0	3954	6.0	80.0	6178
6.0	86.0	4943	6.0	86.0	3954	6.0	86.0	6178
6.0	92.0	4943	6.0	92.0	3954	6.0	92.0	6178
7.0	99.0	6880	7.0	99.0	5504	7.0	99.0	8600
7.0	106.0	6880	7.0	106.0	5504	7.0	106.0	8600
7.0	113.0	6880	7.0	113.0	5504	7.0	113.0	8600
7.0	120.0	6880	7.0	120.0	5504	7.0	120.0	8600
6.0	126.0	6880	6.0	126.0	5504	6.0	126.0	8600
4.0	130.0	4042	4.0	130.0	3233	4.0	130.0	5052
5.0	135.0	4042	5.0	135.0	3233	5.0	135.0	5052
5.0	140.0	4042	5.0	140.0	3233	5.0	140.0	5052
5.0	145.0	4042	5.0	145.0	3233	5.0	145.0	5052
5.0	150.0	4042	5.0	150.0	3233	5.0	150.0	5052
5.0	155.0	4042	5.0	155.0	3233	5.0	155.0	5052
5.0	160.0	4042	5.0	160.0	3233	5.0	160.0	5052
4.0	164.0	3061	4.0	164.0	2449	4.0	164.0	3826
5.0	169.0	3061	5.0	169.0	2449	5.0	169.0	3826
5.0	174.0	3061	5.0	174.0	2449	5.0	174.0	3826
5.0	179.0	3061	5.0	179.0	2449	5.0	179.0	3826
5.0	184.0	3061	5.0	184.0	2449	5.0	184.0	3826
5.0	189.0	3061	5.0	189.0	2449	5.0	189.0	3826
5.0	194.0	3290	5.0	194.0	2632	5.0	194.0	4112
5.0	199.0	3290	5.0	199.0	2632	5.0	199.0	4112

Profile 1			Profile 2			Profile 3		
thickness(ft)	depth (ft)	Vs(ft/s)	thickness(ft)	depth (ft)	Vs(ft/s)	thickness(ft)	depth (ft)	Vs(ft/s)
5.0	204.0	3290	5.0	204.0	2632	5.0	204.0	4112
5.0	209.0	3290	5.0	209.0	2632	5.0	209.0	4112
5.0	214.0	3290	5.0	214.0	2632	5.0	214.0	4112
5.0	219.0	3290	5.0	219.0	2632	5.0	219.0	4112
5.0	224.0	3290	5.0	224.0	2632	5.0	224.0	4112
5.0	229.0	3290	5.0	229.0	2632	5.0	229.0	4112
5.0	234.0	3290	5.0	234.0	2632	5.0	234.0	4112
5.0	239.0	3290	5.0	239.0	2632	5.0	239.0	4112
5.0	244.0	3290	5.0	244.0	2632	5.0	244.0	4112
6.0	250.0	3290	6.0	250.0	2632	6.0	250.0	4112
6.3	256.3	3290	6.3	256.3	2632	6.3	256.3	4112
6.3	262.7	3290	6.3	262.7	2632	6.3	262.7	4112
6.3	269.0	3290	6.3	269.0	2632	6.3	269.0	4112
10.0	279.0	3429	10.0	279.0	2743	10.0	279.0	4286
10.0	289.0	3429	10.0	289.0	2743	10.0	289.0	4286
10.0	299.0	3429	10.0	299.0	2743	10.0	299.0	4286
10.0	309.0	3429	10.0	309.0	2743	10.0	309.0	4286
10.0	319.0	3429	10.0	319.0	2743	10.0	319.0	4286
12.0	331.0	3429	12.0	331.0	2743	12.0	331.0	4286
10.0	341.0	3092	10.0	341.0	2473	10.0	341.0	3865
10.0	351.0	3092	10.0	351.0	2473	10.0	351.0	3865
10.0	361.0	3092	10.0	361.0	2473	10.0	361.0	3865
10.0	371.0	3092	10.0	371.0	2473	10.0	371.0	3865
10.0	381.0	3092	10.0	381.0	2473	10.0	381.0	3865
12.0	393.0	3092	12.0	393.0	2473	12.0	393.0	3865
7.0	400.0	5546	7.0	400.0	3549	7.0	400.0	8707
10.0	410.0	5546	10.0	410.0	3549	10.0	410.0	8707
10.0	420.0	5546	10.0	420.0	3549	10.0	420.0	8707
10.0	430.0	5546	10.0	430.0	3549	10.0	430.0	8707
10.0	440.0	5546	10.0	440.0	3549	10.0	440.0	8707
10.0	450.0	5546	10.0	450.0	3549	10.0	450.0	8707
10.0	460.0	5546	10.0	460.0	3549	10.0	460.0	8707
10.0	470.0	5546	10.0	470.0	3549	10.0	470.0	8707
10.0	480.0	5546	10.0	480.0	3549	10.0	480.0	8707
10.0	490.0	5546	10.0	490.0	3549	10.0	490.0	8707
10.0	500.0	5546	10.0	500.0	3549	10.0	500.0	8707
314.2	814.2	5546	314.2	814.2	3549	314.2	814.2	8707
314.2	1128.4	5546	314.2	1128.4	3549	314.2	1128.4	8707
314.2	1442.7	5546	314.2	1442.7	3549	314.2	1442.7	8707
314.2	1756.9	5546	314.2	1756.9	3549	314.2	1756.9	8707
314.2	2071.1	5546	314.2	2071.1	3549	314.2	2071.1	8707

Profile 1			Profile 2			Profile 3		
thickness(ft)	depth (ft)	Vs(ft/s)	thickness(ft)	depth (ft)	Vs(ft/s)	thickness(ft)	depth (ft)	Vs(ft/s)
314.2	2385.4	5546	314.2	2385.4	3549	314.2	2385.4	8707
209.5	2594.9	5546	209.5	2594.9	3549	209.5	2594.9	8707
405.7	3000.6	7642	405.7	3000.6	4867	405.7	3000.6	9285
405.7	3406.3	7642	405.7	3406.3	4867	405.7	3406.3	9285
405.7	3812.0	7642	405.7	3812.0	4867	405.7	3812.0	9285
405.7	4217.8	7642	405.7	4217.8	4867	405.7	4217.8	9285
281.9	4499.7	7642	281.9	4499.7	4867	281.9	4499.7	9285
500.0	4999.7	9285	500.0	4999.7	5914	500.0	4999.7	9285
300.7	5300.4	7782	300.7	5300.4	4957	300.7	5300.4	9285
3280.8	8581.2	9285	3280.8	8581.2	9285	3280.8	8581.2	9285

2.3.2.1 Shear Modulus and Damping Curves

Recent nonlinear dynamic material properties were not available for the CPNPP for sedimentary rocks. The rock material over the upper 500 ft (150 m) was assumed to have behavior that could be modeled as either linear or non-linear. To represent this potential for either case in the upper 500 ft of sedimentary rock at the CPNPP site, two sets of shear modulus reduction and hysteretic damping curves were used. Consistent with the SPID [2], the EPRI rock curves (model M1) were considered to be appropriate to represent the upper range nonlinearity likely in the materials at this site and linear analyses (model M2) was assumed to represent an equally plausible alternative rock response across loading level. For the linear analyses, the low strain damping from the EPRI rock curves were used as the constant damping values in the upper 500 ft.

2.3.2.2 Kappa

Base-case kappa estimates were determined using Section B-5.1.3.1 of the SPID [2] for a firm CEUS rock site. Kappa for a firm rock site with at least 3,000 ft (1 km) of sedimentary rock may be estimated from the average S-wave velocity over the upper 100 ft (V_{s100}) of the subsurface profile while for a site with less than 3,000 ft (1 km) of firm rock, kappa may be estimated with a Q_s of 40 below 500 ft combined with the low strain damping from the EPRI rock curves and an additional kappa of 0.006s for the underlying hard rock. For the CPNPP site, with at least 3,000 ft (1km) of firm rock, the corresponding average shear-wave velocities over the top 100 ft (30.5m) were 5,414 ft/s (1,650m/s) (P1), 4,347ft/s (1,325m/s) (P2), and 6,800 ft/s (2,073m/s) (P3). The corresponding kappa estimates were 0.019s, 0.025s, and 0.015s respectively. The range in kappa was considered an insufficient expression of epistemic uncertainty (± 30%). The range in kappa was increased about the best estimate base-case value of 0.020s (profile P1) by a factor of roughly 1.6 and these values were considered to adequately reflect epistemic uncertainty in low strain damping (kappa) for the profile (Table 2.3.2-2).

Table 2.3.2-2
Kappa Values and Weights Used for Site Response Analyses

Velocity Profile	Kappa(s)
P1	0.020
P2	0.030
P3	0.010
	Weights
P1	0.4
P2	0.3
P3	0.3
G/G_{max} and Hysteretic Damping Curves	
M1	0.5
M2	0.5

2.3.3 Randomization of Base Case Profiles

To account for the aleatory variability in dynamic material properties that is expected to occur across a site at the scale of a typical nuclear facility, variability in the assumed shear-wave velocity profiles has been incorporated in the site response calculations. For the CPNPP site, random shear wave velocity profiles were developed from the base case profiles shown in Figure 2.3.2-1. Consistent with the discussion in Appendix B of the SPID [2], the velocity randomization procedure made use of random field models which describe the statistical correlation between layering and shear wave velocity. The default randomization parameters developed in Toro [5] for USGS "A" site conditions were used for this site. Thirty random velocity profiles were generated for each base case profile. These random velocity profiles were generated using a natural log standard deviation of 0.25 over the upper 50 ft and 0.15 below that depth. As specified in the SPID [2], correlation of shear wave velocity between layers was modeled using the footprint correlation model. In the correlation model, a limit of +/- 2 standard deviations about the median value in each layer was assumed for the limits on random velocity fluctuations.

2.3.4 Input Spectra

Consistent with the guidance in Appendix B of the SPID [2], input Fourier amplitude spectra were defined for a single representative earthquake magnitude (**M** 6.5) using two different assumptions regarding the shape of the seismic source spectrum (single-corner and double-corner). A range of 11 different input amplitudes (median PGA ranging from 0.01 to 1.5 g) were used in the site response analyses. The characteristics of the seismic source and upper crustal attenuation properties assumed for the analysis of the CPNPP site were the same as those identified in Tables B-4, B-5, B-6 and B-7 of the SPID [2] as appropriate for typical CEUS sites.

2.3.5 Methodology

To perform the response analyses for the CPNPP site, a random vibration theory (RVT) approach was employed. This process utilizes a simple, efficient approach for computing site-specific amplification functions and is consistent with existing NRC guidance and the SPID [2]. The guidance contained in Appendix B of the SPID [2] on incorporating epistemic uncertainty in shear-wave velocities, kappa, non-linear dynamic properties and source spectra for plants with limited at-site information was followed for the CPNPP site.

2.3.6 Amplification Functions

The results of the site response analysis consist of amplification factors (5% damped pseudo absolute response spectra) which describe the amplification (or de-amplification) of hard reference rock motion as a function of frequency and input reference rock amplitude. The amplification factors are represented in terms of a median amplification value and an associated standard deviation (sigma) for each oscillator frequency and input rock amplitude. Consistent with the SPID [2] a minimum median amplification value of 0.5 was employed in the present analysis. Figure 2.3.6-1 illustrates the median and ±1 standard deviation in the predicted amplification factors developed for the eleven loading levels parameterized by the median reference (hard rock) peak acceleration (0.01g to 1.50g) for profile P1 and EPRI [2] rock G/G_{max} and hysteretic damping curves. The variability in the amplification factors results from variability in shear-wave velocity, depth to hard rock, and modulus reduction and hysteretic damping curves. To illustrate the effects of nonlinearity at the CPNPP firm rock site, Figure 2.3.6-2 shows the corresponding amplification factors developed with linear site response analyses (model M2). Between the linear and nonlinear (equivalent-linear) analyses, Figures 2.3.6-1 and Figure 2.3.6-2 respectively show only very minor difference for frequencies below about 10 Hz and the 0.5g loading level and below. Above about the 0.5g loading level, the differences increase significantly but only above about 2 Hz.

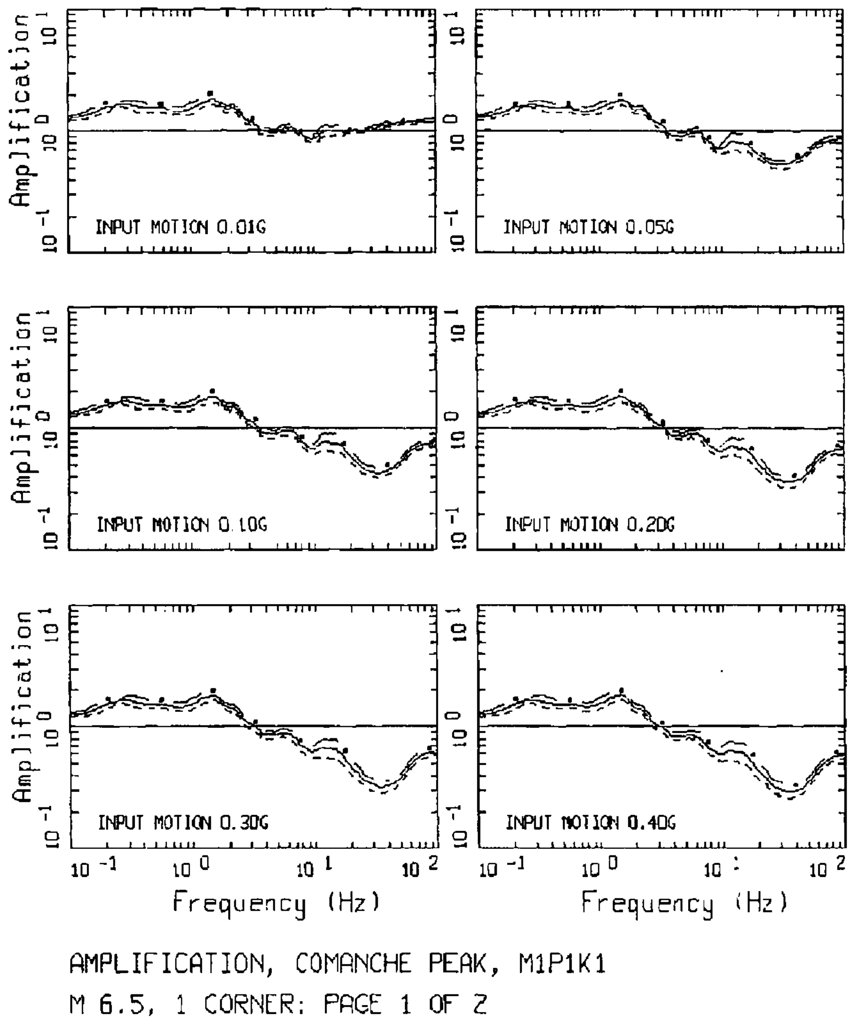
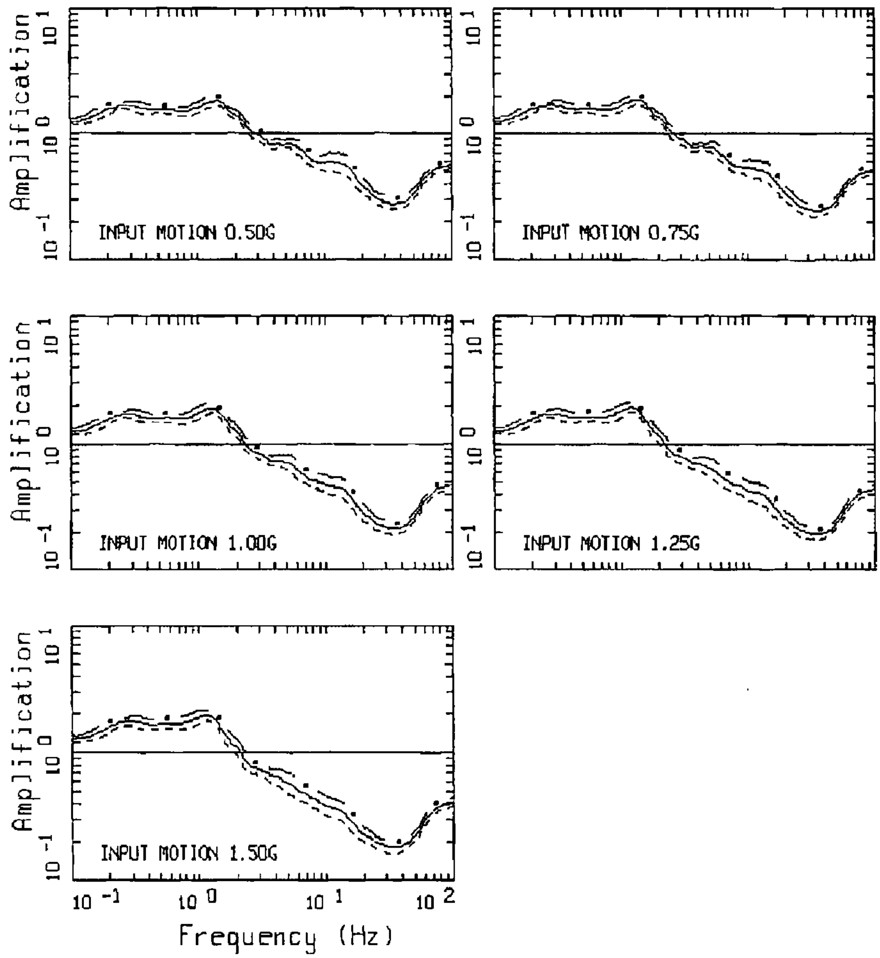


Figure 2.3.6-1: Example suite of amplification factors (5% damping pseudo absolute acceleration spectra) developed for the mean base-case profile (P1), EPRI rock modulus reduction and hysteretic damping curves (model M1), and base-case kappa (K1) at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g. **M** 6.5 and single-corner source model [2].



AMPLIFICATION, COMANCHE PEAK, M1P1K1
M 6.5, 1 CORNER: PAGE 2 OF 2

Figure 2.3.6-1: (cont.)

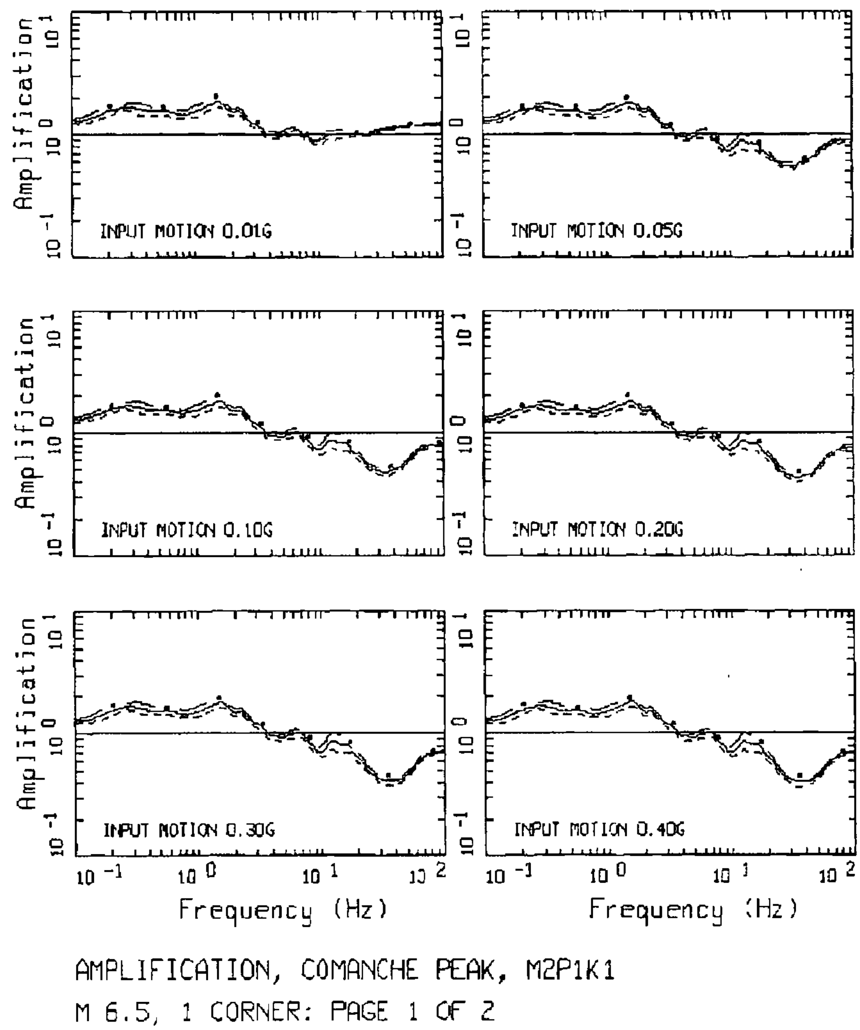
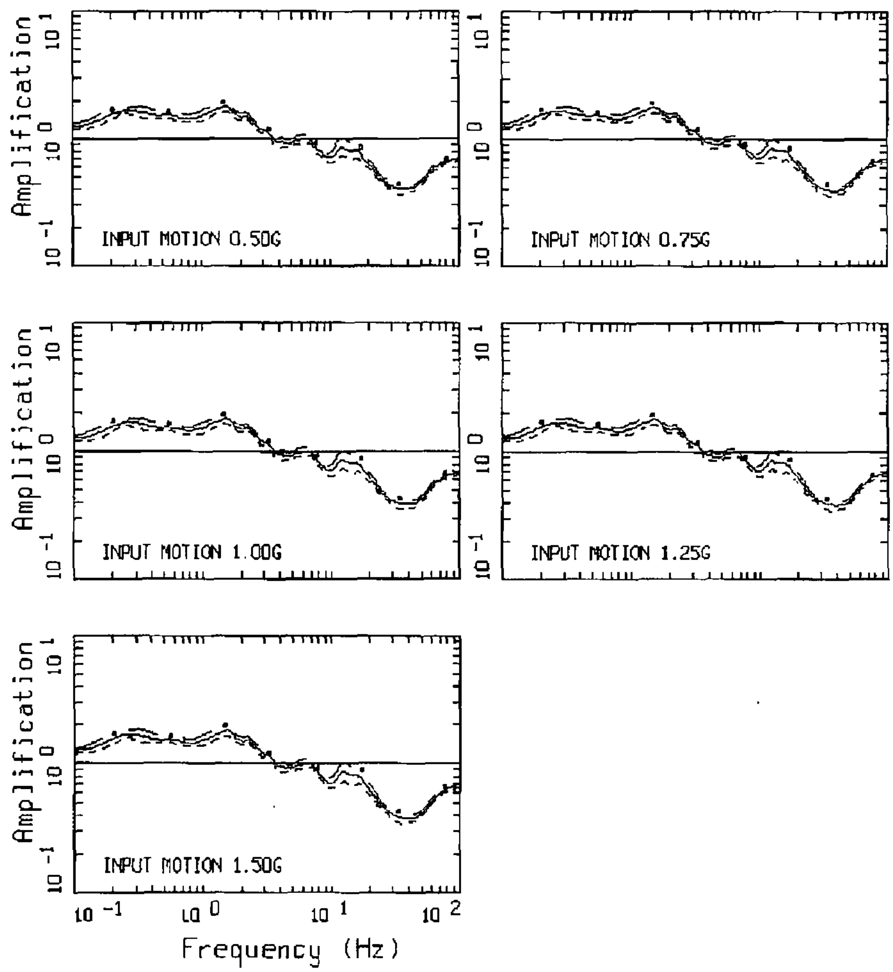


Figure 2.3.6-2: Example suite of amplification factors (5% damping pseudo absolute acceleration spectra) developed for the mean base-case profile (P1), linear site response (model M2), and base-case kappa (K1) at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g. **M** 6.5 and single-corner source model [2].



AMPLIFICATION, COMANCHE PEAK, M2P1K1
M 6.5, 1 CORNER: PAGE 2 OF 2

Figure 2.3.6-2:(cont.)

2.3.7 Control Point Seismic Hazard Curves

The procedure to develop probabilistic site-specific control point hazard curves used in the present analysis follows the methodology described in Section B-6.0 of the SPID [2]. This procedure (referred to as Method 3) computes a site-specific control point hazard curve for a broad range of spectral accelerations given the site-specific bedrock hazard curve and site-specific estimates of soil or soft-rock response and associated uncertainties. This process is repeated for each of the seven spectral frequencies for which ground motion equations are available. The dynamic response of the materials below the control point was represented by the frequency- and amplitude-dependent amplification functions (median values and standard deviations) developed and described in the previous section. The resulting control point mean hazard curves for CPNPP are shown in Figure 2.3.7-1 for the seven spectral frequencies for which ground motion equations are defined. Tabulated values of mean and fractile seismic hazard curves and site response amplification functions are provided in Appendix A.

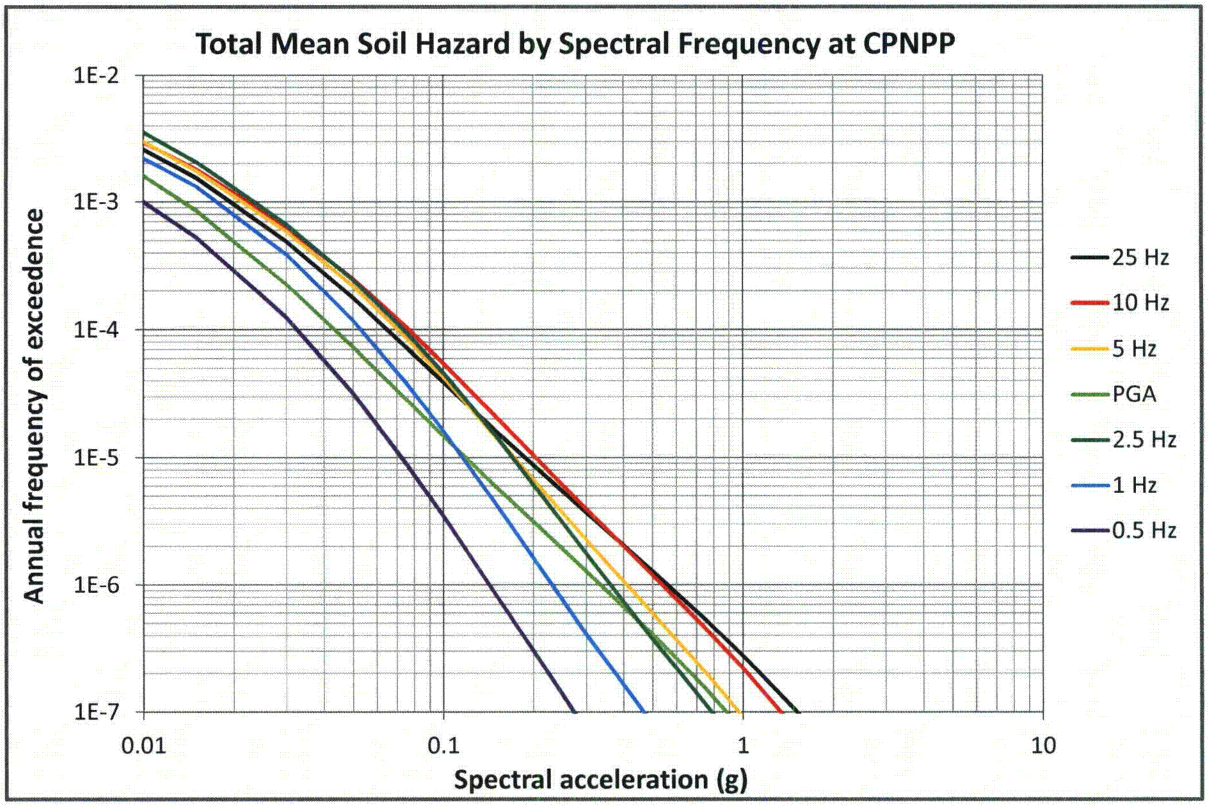


Figure 2.3.7-1: Control point mean hazard curves for spectral frequencies of 0.5, 1, 2.5, 5, 10, 25 and 100 Hz at CPNPP.

2.4 Control Point Response Spectra

The control point hazard curves described above have been used to develop uniform hazard response spectra (UHRS) and the ground motion response spectrum (GMRS). The UHRS were obtained through linear interpolation in log-log space to estimate the spectral acceleration at each spectral frequency for the 1E-4 and 1E-5 per year hazard levels. Table 2.4-1 shows the UHRS and GMRS accelerations for a range of frequencies.

Table 2.4-1: UHRS and GMRS for CPNPP

Freq. (Hz)	10^{-4} UHRS (g)	10^{-5} UHRS (g)	GMRS (g)
100	4.33E-02	1.19E-01	5.82E-02
90	4.35E-02	1.18E-01	5.81E-02
80	4.38E-02	1.18E-01	5.83E-02
70	4.43E-02	1.20E-01	5.89E-02
60	4.54E-02	1.23E-01	6.06E-02
50	4.77E-02	1.32E-01	6.47E-02
40	5.18E-02	1.47E-01	7.17E-02
35	5.43E-02	1.55E-01	7.56E-02
30	5.78E-02	1.66E-01	8.07E-02
25	6.50E-02	1.88E-01	9.11E-02
20	7.68E-02	2.23E-01	1.08E-01
15	8.50E-02	2.39E-01	1.17E-01
12.5	8.22E-02	2.27E-01	1.11E-01
10	7.68E-02	2.04E-01	1.00E-01
9	7.66E-02	2.00E-01	9.89E-02
8	7.69E-02	1.98E-01	9.83E-02
7	7.71E-02	1.95E-01	9.73E-02
6	7.44E-02	1.86E-01	9.27E-02
5	7.06E-02	1.73E-01	8.66E-02
4	6.96E-02	1.66E-01	8.37E-02
3.5	7.14E-02	1.68E-01	8.48E-02
3	7.46E-02	1.73E-01	8.78E-02
2.5	7.37E-02	1.70E-01	8.64E-02
2	7.70E-02	1.76E-01	8.94E-02
1.5	6.89E-02	1.56E-01	7.93E-02
1.25	6.03E-02	1.35E-01	6.88E-02
1	5.30E-02	1.16E-01	5.94E-02
0.9	4.97E-02	1.09E-01	5.59E-02
0.8	4.58E-02	1.01E-01	5.17E-02
0.7	4.17E-02	9.23E-02	4.72E-02
0.6	3.82E-02	8.49E-02	4.34E-02
0.5	3.25E-02	7.27E-02	3.71E-02
0.4	2.60E-02	5.81E-02	2.97E-02
0.35	2.28E-02	5.09E-02	2.60E-02
0.3	1.95E-02	4.36E-02	2.23E-02
0.25	1.63E-02	3.63E-02	1.86E-02
0.2	1.30E-02	2.91E-02	1.48E-02
0.15	9.76E-03	2.18E-02	1.11E-02
0.125	8.14E-03	1.82E-02	9.28E-03
0.1	6.51E-03	1.45E-02	7.42E-03

The 1E-4 and 1E-5 UHRS are used to compute the GMRS at the control point and are shown in Figure 2.4-1.

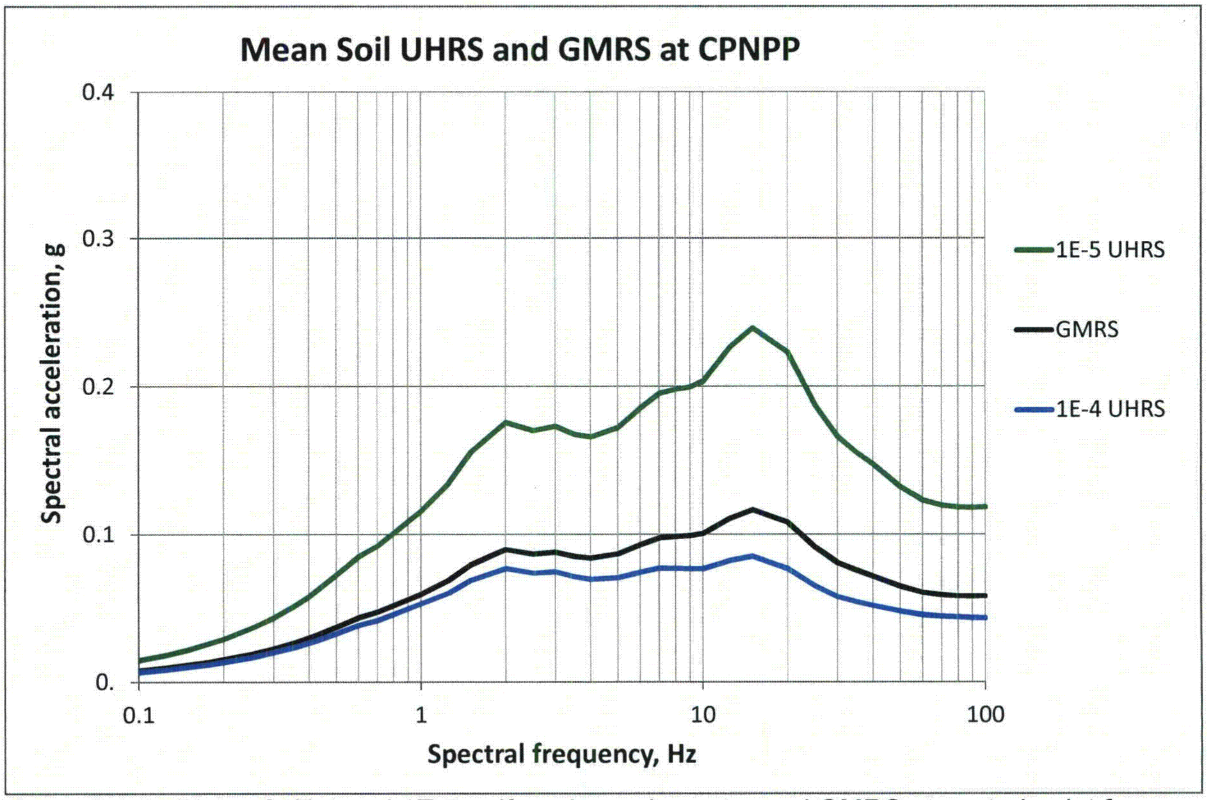


Figure 2.4-1: Plots of 1E-4 and 1E-5 uniform hazard spectra and GMRS at control point for CPNPP (5%-damped response spectra).

3.0 Plant Design Basis

The SSE for CPNPP was developed through an evaluation of the maximum earthquake potential for the region surrounding the site. Considering the historic seismicity of the site region, Luminant Power determined that the maximum potential earthquake to be an intensity VII (Modified Mercalli Scale) event near the site. Historical records suggest that the resulting ground accelerations at the site would be less than or equal to 0.10g [7.b]. Conservatively, the SSE was selected to have a PGA of 0.12g at what was originally characterized to be the top of bedrock [7.c].

3.1 SSE Description of Spectral Shape

The SSE was developed in accordance with 10 CFR Part 100, Appendix A through an evaluation of the maximum earthquake potential for the region surrounding the site. The SSE horizontal design response spectrum was constructed on the basis of the recommendations of Newmark, Blume, and Kapur [7.d].

The SSE is defined in terms of a PGA and a design response spectrum. The SSE horizontal design response spectrum is anchored at 0.12g at a frequency of 33 Hz [7.c], [7.e]. Table 3.1-1 shows the spectral acceleration values as a function of frequency for the 5% damped horizontal SSE.

Table 3.1-1: SSE for CPNPP

Freq. (Hz)	50	33	9	2.5	0.5	0.25	0.1
SA (g)	0.12	0.12	0.3	0.38	0.095	0.056	0.01

3.2 Control Point Elevation

The SSE control point elevation is defined at the surface elevation of the site [7.c].

4.0 Screening Evaluation

In accordance with SPID [2] Section 3, a screening evaluation was performed as described below. The GMRS and 5% damped horizontal SSE are shown together in Figure 4.1-1.

4.1 Risk Evaluation Screening (1 to 10 Hz)

In the 1 to 10 Hz part of the response spectrum, the SSE exceeds the GMRS. Therefore, a risk evaluation will not be performed.

4.2 High Frequency Screening (>10 Hz)

Above 10 Hz, the SSE exceeds the GMRS. Therefore, the high frequency confirmation will not be performed.

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

In the 1 to 10 Hz part of the response spectrum, the SSE exceeds the GMRS. Therefore, a spent fuel pool evaluation will not be performed.

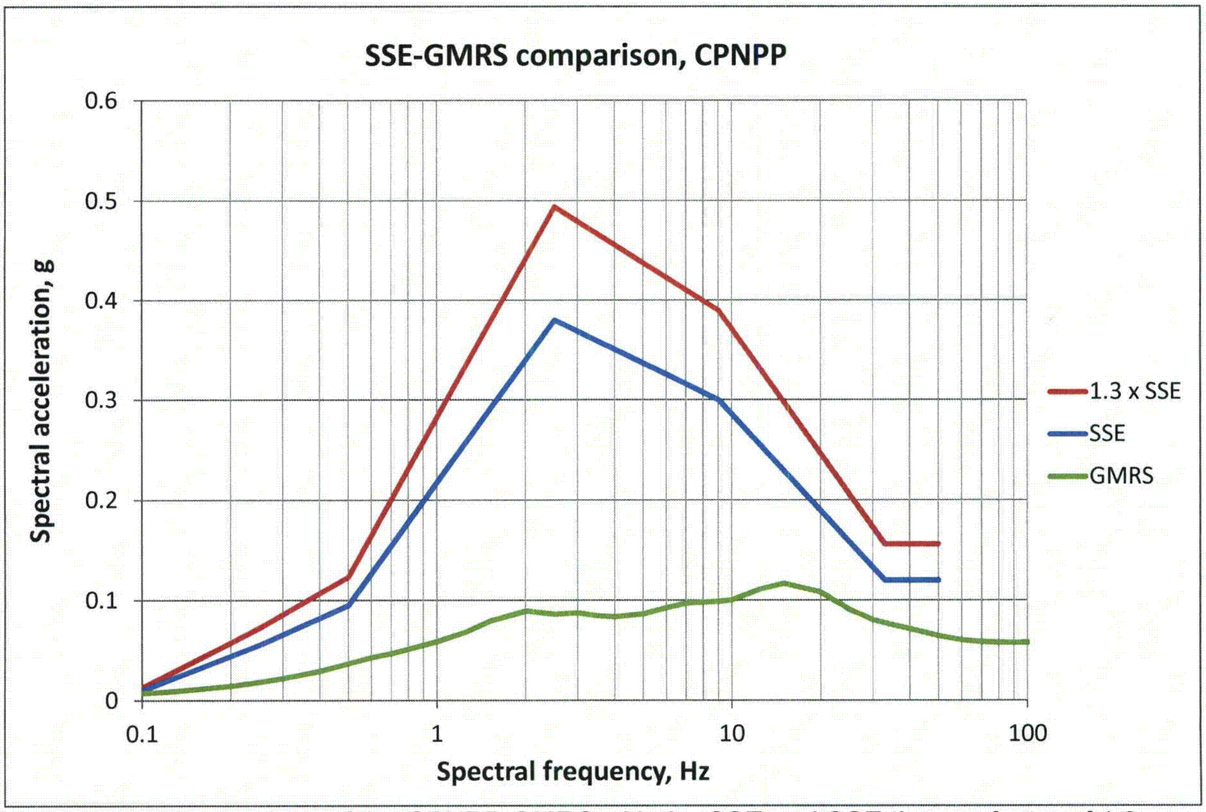


Figure 4.1-1: Comparison of the CPNPP GMRS with the SSE and SSE times a factor of 1.3.

5.0 Interim Actions

Based on the screening evaluation outcome, no Interim Actions are required by Luminant Power per Section 3.2 of the SPID [2].

NRC letter dated February 20, 2014 [9], also requests that licensees provide an interim evaluation or actions to demonstrate that the plant can cope with the reevaluated hazard while the expedited approach and risk evaluations are conducted. In response to that request, NEI letter dated March 12, 2014 [10], provides seismic core damage risk estimates using the updated seismic hazards for the operating nuclear plants in the Central and Eastern United States. These risk estimates continue to support the following conclusions of the NRC GI-199 Safety/Risk Assessment:

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

CPNPP (Comanche Peak 1 & 2) is included in the March 12, 2014 risk estimates. Using the methodology described in the NEI letter [10], all sixty-one of the CEUS sites were shown to have SCDF estimates below the 10^{-4}/year threshold considered in the NRC GI-199 Safety/Risk Assessment; thus, the above conclusions apply.

6.0 Conclusions

In accordance with the 50.54(f) request for information, a seismic hazard and screening evaluation was performed for CPNPP. A GMRS was developed solely for purpose of screening for additional evaluations in accordance with the SPID [2]. Based on the results of the screening evaluation, no further evaluations will be performed.

References

[1] *Central and Eastern United States Seismic Source Characterization for Nuclear Facilities*, U.S. Nuclear Regulatory Commission Report, NUREG-2115; EPRI Report 1021097, 6 Volumes; DOE Report # DOE/NE-0140, 2012.

[2] Seismic Evaluation Guidance Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic, Electric Power Research Institute, Palo Alto, CA, Report 1025287, February, 2013.

[3] *EPRI (2004, 2006) Ground-Motion Model (GMM) Review Project,* Electric Power Research Institute, Palo Alto, CA, Report 3002000717, June, 2013, 2 volumes.

[4] Not Used.

[5] Appendix of: Silva, W.J., Abrahamson, N., Toro, G., and Costantino, C., "Description and validation of the stochastic ground motion model", Report Submitted to Brookhaven National Laboratory, Associated Universities, Inc., Upton, New York 11973, Contract No. 770573, 1997.

[6] "A performance-based approach to define the site-specific earthquake ground motion," U.S. Nuclear Regulatory Commission Regulatory Guide 1.208, March, 2007.

[7] Comanche Peak Nuclear Power Plant, Units 1 And 2, Docket Numbers 50-445 And 50-446, Final Safety Analysis Report (FSAR)
   a. Section 2.5.1 "Basic Geological and Seismic Information"
   b. Section 2.5.2.4 "Maximum Earthquake Potential"
   c. Section 2.5.2.6 "Safe Shutdown Earthquake (SSE)"
   d. Section 3.7B.1.1 "Design Response Spectra"
   e. Figure 3.7B-1 "Design Response Spectra for Horizontal Safe Shutdown Earthquake"
   f. Section 3.7B.1.4 "Supporting Media for Seismic Category I Structures"
   g. Section 1.1.1 "Station Location"
   h. Section 2.5.1.2.2 "Geologic History"

[8] Comanche Peak Nuclear Power Plant, Units 3 And 4, Docket Numbers 52-034 And 52-035, Final Safety Analysis Report (FSAR)
   a. Section 2.5.1.1.4.3.6 "Quaternary Tectonic Features Within the Site Region"
   b. Section 2.5.2.1.3 "Recent Earthquakes and Historical Seismicity"
   c. Table 2.5.2-227 "Dynamic Properties of Subsurface Rock Materials"
   d. Figure 2.5.1-219 "Site Area Stratigraphy"
   e. Section 2.5.1.1.2 "Regional Stratigraphy and Geologic History"
   f. Section 2.5.1.1.2.1 "Laurentian Margin Basement-Cover Sequence"
   g. Section 2.5.4.2 "Properties of Subsurface Materials"

[9] NRC Letter, Supplemental Information Related To Request For Information Pursuant To Title 10 Of The Code Of Federal Regulations 50.54(F) Regarding Seismic Hazard Reevaluations For Recommendation 2.1 Of The Near-Term Task Force Review Of Insights From The Fukushima Dai-Ichi Accident, dated February 20, 2014, ADAMS Accession No. ML12053A340.

[10] NEI Letter, Seismic Risk Evaluations for Plants in the Central and Eastern United States, dated March 12, 2014.

Appendix A

Table A-1a: Mean and Fractile Seismic Hazard Curves for PGA at CPNPP

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	2.09E-02	1.01E-02	1.62E-02	2.13E-02	2.60E-02	2.92E-02
0.001	1.51E-02	5.75E-03	1.07E-02	1.49E-02	1.98E-02	2.32E-02
0.005	3.83E-03	1.13E-03	1.98E-03	3.33E-03	5.42E-03	8.85E-03
0.01	1.60E-03	3.47E-04	6.36E-04	1.29E-03	2.39E-03	4.31E-03
0.015	8.54E-04	1.32E-04	2.53E-04	6.17E-04	1.36E-03	2.57E-03
0.03	2.24E-04	1.36E-05	3.14E-05	1.08E-04	3.63E-04	8.98E-04
0.05	7.27E-05	1.79E-06	5.35E-06	2.42E-05	1.04E-04	3.23E-04
0.075	2.87E-05	3.63E-07	1.38E-06	7.89E-06	3.79E-05	1.25E-04
0.1	1.48E-05	1.01E-07	5.91E-07	3.95E-06	2.04E-05	6.17E-05
0.15	5.86E-06	1.29E-08	1.95E-07	1.64E-06	8.72E-06	2.39E-05
0.3	1.28E-06	4.19E-10	2.96E-08	3.79E-07	2.10E-06	5.20E-06
0.5	4.06E-07	1.53E-10	6.00E-09	1.11E-07	6.64E-07	1.72E-06
0.75	1.52E-07	1.53E-10	1.46E-09	3.63E-08	2.39E-07	6.64E-07
1.	7.15E-08	1.53E-10	5.35E-10	1.49E-08	1.08E-07	3.19E-07
1.5	2.24E-08	1.38E-10	1.90E-10	3.52E-09	3.05E-08	1.02E-07
3.	2.24E-09	1.21E-10	1.53E-10	2.92E-10	2.42E-09	1.01E-08
5.	3.00E-10	1.11E-10	1.21E-10	1.53E-10	3.52E-10	1.40E-09
7.5	4.93E-11	1.11E-10	1.21E-10	1.53E-10	1.60E-10	3.09E-10
10.	1.22E-11	1.11E-10	1.21E-10	1.53E-10	1.53E-10	1.69E-10

Table A-1b: Mean and Fractile Seismic Hazard Curves for 25 Hz at CPNPP

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	2.22E-02	1.27E-02	1.77E-02	2.25E-02	2.68E-02	2.96E-02
0.001	1.69E-02	8.12E-03	1.25E-02	1.69E-02	2.16E-02	2.49E-02
0.005	5.38E-03	1.84E-03	2.92E-03	4.83E-03	7.45E-03	1.16E-02
0.01	2.59E-03	7.34E-04	1.20E-03	2.19E-03	3.73E-03	6.45E-03
0.015	1.53E-03	3.52E-04	6.09E-04	1.21E-03	2.32E-03	4.01E-03
0.03	4.90E-04	6.54E-05	1.25E-04	3.23E-04	8.12E-04	1.55E-03
0.05	1.76E-04	1.34E-05	2.84E-05	9.11E-05	2.92E-04	6.54E-04
0.075	7.34E-05	3.37E-06	8.00E-06	3.09E-05	1.16E-04	2.96E-04
0.1	3.90E-05	1.25E-06	3.37E-06	1.49E-05	6.09E-05	1.57E-04
0.15	1.61E-05	2.80E-07	1.10E-06	5.83E-06	2.60E-05	6.26E-05
0.3	3.69E-06	1.53E-08	1.84E-07	1.44E-06	6.64E-06	1.44E-05
0.5	1.28E-06	1.53E-09	4.98E-08	5.12E-07	2.39E-06	5.12E-06
0.75	5.33E-07	3.19E-10	1.60E-08	2.10E-07	9.93E-07	2.19E-06
1.	2.76E-07	1.74E-10	6.54E-09	1.05E-07	5.12E-07	1.15E-06
1.5	1.02E-07	1.53E-10	1.72E-09	3.52E-08	1.84E-07	4.31E-07
3.	1.48E-08	1.40E-10	2.22E-10	4.07E-09	2.53E-08	6.64E-08
5.	2.91E-09	1.21E-10	1.53E-10	7.03E-10	4.56E-09	1.34E-08
7.5	7.01E-10	1.21E-10	1.53E-10	2.25E-10	1.08E-09	3.42E-09
10.	2.38E-10	1.11E-10	1.25E-10	1.57E-10	4.13E-10	1.23E-09

Table A-1c: Mean and Fractile Seismic Hazard Curves for 10 Hz at CPNPP

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	2.44E-02	1.69E-02	2.01E-02	2.46E-02	2.88E-02	3.14E-02
0.001	1.93E-02	1.16E-02	1.49E-02	1.92E-02	2.39E-02	2.68E-02
0.005	6.33E-03	2.49E-03	3.68E-03	5.91E-03	8.85E-03	1.16E-02
0.01	3.00E-03	9.93E-04	1.53E-03	2.68E-03	4.31E-03	6.26E-03
0.015	1.80E-03	5.05E-04	8.23E-04	1.55E-03	2.68E-03	4.01E-03
0.03	6.37E-04	1.13E-04	2.07E-04	4.90E-04	1.04E-03	1.69E-03
0.05	2.48E-04	2.80E-05	5.66E-05	1.62E-04	4.19E-04	7.77E-04
0.075	1.06E-04	7.77E-06	1.77E-05	5.83E-05	1.77E-04	3.68E-04
0.1	5.48E-05	2.92E-06	7.34E-06	2.68E-05	9.11E-05	2.01E-04
0.15	2.08E-05	7.03E-07	2.07E-06	8.98E-06	3.42E-05	7.89E-05
0.3	3.94E-06	4.77E-08	2.39E-07	1.51E-06	6.83E-06	1.57E-05
0.5	1.19E-06	4.25E-09	4.90E-08	4.31E-07	2.13E-06	4.90E-06
0.75	4.52E-07	6.00E-10	1.31E-08	1.55E-07	8.12E-07	1.90E-06
1.	2.19E-07	2.16E-10	4.77E-09	7.03E-08	3.90E-07	9.51E-07
1.5	7.26E-08	1.53E-10	1.10E-09	2.10E-08	1.25E-07	3.19E-07
3.	8.43E-09	1.29E-10	1.72E-10	1.82E-09	1.29E-08	3.90E-08
5.	1.35E-09	1.21E-10	1.53E-10	3.05E-10	1.87E-09	6.36E-09
7.5	2.72E-10	1.11E-10	1.25E-10	1.55E-10	4.19E-10	1.34E-09
10.	7.97E-11	1.11E-10	1.21E-10	1.53E-10	2.04E-10	4.70E-10

Table A-1d: Mean and Fractile Seismic Hazard Curves for 5 Hz at CPNPP

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	2.54E-02	1.79E-02	2.10E-02	2.57E-02	2.96E-02	3.23E-02
0.001	2.08E-02	1.27E-02	1.60E-02	2.07E-02	2.57E-02	2.84E-02
0.005	6.82E-03	2.64E-03	4.07E-03	6.54E-03	9.65E-03	1.18E-02
0.01	3.03E-03	1.02E-03	1.62E-03	2.80E-03	4.43E-03	5.91E-03
0.015	1.75E-03	5.20E-04	8.60E-04	1.55E-03	2.60E-03	3.63E-03
0.03	5.86E-04	1.23E-04	2.19E-04	4.77E-04	9.51E-04	1.42E-03
0.05	2.18E-04	3.23E-05	6.26E-05	1.55E-04	3.63E-04	6.17E-04
0.075	8.73E-05	9.51E-06	1.95E-05	5.42E-05	1.44E-04	2.76E-04
0.1	4.26E-05	3.63E-06	8.00E-06	2.42E-05	7.03E-05	1.40E-04
0.15	1.46E-05	8.23E-07	2.04E-06	7.23E-06	2.42E-05	4.98E-05
0.3	2.26E-06	4.63E-08	1.74E-07	9.37E-07	3.95E-06	8.72E-06
0.5	5.96E-07	3.47E-09	2.60E-08	2.19E-07	1.07E-06	2.46E-06
0.75	2.04E-07	4.31E-10	5.35E-09	6.54E-08	3.57E-07	8.85E-07
1.	9.15E-08	1.74E-10	1.62E-09	2.57E-08	1.55E-07	4.07E-07
1.5	2.75E-08	1.53E-10	3.47E-10	6.00E-09	4.31E-08	1.27E-07
3.	2.77E-09	1.21E-10	1.53E-10	4.19E-10	3.63E-09	1.31E-08
5.	4.14E-10	1.11E-10	1.23E-10	1.53E-10	5.20E-10	1.95E-09
7.5	7.95E-11	1.11E-10	1.21E-10	1.53E-10	1.82E-10	4.50E-10
10.	2.27E-11	1.11E-10	1.21E-10	1.53E-10	1.53E-10	2.07E-10

Table A-1e: Mean and Fractile Seismic Hazard Curves for 2.5 Hz at CPNPP

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	2.58E-02	1.87E-02	2.16E-02	2.57E-02	3.01E-02	3.28E-02
0.001	2.14E-02	1.34E-02	1.62E-02	2.13E-02	2.64E-02	2.92E-02
0.005	7.65E-03	3.19E-03	4.56E-03	7.23E-03	1.08E-02	1.32E-02
0.01	3.58E-03	1.18E-03	1.82E-03	3.23E-03	5.35E-03	7.13E-03
0.015	2.05E-03	5.83E-04	9.37E-04	1.79E-03	3.14E-03	4.43E-03
0.03	6.62E-04	1.29E-04	2.35E-04	5.27E-04	1.08E-03	1.67E-03
0.05	2.43E-04	3.28E-05	6.54E-05	1.72E-04	4.13E-04	7.03E-04
0.075	9.62E-05	9.51E-06	2.01E-05	5.91E-05	1.62E-04	3.09E-04
0.1	4.61E-05	3.57E-06	8.00E-06	2.53E-05	7.66E-05	1.55E-04
0.15	1.47E-05	7.89E-07	1.92E-06	6.93E-06	2.32E-05	5.12E-05
0.3	1.76E-06	4.13E-08	1.32E-07	6.45E-07	2.72E-06	6.45E-06
0.5	3.73E-07	3.28E-09	1.57E-08	1.15E-07	5.91E-07	1.51E-06
0.75	1.14E-07	4.25E-10	2.68E-09	2.88E-08	1.82E-07	4.98E-07
1.	4.93E-08	1.72E-10	7.66E-10	1.07E-08	7.55E-08	2.22E-07
1.5	1.45E-08	1.53E-10	2.07E-10	2.32E-09	2.01E-08	6.64E-08
3.	1.44E-09	1.21E-10	1.53E-10	2.19E-10	1.57E-09	6.45E-09
5.	2.14E-10	1.11E-10	1.21E-10	1.53E-10	2.68E-10	9.79E-10
7.5	4.12E-11	1.11E-10	1.21E-10	1.53E-10	1.53E-10	2.60E-10
10.	1.19E-11	1.11E-10	1.21E-10	1.53E-10	1.53E-10	1.60E-10

Table A-1f: Mean and Fractile Seismic Hazard Curves for 1 Hz at CPNPP

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	1.94E-02	1.05E-02	1.38E-02	1.95E-02	2.46E-02	2.76E-02
0.001	1.37E-02	6.36E-03	8.98E-03	1.34E-02	1.82E-02	2.13E-02
0.005	4.33E-03	1.29E-03	2.13E-03	4.01E-03	6.54E-03	8.35E-03
0.01	2.22E-03	4.19E-04	7.89E-04	1.84E-03	3.68E-03	5.27E-03
0.015	1.32E-03	1.82E-04	3.73E-04	9.93E-04	2.29E-03	3.52E-03
0.03	3.88E-04	3.14E-05	7.23E-05	2.39E-04	6.83E-04	1.25E-03
0.05	1.17E-04	6.45E-06	1.62E-05	6.09E-05	2.01E-04	4.25E-04
0.075	3.85E-05	1.55E-06	4.19E-06	1.69E-05	6.36E-05	1.51E-04
0.1	1.61E-05	5.20E-07	1.49E-06	6.36E-06	2.57E-05	6.54E-05
0.15	4.30E-06	1.01E-07	3.09E-07	1.46E-06	6.54E-06	1.74E-05
0.3	4.05E-07	4.70E-09	1.77E-08	1.08E-07	5.83E-07	1.64E-06
0.5	8.02E-08	4.63E-10	1.90E-09	1.62E-08	1.10E-07	3.42E-07
0.75	2.54E-08	1.60E-10	3.79E-10	3.73E-09	3.19E-08	1.13E-07
1.	1.17E-08	1.53E-10	1.87E-10	1.34E-09	1.34E-08	5.20E-08
1.5	3.88E-09	1.21E-10	1.53E-10	3.73E-10	3.84E-09	1.69E-08
3.	4.97E-10	1.11E-10	1.21E-10	1.53E-10	4.31E-10	1.95E-09
5.	8.96E-11	1.11E-10	1.21E-10	1.53E-10	1.64E-10	3.95E-10
7.5	2.00E-11	1.11E-10	1.21E-10	1.53E-10	1.53E-10	1.74E-10
10.	6.38E-12	1.11E-10	1.21E-10	1.53E-10	1.53E-10	1.53E-10

Table A-1g: Mean and Fractile Seismic Hazard Curves for 0.5 Hz at CPNPP

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	1.02E-02	5.12E-03	7.03E-03	9.93E-03	1.32E-02	1.60E-02
0.001	6.67E-03	2.88E-03	4.13E-03	6.45E-03	9.24E-03	1.13E-02
0.005	2.17E-03	3.09E-04	6.45E-04	1.79E-03	3.73E-03	5.35E-03
0.01	9.97E-04	6.64E-05	1.69E-04	6.36E-04	1.87E-03	3.09E-03
0.015	5.29E-04	2.25E-05	6.26E-05	2.80E-04	9.93E-04	1.87E-03
0.03	1.24E-04	2.49E-06	8.00E-06	4.50E-05	2.13E-04	5.12E-04
0.05	3.17E-05	3.84E-07	1.34E-06	8.72E-06	4.83E-05	1.40E-04
0.075	9.06E-06	7.55E-08	2.84E-07	1.98E-06	1.23E-05	4.07E-05
0.1	3.47E-06	2.22E-08	8.85E-08	6.45E-07	4.43E-06	1.53E-05
0.15	8.31E-07	3.63E-09	1.60E-08	1.23E-07	9.79E-07	3.52E-06
0.3	7.10E-08	2.25E-10	7.66E-10	6.93E-09	7.23E-08	2.96E-07
0.5	1.40E-08	1.53E-10	1.72E-10	9.37E-10	1.16E-08	5.83E-08
0.75	4.45E-09	1.21E-10	1.53E-10	2.64E-10	2.92E-09	1.72E-08
1.	2.05E-09	1.21E-10	1.46E-10	1.67E-10	1.13E-09	7.23E-09
1.5	6.83E-10	1.11E-10	1.21E-10	1.53E-10	3.37E-10	2.13E-09
3.	8.97E-11	1.11E-10	1.21E-10	1.53E-10	1.53E-10	2.96E-10
5.	1.66E-11	1.11E-10	1.21E-10	1.53E-10	1.53E-10	1.53E-10
7.5	3.79E-12	1.11E-10	1.21E-10	1.53E-10	1.53E-10	1.53E-10
10.	1.22E-12	1.11E-10	1.21E-10	1.53E-10	1.53E-10	1.53E-10

Table A-2a: Medians and Logarithmic Sigmas of Amplification Factors for CPNPP

PGA	Median AF	Sigma ln(AF)	25 Hz	Median AF	Sigma ln(AF)	10 Hz	Median AF	Sigma ln(AF)	5 Hz	Median AF	Sigma ln(AF)
1.00E-02	1.05E+00	4.05E-02	1.30E-02	8.71E-01	4.88E-02	1.90E-02	8.16E-01	9.18E-02	2.09E-02	9.20E-01	7.44E-02
4.95E-02	7.92E-01	6.29E-02	1.02E-01	5.26E-01	1.09E-01	9.99E-02	7.18E-01	1.26E-01	8.24E-02	8.75E-01	8.39E-02
9.64E-02	7.18E-01	7.25E-02	2.13E-01	5.00E-01	1.30E-01	1.85E-01	6.93E-01	1.33E-01	1.44E-01	8.60E-01	8.67E-02
1.94E-01	6.63E-01	7.92E-02	4.43E-01	5.00E-01	1.46E-01	3.56E-01	6.65E-01	1.40E-01	2.65E-01	8.40E-01	9.05E-02
2.92E-01	6.37E-01	8.20E-02	6.76E-01	5.00E-01	1.56E-01	5.23E-01	6.45E-01	1.44E-01	3.84E-01	8.24E-01	9.42E-02
3.91E-01	6.20E-01	8.34E-02	9.09E-01	5.00E-01	1.62E-01	6.90E-01	6.29E-01	1.47E-01	5.02E-01	8.11E-01	9.65E-02
4.93E-01	6.06E-01	8.38E-02	1.15E+00	5.00E-01	1.66E-01	8.61E-01	6.15E-01	1.48E-01	6.22E-01	7.99E-01	9.80E-02
7.41E-01	5.83E-01	8.42E-02	1.73E+00	5.00E-01	1.73E-01	1.27E+00	5.87E-01	1.52E-01	9.13E-01	7.73E-01	1.02E-01
1.01E+00	5.65E-01	8.40E-02	2.36E+00	5.00E-01	1.78E-01	1.72E+00	5.62E-01	1.54E-01	1.22E+00	7.48E-01	1.08E-01
1.28E+00	5.49E-01	8.42E-02	3.01E+00	5.00E-01	1.80E-01	2.17E+00	5.39E-01	1.55E-01	1.54E+00	7.23E-01	1.18E-01
1.55E+00	5.36E-01	8.68E-02	3.63E+00	5.00E-01	1.82E-01	2.61E+00	5.20E-01	1.57E-01	1.85E+00	7.02E-01	1.27E-01
2.5 Hz	**Median AF**	**Sigma ln(AF)**	**1 Hz**	**Median AF**	**Sigma ln(AF)**	**0.5 Hz**	**Median AF**	**Sigma ln(AF)**			
2.18E-02	1.31E+00	7.44E-02	1.27E-02	1.52E+00	1.19E-01	8.25E-03	1.31E+00	1.49E-01			
7.05E-02	1.27E+00	7.41E-02	3.43E-02	1.51E+00	1.15E-01	1.96E-02	1.30E+00	1.43E-01			
1.18E-01	1.25E+00	7.40E-02	5.51E-02	1.50E+00	1.13E-01	3.02E-02	1.30E+00	1.41E-01			
2.12E-01	1.22E+00	7.42E-02	9.63E-02	1.51E+00	1.11E-01	5.11E-02	1.30E+00	1.39E-01			
3.04E-01	1.20E+00	7.47E-02	1.36E-01	1.51E+00	1.10E-01	7.10E-02	1.31E+00	1.38E-01			
3.94E-01	1.18E+00	7.60E-02	1.75E-01	1.52E+00	1.10E-01	9.06E-02	1.31E+00	1.38E-01			
4.86E-01	1.16E+00	7.78E-02	2.14E-01	1.53E+00	1.10E-01	1.10E-01	1.31E+00	1.38E-01			
7.09E-01	1.12E+00	8.45E-02	3.10E-01	1.54E+00	1.09E-01	1.58E-01	1.32E+00	1.38E-01			
9.47E-01	1.08E+00	9.52E-02	4.12E-01	1.55E+00	1.11E-01	2.09E-01	1.32E+00	1.40E-01			
1.19E+00	1.05E+00	1.08E-01	5.18E-01	1.55E+00	1.18E-01	2.62E-01	1.33E+00	1.42E-01			
1.43E+00	1.02E+00	1.20E-01	6.19E-01	1.55E+00	1.26E-01	3.12E-01	1.34E+00	1.43E-01			

Table A2-b1: Median AFs and Sigmas for Model 1, Profile 1, for 2 PGA Levels for CPNPP

M1P1K1	Rock PGA=0.0495			M1P1K1	PGA=0.194		
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
100.0	0.042	0.844	0.056	100.0	0.127	0.656	0.079
87.1	0.042	0.835	0.057	87.1	0.128	0.642	0.080
75.9	0.042	0.818	0.057	75.9	0.128	0.616	0.081
66.1	0.042	0.786	0.058	66.1	0.129	0.569	0.083
57.5	0.043	0.727	0.060	57.5	0.131	0.493	0.087
50.1	0.044	0.653	0.062	50.1	0.134	0.421	0.092
43.7	0.045	0.585	0.070	43.7	0.139	0.370	0.103
38.0	0.047	0.540	0.085	38.0	0.145	0.350	0.123
33.1	0.048	0.510	0.092	33.1	0.151	0.344	0.135
28.8	0.050	0.510	0.089	28.8	0.157	0.356	0.130
25.1	0.053	0.519	0.091	25.1	0.167	0.376	0.131
21.9	0.058	0.580	0.102	21.9	0.186	0.440	0.142
19.1	0.067	0.649	0.117	19.1	0.216	0.519	0.153
16.6	0.076	0.742	0.131	16.6	0.245	0.611	0.170
14.5	0.076	0.758	0.155	14.5	0.249	0.650	0.181
12.6	0.079	0.782	0.140	12.6	0.249	0.668	0.175
11.0	0.073	0.725	0.128	11.0	0.237	0.651	0.154
9.5	0.068	0.690	0.108	9.5	0.214	0.616	0.125
8.3	0.071	0.763	0.116	8.3	0.213	0.664	0.132
7.2	0.080	0.895	0.108	7.2	0.234	0.780	0.135
6.3	0.081	0.954	0.094	6.3	0.247	0.872	0.114
5.5	0.076	0.914	0.082	5.5	0.234	0.866	0.093
4.8	0.074	0.896	0.083	4.8	0.225	0.850	0.089
4.2	0.074	0.912	0.109	4.2	0.220	0.857	0.116
3.6	0.077	0.964	0.106	3.6	0.224	0.898	0.115
3.2	0.082	1.077	0.085	3.2	0.235	0.998	0.096
2.8	0.089	1.209	0.080	2.8	0.251	1.125	0.096
2.4	0.091	1.330	0.068	2.4	0.257	1.249	0.075
2.1	0.095	1.513	0.078	2.1	0.270	1.444	0.082
1.8	0.091	1.600	0.086	1.8	0.262	1.563	0.077

M1P1K1	Rock PGA=0.0495			M1P1K1	PGA=0.194		
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
1.6	0.081	1.630	0.094	1.6	0.237	1.631	0.090
1.4	0.072	1.654	0.106	1.4	0.208	1.664	0.102
1.2	0.063	1.624	0.124	1.2	0.180	1.637	0.121
1.0	0.057	1.613	0.116	1.0	0.161	1.623	0.112
0.91	0.052	1.605	0.114	0.91	0.146	1.611	0.108
0.79	0.044	1.467	0.138	0.79	0.121	1.475	0.133
0.69	0.036	1.352	0.118	0.69	0.099	1.361	0.113
0.60	0.031	1.304	0.145	0.60	0.083	1.311	0.139
0.52	0.026	1.267	0.125	0.52	0.069	1.273	0.120
0.46	0.022	1.257	0.095	0.46	0.057	1.262	0.092
0.10	0.001	1.455	0.105	0.10	0.003	1.458	0.112

Table A2-b2: Median AFs and Sigmas for Model 2, Profile 1, for 2 PGA Levels for CPNPP

M2P1K1	PGA=0.0495			M2P1K1	PGA=0.194		
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
100.0	0.043	0.868	0.038	100.0	0.142	0.731	0.047
87.1	0.043	0.859	0.038	87.1	0.142	0.716	0.047
75.9	0.043	0.842	0.038	75.9	0.143	0.689	0.048
66.1	0.044	0.809	0.039	66.1	0.145	0.639	0.049
57.5	0.044	0.750	0.039	57.5	0.148	0.559	0.050
50.1	0.045	0.675	0.039	50.1	0.154	0.484	0.051
43.7	0.047	0.607	0.048	43.7	0.164	0.434	0.069
38.0	0.048	0.561	0.060	38.0	0.173	0.416	0.090
33.1	0.050	0.531	0.064	33.1	0.180	0.411	0.095
28.8	0.052	0.532	0.062	28.8	0.188	0.428	0.087
25.1	0.055	0.545	0.067	25.1	0.204	0.459	0.090
21.9	0.062	0.613	0.083	21.9	0.231	0.548	0.106
19.1	0.071	0.685	0.097	19.1	0.268	0.642	0.115
16.6	0.081	0.788	0.104	16.6	0.305	0.761	0.116

M2P1K1		PGA=0.0495		M2P1K1		PGA=0.194	
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
14.5	0.080	0.794	0.129	14.5	0.295	0.770	0.143
12.6	0.083	0.822	0.114	12.6	0.299	0.802	0.124
11.0	0.076	0.750	0.116	11.0	0.265	0.729	0.126
9.5	0.070	0.716	0.100	9.5	0.241	0.692	0.109
8.3	0.074	0.800	0.103	8.3	0.250	0.779	0.110
7.2	0.084	0.940	0.085	7.2	0.278	0.925	0.089
6.3	0.084	0.985	0.077	6.3	0.275	0.973	0.080
5.5	0.077	0.934	0.077	5.5	0.249	0.923	0.079
4.8	0.075	0.914	0.078	4.8	0.239	0.903	0.080
4.2	0.076	0.933	0.100	4.2	0.236	0.922	0.102
3.6	0.079	0.988	0.096	3.6	0.244	0.979	0.098
3.2	0.085	1.106	0.074	3.2	0.258	1.097	0.075
2.8	0.091	1.240	0.066	2.8	0.275	1.231	0.066
2.4	0.093	1.360	0.067	2.4	0.278	1.349	0.067
2.1	0.097	1.542	0.080	2.1	0.286	1.528	0.079
1.8	0.092	1.615	0.087	1.8	0.268	1.600	0.084
1.6	0.081	1.633	0.092	1.6	0.235	1.619	0.090
1.4	0.072	1.653	0.105	1.4	0.205	1.639	0.102
1.2	0.063	1.621	0.126	1.2	0.177	1.609	0.123
1.0	0.057	1.610	0.117	1.0	0.159	1.598	0.114
0.91	0.052	1.603	0.116	0.91	0.144	1.592	0.112
0.79	0.044	1.465	0.139	0.79	0.119	1.458	0.135
0.69	0.036	1.351	0.119	0.69	0.098	1.348	0.116
0.60	0.031	1.304	0.147	0.60	0.083	1.302	0.142
0.52	0.026	1.266	0.126	0.52	0.069	1.266	0.123
0.46	0.022	1.257	0.096	0.46	0.057	1.257	0.093
0.10	0.001	1.456	0.105	0.10	0.003	1.457	0.112

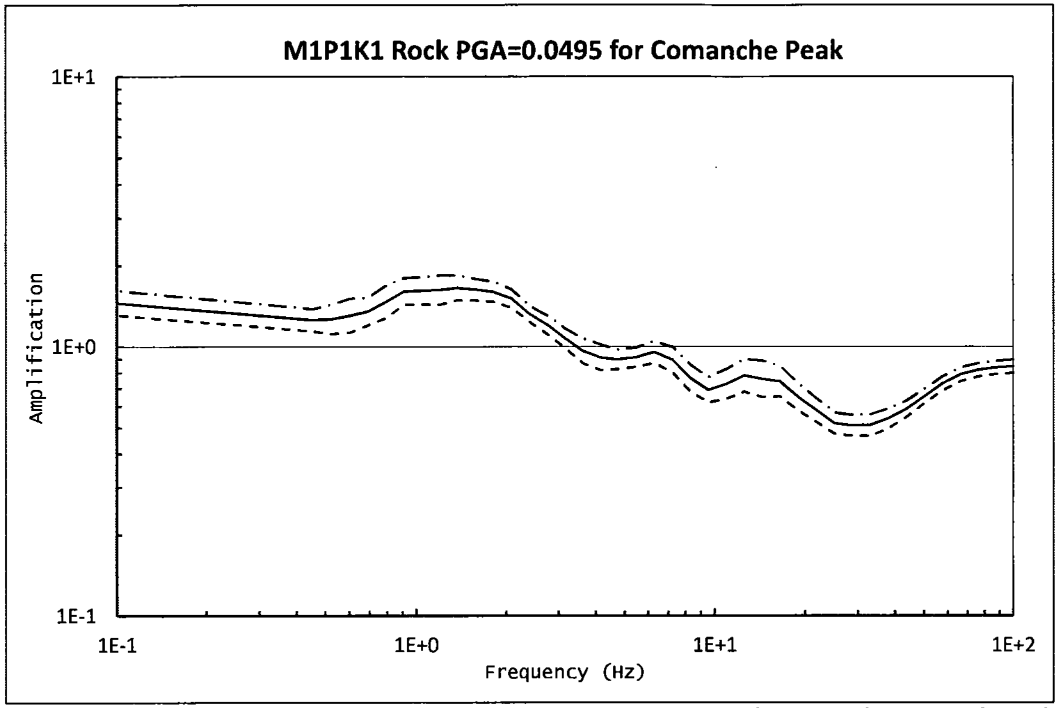


Figure A1: Amplification Factors (Median and Median ± Sigma) Plotted from Table A2-b1 for PGA 0.0495 g

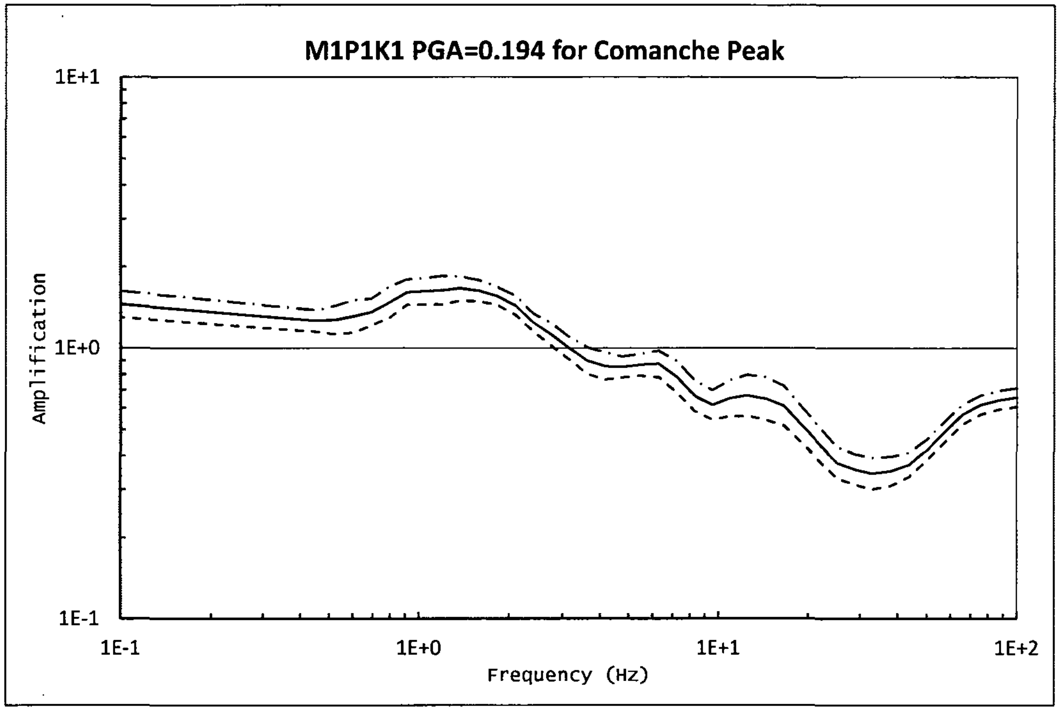


Figure A2: Amplification Factors (Median and Median ± Sigma) Plotted from Table A2-b1 for PGA 0.194 g

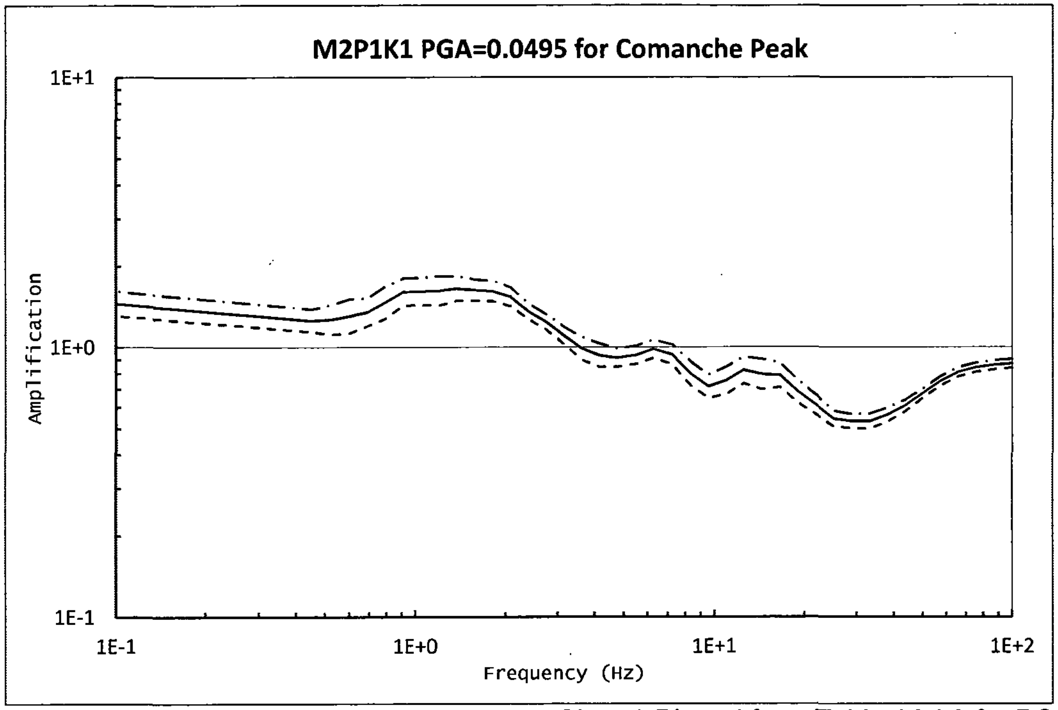


Figure A3: Amplification Factors (Median and Median + Sigma) Plotted from Table A2-b2 for PGA 0.0495 g

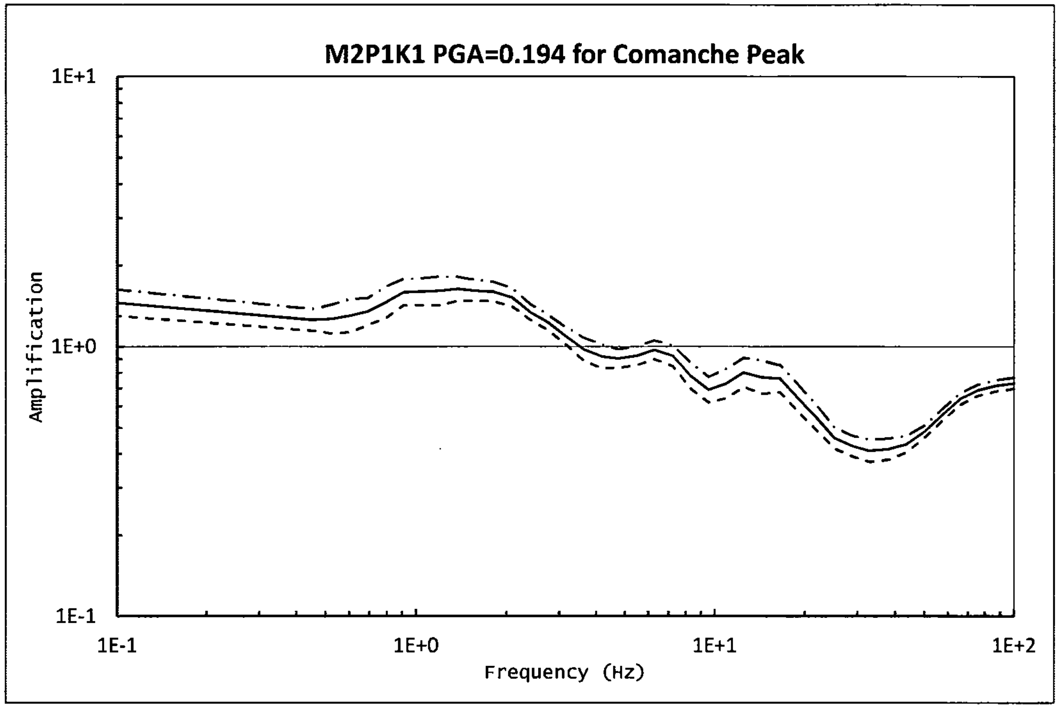


Figure A4: Amplification Factors (Median and Median ± Sigma) Plotted from Table A2-b2 for PGA 0.194 g