Exelon Generation®

RS-14-066 10 CFR 50.54(f)

March 31, 2014

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
11555 Rockville Pike,
Rockville, MD 20852

Clinton Power Station, Unit 1
Facility Operating License No. NPF-62
NRC Docket No. 50-461

Subject: Exelon Generation Company, LLC, Seismic Hazard and Screening Report (Central and Eastern United States (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 Reevaluations, dated April 9, 2013
3. NRC Letter, 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
4. Exelon Generation Company, LLC letter to the NRC, 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
5. 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
6. NRC Letter, Endorsement of Electric Power Research Institute Final Draft Report 1025287, "Seismic Evaluation Guidance," dated February 15, 2013
7. EPRI Technical Report 3002000704, "Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic," dated May 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 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.

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, with the remaining seismic hazard and screening information submitted by March 31, 2014. NRC agreed with that proposed path forward in Reference 3. In Reference 4, Exelon Generation Company, LLC (EGC) provided the description of subsurface materials and properties and base case velocity profiles for Clinton Power Station, Unit 1.

Reference 5 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 6.

The enclosed Seismic Hazard Evaluation and Screening Report for Clinton Power Station, Unit 1, provides the information described in Section 4 of Reference 5 in accordance with the schedule identified in Reference 2. As described in Enclosure 1, Clinton Power Station, Unit 1 meets the requirements of SPID Sections 3.2 and 7 (Reference 5) and therefore screens out and does not need to prepare an Expedited Seismic Evaluation Process (ESEP) Report, in accordance with Reference 7. Additionally, no Seismic Risk Assessment or Spent Fuel Pool evaluation is needed. Clinton Power Station, Unit 1, will perform a High Frequency Confirmation evaluation as determined by NRC prioritization following submittal of all nuclear power plant Seismic Hazard Re-evaluations per Reference 1.

A list of regulatory commitments contained in this letter is provided in Enclosure 2. If you have any questions regarding this report, please contact Ron Gaston at (630) 657-3359.

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

Respectfully submitted,

Glen T. Kaegi

Glen T. Kaegi
Director - Licensing & Regulatory Affairs
Exelon Generation Company, LLC

Enclosures:

1. Clinton Power Station, Unit 1, Seismic Hazard and Screening Report
2. Summary of Regulatory Commitments

cc: Director, Office of Nuclear Reactor Regulation
Regional Administrator - NRC Region III
NRC Senior Resident Inspector – Clinton Power Station
NRC Project Manager, NRR – Clinton Power Station
Ms. Jessica A. Kratchman, NRR/JLD/PMB, NRC
Mr. Eric E. Bowman, NRR/DPR/PGCB, NRC or Ms. Eileen M. McKenna, NRO/DSRA/BPTS, NRC
Illinois Emergency Management Agency - Division of Nuclear Safety

Enclosure 1

Clinton Power Station, Unit 1

Seismic Hazard and Screening Report

(48 pages)

SEISMIC HAZARD AND SCREENING REPORT

IN RESPONSE TO THE 50.54(f) INFORMATION REQUEST REGARDING FUKUSHIMA NEAR-TERM TASK FORCE RECOMMENDATION 2.1: SEISMIC

for the

Clinton Power Station, Unit 1
8401 Power Road Clinton, Illinois 61727
Facility Operating License No. NPF-62
NRC Docket No. STN 50-461
Correspondence No.: RS-14-066

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Report Number: SL-012169, Revision 0

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Exelon.

Sargent & Lundy LLC

Seismic Hazard and Screening Report – Clinton Unit 1

Report No.: SL-012189
Revision 0 – Initial Issue

S&L Project No.: 11332-183
Nuclear Non-Safety Related

Sections: Cover Page, Executive Summary, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, and Appendix A	
Prepared by:	Alexander Gonzalez/Ryan Foley — 3-14-14
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Section: 4.2	
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Reviewed by:	Brent Starks — 3/14/14
All Sections	
Approved by:	Javad Moslemian — 3/14/14

RECORD OF REVISIONS

Revision	Affected Pages	Description
0	All	Initial Issue

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Executive Summary

PURPOSE

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) issued a 50.54(f) letter (Reference 1) requesting information in response to NRC Near-Term Task Force (NTTF) recommendations intended to clarify and strengthen the regulatory framework for protection against natural phenomena. The 50.54(f) letter (Reference 1) requests that licensees and holders of construction permits under Title 10 Code of Federal Regulations Part 50 (Reference 2) reevaluate the seismic hazards at their sites against present-day NRC requirements. 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 (Reference 1) pertaining to NTTF Recommendation 2.1 for Clinton Power Station (Clinton station) in accordance with the documented intention of Exelon Generating Company transmitted to the NRC via letter dated April 29, 2013 (Reference 20).

SCOPE

In response to the 50.54(f) letter (Reference 1) and following the Screening, Prioritization, and Implementation Details (SPID) industry guidance document (Reference 3), a seismic hazard reevaluation for Clinton station was performed to develop a Ground Motion Response Spectrum (GMRS) for screening purposes to compare with the Safe Shutdown Earthquake (SSE). The new GMRS represents a beyond-design-basis seismic demand developed by more modern techniques than were used for plant licensing. Consistent with NRC letter dated February 20, 2014, (Reference 28) the seismic hazard reevaluations performed in response to the 50.54(f) letter (Reference 1) are distinct from the current design or licensing bases of operating plants. Therefore, the results generally do not call into question the operability or functionality of SSCs and are not expected to be reportable pursuant to 10 CFR 50.72, "Immediate notification requirements for operating nuclear power reactors," and 10 CFR 50.73, "Licensee event report system."

Section 2 provides a summary of the regional and local geology, seismicity, other major inputs to the seismic hazard reevaluation, and detailed seismic hazard results including definition of the GMRS. Seismic hazard analysis for Clinton station, including the site response evaluation and GMRS development (Sections 2.2, 2.3, and 2.4 of this report) was performed by the Electric Power Research Institute (EPRI) (Reference 11). A more in-depth discussion of the calculation methods used in the seismic hazard reevaluation can be found in References 3, 7, 8, 9, and 16. Section 3 describes the characteristics of the appropriate plant-level SSE. Section 4 provides a comparison of the GMRS to the SSE. Sections 5 and 6 discuss interim actions and conclusions, respectively.

CONCLUSIONS

For Clinton station, the SSE envelopes the GMRS in the frequency range from 1 Hz to 10 Hz. Therefore, in accordance with the SPID Sections 3.2 and 7 (Reference 3), Clinton station screens out of further risk assessments and spent fuel pool integrity evaluation in response to NTTF 2.1: Seismic. Additionally, Clinton station screens out of the Expedited Seismic Evaluation Process (ESEP) interim action per the ESEP guidance, Section 2.2 (Reference 4).

Due to the GMRS exceeding the SSE for a portion of the frequency range above 10 Hz, high frequency confirmations will be performed for Clinton station based upon the schedule for central and eastern United States (CEUS) nuclear plants provided via letter from the industry to the NRC dated April 9, 2013 (Reference 6), as endorsed by the NRC in the May 7, 2013 letter to the industry (Reference 27).

1 Introduction

Following the accident at the Fukushima Daiichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the NRC Commission established a Near Term Task Force (NTTF) to conduct a systematic review of NRC processes and regulations and to determine if the agency should make additional improvements to its regulatory system. The NTTF developed a set of recommendations intended to clarify and strengthen the regulatory framework for protection against natural phenomena. Subsequently, the NRC issued a 50.54(f) letter that requests information to assure that these recommendations are addressed by all U.S. nuclear power plants (Reference 1). The 50.54(f) letter (Reference 1) requests that licensees and holders of construction permits under 10 CFR Part 50 (Reference 2) reevaluate the seismic hazards at their sites against present-day NRC requirements. Depending on the comparison between the reevaluated seismic hazard and the current design basis, the result is either no further risk evaluation or the performance of a seismic risk assessment. Risk assessment approaches acceptable to the staff include a seismic probabilistic risk assessment (SPRA), or a seismic margin assessment (SMA). Based upon the risk assessment results, the NRC staff will determine whether additional regulatory actions are necessary.

This report provides the information requested in items (1) through (7) of the "Requested Information" section and Attachment 1 of the 50.54(f) letter (Reference 1) pertaining to NTTF Recommendation 2.1 for the Clinton Power Station (Clinton station), located in Dewitt County, Illinois. In providing this information, Exelon 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* (Reference 3). The Augmented Approach, *Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic* (Reference 4), has been developed as the process for evaluating critical plant equipment as an interim action to demonstrate additional plant safety margin, prior to performing the complete plant seismic risk evaluations. The SPID (Reference 3) and the Augmented Approach (Reference 4) have been endorsed by the NRC in letters to NEI (Reference 26 and Reference 27).

The original geologic and seismic siting investigations for the Clinton station were performed in accordance with Appendix A of Title 10 Code of Federal Regulations Part 100 (Reference 5) and meet General Design Criterion 2 in Appendix A of Reference 2. The Safe Shutdown Earthquake (SSE) ground motion was developed in accordance with Appendix A of Reference 5 and is used for the design of seismic Category I systems, structures and components. See Section 3 of this report for further discussion on the development of the SSE.

In response to the 50.54(f) letter (Reference 1) and following the SPID guidance (Reference 3), a seismic hazard reevaluation was performed. For screening purposes, a Ground Motion Response Spectrum (GMRS) was developed.

2

Seismic Hazard Reevaluation

The Clinton station is located in the central stable region of North America in the Illinois Basin, slightly west of the La Salle Anticlinal Belt, approximately 6 miles east of the city of Clinton, DeWitt County Illinois. The site area consists of a gently rolling upland developed on ground moraine, which has been dissected by the southwest-flowing Salt Creek and the North Fork of Salt Creek. Topographic relief varies from approximately 10 feet on the upland to a maximum of about 80 feet between the upland and valley bottoms. Strata underlying the site consist of an estimated 170 to 360 feet of Quaternary overburden, largely Wisconsinan, Illinoian, and pre-Illinoian aged glacial deposits resting on essentially flat-lying Pennsylvanian aged shales, sandstones, and thin coal beds. (Reference 10)

Seismicity reviews performed during the plant licensing determined that there were no recorded earthquakes with a Modified Mercalli Intensity (MMI) of VIII or greater within 200 miles of the site. The largest earthquakes within 200 miles were MMI-VII, which corresponded to a horizontal ground acceleration of 0.13g, and this criterion was originally selected as the design SSE. During licensing the NRC considered a MMI-VIII earthquake corresponding to a horizontal ground surface acceleration of 0.25g at the site as an acceptable earthquake, and the value was applied at the foundation level in the free field. Utilizing the subsurface properties of the site, the corresponding ground surface acceleration was found to be 0.26g (Reference 10).

2.1 Regional and Local Geology

The region surrounding the site lies within the Central Stable Region of the North American Continent. This province is a tectonically stable area characterized by gently dipping sedimentary rock of Paleozoic overlain by thin Cenozoic deposits mostly quarternary glacial drift, and, locally by Mosozoic strata. Beneath the Paleozoic is a basement complex of Precambrian and igneous and metamorphic rocks. Intermittent slow subsidence and gentle uplift through the Paleozoic has result in broad basins (e.g., the Illinois, Michigan, and Forest City Basins), filled with gently dipping sedimentary rocks, and in intervening broad arches or highs (e.g., the Kankakee arch, Mississippi River Arch, etc.). Locally, folds and faults have been superimposed on this pattern.

The site lies within the Bloomington Ridged Plain physiographic subsection of the Till Plains Section. The site area consists of a gently rolling upland developed on ground moraine, which has been dissected by the southwest-flowing Salt Creek and the North Fork of Salt Creek. The strata underlying the site consist of Quartnary overburden, largely Wisconsinan, Illinoian, and pre-Illinoian glacial deposits, resting on Pennsylvanian-age bedrock. The main plant is located in an area of uplands, consisting of Wisconsinan-age ground moraine. (Reference 10)

2.2 PROBABILISTIC SEISMIC HAZARD ANALYSIS

2.2.1 *Probabilistic Seismic Hazard Analysis Results*

In accordance with the 50.54(f) letter (Reference 1) and following the guidance in the SPID (Reference 3), 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 (Reference 7) together with the updated EPRI Ground-Motion Model (GMM) for the CEUS (Reference 8). For the PSHA, a lower-bound moment magnitude of 5.0 was used, as specified in the 50.54(f) letter (Reference 1).

For the PSHA, the CEUS-SSC background seismic source zones out to a distance of 400 miles around Clinton station were included. This distance exceeds the 200 mile recommendation contained in Reg. Guide 1.208 (Reference 16) and was chosen for completeness. Background sources included in this site analysis are the following:

1. Extended Continental Crust—Gulf Coast (ECC_GC)
2. Illinois Basin Extended Basement (IBEB)
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. Paleozoic Extended Crust narrow (PEZ_N)
12. Paleozoic Extended Crust wide (PEZ_W)
13. Reelfoot Rift (RR)
14. Reelfoot Rift including the Rough Creek Graben (RR-RCG)
15. Study region (STUDY_R)

For sources of large magnitude earthquakes, designated Repeated Large Magnitude Earthquake (RLME) sources in CEUS-SSC (Reference 7), the following sources lie within 621 miles (1,000 km) of the site and were included in the PSHA:

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

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

2.2.2 *Base Rock Seismic Hazard Curves*

Consistent with the SPID (Reference 3), 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 2.3.7 at the SSE control point elevation.

2.3 SITE RESPONSE EVALUATION

Following the guidance contained in Seismic Enclosure 1 of the 50.54(f) Request for Information (Reference 1) and in the SPID (Reference 3) for nuclear power plant sites that are not founded on hard rock (hard rock is defined as having a shear wave velocity of at least 9285 ft/s), a site response analysis was performed for Clinton station.

2.3.1 *Description of Subsurface Material*

Clinton station is located in the Illinois Basin near Clinton, Illinois. The general site conditions consist of about 240 feet of soils overlying limestone and shales with Precambrian basement at a depth of about 6,000 feet. As illustrated in Table 2.3.1-1, the SSE was specified at an elevation of 736 feet. Hard reference rock (shear-wave velocity at or exceeding 9,285 feet/s) occurs at elevation -5,300 feet. The profile then consists of about 240 feet of soil overlying about 5,800 feet of firm sedimentary rock.

The strata underlying the site consist of Quaternary overburden, largely Wisconsinan, Illinoian, and pre-Illinoian glacial deposits, about 225 to 360 feet in thickness in the upland areas, resting on Pennsylvanian-age bedrock. Overburden materials occurring in the site vicinity, in order of increasing age, consist of stream alluvium, windblown loess, and glacial drift. Colluvium and glacial outwash are also present. (Reference 10)

In the vicinity of primary structures, loess and glacial drift comprise the surficial deposits. The loess, known as the Richland Loess, generally consists of clayey silt with a trace of sand, and is present to thicknesses of 5 to 10 feet. The uppermost glacial drift deposits consist of Wisconsinan-age glacial till of the Wedron Formation (alternately referred to as Wisconsinan Glacial Till). The Wedron Formation is from 20 to 55 feet thick in the site area where it has not been partially removed by erosion. It is composed of stiff to very stiff clayey sandy silt till. Discontinuous lenses of stratified sand, silt, or gravel are randomly interbedded within the till of the Wedron Formation.

Underlying the till of the Wedron Formation is the Robein Silt. It is a dark colored silt, rich in organic material. It is present over much of the site area, and may be up to 2 feet thick, although locally it may be absent due to erosion. (Reference 10)

Underlying the Robein Silt are deposits of Illinoian-age collectively referred to as the Glasford Formation. The upper part of the Glasford Formation was weathered during the late Illinoian Sangamonian and possibly Altonian stages, and these weathered deposits are alternately referred to as the weathered Glasford Formation, Interglacial Zone, Sangamon Interglacial Zone, or Sangamon Soil Interval in various reference documents. Preserved mostly in the uplands, the weathered Glasford Formation is 10 to 20 feet thick in the site area. The weathered materials are dominantly glacial till, consisting of silty clay and clayey silt, but locally they may be discontinuous lenses of

silts, sands, or sandy silts interbedded within the glacial till of the Glasford Formation. (Reference 10)

Beneath the weathered Glasford Formation, the unaltered Glasford Formation ranges in thickness from 90 to more than 140 feet. It is dominantly a hard, gray-brown sandy silt till. Discontinuous layers of stratified sand, gravel, or silt, up to 2 to 3 feet in thickness may be interbedded within the till in the uppermost part of the unaltered Glasford Formation. The lower part of the unaltered Glasford Formation appears to have virtually no interbedded stratified deposits. The unaltered Glasford Formation is alternately referred to as "Illinoian Till" or "Illinoian Glacial Till" in the various reference documents. (Reference 10)

Beneath the Glasford Formation is a complex assemblage of glacial materials consisting of occasionally sandy clay till, reworked till and outwash, and glaciolacustrine gray silt. Correlation of these formations throughout the site area is difficult and uncertain. The sequence is probably pre-Illinoian in age and varies in thickness from 10 to 105 feet across the site.

In some areas of the site, as beneath the main power block, the complex of probable pre-Illinoian till, outwash, and glaciolacustrine deposits lies in direct contact with bedrock. Generally, however, it is underlain by a clean sand and gravel deposit of highly variable thickness which is identified as Kansan Stage glacial outwash. This interval shows pronounced thickening where the bedrock surface slopes to lower elevations and is a glaciofluvial filling in the bedrock valleys. Its thickness ranges from zero on the highest bedrock surfaces to 140 feet at the lowest bedrock elevations.

The site is underlain by bedrock of Pennsylvanian age. The bedrock surface at the site is an erosional surface that varies in elevation from El. 360 to 510 feet MSL. The Pennsylvanian bedrock is characterized by sharp vertical changes in rock type and by lateral persistence of units such as limestone or coal, where they have not been removed by erosion. The bedrock comprises three formations: the Bond Formation, Modesto Formation, and Carbondale Formation. The thicknesses and composition of the various formations are described in detail in USAR Section 2.5.1.2.2.2 (Reference 10).

Below the Pennsylvanian strata, data indicates approximately 560 feet of Mississippian shale and limestone, which in turn are underlain by 180 feet of Devonian limestone and shale, underlain by Silurian dolomite (see USAR Section 2.5.1.2.5 for information on older strata beneath the site) (Reference 10). Approximately 1000 feet of Ordovician sediment and approximately 3100 feet of late Cambrian sediment underlies the site (Reference 15).

Data from the regional area suggest that the Precambrian rocks are igneous rocks, composed of granite, rhyolite, and associated rock. The elevation of the Precambrian basement in the site vicinity is estimated to be approximately (-)6000 feet MSL at a depth of approximately 6700 feet (References 10 and 15).

Table 2.3.1-1: Summary of geotechnical profile data for Clinton station (Reference 21)

Elevations of Layer Boundaries At Containment Buildings (feet, MSL)	Range in Thickness Across Site (feet)	Soil/Rock Description and Age	Density (pcf)	Shear Wave Velocity (fps)	Compressional Wave Velocity (fps)	Poisson's Ratio
736[a] to 732	4-10	Wisconsinan Richland Loess, soft, clayey silt	118-131	641-1354	1680-2875	0.37
732 to 702	20-55	Wisconsinan Wedron Formation, stiff to very stiff clayey sandy silt with lenses of stratified sand, gravel or silt	130-157	641-1354	4800-7300	0.48
702 to 680[b]	10-22	Illinoian weathered Glasford Formation, clayey silt with sand and gravel	120-160	860-1970	4800-7500	0.48
680 to 577	90-140	Illinoian unaltered Glasford Formation, hard sandy silt till with discontinuous layers of stratified sand, gravel or silt up to 3 feet thick in the uppermost part	140-160	1100-3250	5700-8900	0.46
577 to 560	0-17	Probably-Pre-Illinoian lacustrine deposit of clayey silt (reworked and weathered Pre-Illinoian glacial till)	133-142	1390-2670	7500	0.46-0.47
560 to 510	50-68	Pre-Illinoian silty clay and clayey silt with some sand and gravel	134-162	1560-2800	5270-8230	0.46-0.47
510 to 500	5-15	Pre-Illinoian lacustrine deposits of clayey silt and silty clay with sand and some gravel (reworked glacial till)	126-142	1190-3310	5270-7940	0.40-0.46
500 to 0	300-800	Pennsylvanian limestone, shale, sandstone, coal, and siltstone	160-166	3250-5700	7850-12000	0.29
0 to -500	500-600	Mississippian limestone, with lesser siltstone and shale	N/A	4500-6500	N/A	0.33
-500 to -700	150-250	Devonian shale and limestone	N/A	4500-8500	N/A	0.33
-700 to -1200	450-550	Silurian carbonates, some of which include reef structure	N/A	4500-8500	N/A	0.33
-1200 to -2300	1000-1500	Ordovician dolomite, sandstone, basal sandstone, limestone, and shales	N/A	6500-10500	N/A	0.25-0.33
-2300 to -5300	2900-3100	Cambrian siltstone, shale, sandstone, and dolomite	N/A	6500-10500	N/A	0.25-0.33
-5300 and below	N/A	Precambrian igneous rocks, dominantly granite with associated granodiorite, rhyolite, felsite, or granophyre of closely related composition	N/A	>9200	N/A	0.25

a Surface of finish grade is nominally at El. 736 feet MSL in the vicinity of the main power block. This is the control point elevation for the SSE and the IPEEE HCLPF.
b Bottom of the deepest foundation in the vicinity of the main power block is at El. 693 feet MSL, within the weathered Glasford Formation. Beneath the main power block, the native soils were excavated down to El. 680 feet MSL to the surface of the unaltered Glasford Formation. Type B structural fill is placed between El. 680 feet MSL and the bottom of the foundations. The structural backfill is described in UFSAR Section 2.5.4.5.1.5 (Reference 10).

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 verses depth for the best estimate single profile. Velocity measurements consist of refraction, uphole, and downhole surveys at the site as well as consideration of more recent ESP measurements of unspecified proximity to the site (Reference 14). Recommended shear-wave velocities listed in Table 2.3.1-1 (means of the specified ranges) were taken as the mean base-case profile (P1). As depths of measurements verses assumed[1] shear-wave velocities was not specified, lower- and upper-range profiles (P2 and P3 respectively) were developed with a scale factor of 1.57. The scale factor of 1.57 reflects a $\sigma_{\mu ln}$ of about 0.35 based on the SPID (Reference 3) 10th and 90th fractiles which implies a 1.28 scale factor on σ_{μ}. Depth to Precambrian basement was taken as 6,036 feet +/- 1,800 feet. The depth randomization reflects +/- 30% of the depth and was included to provide a realistic broadening of the fundamental resonance at deep sites rather than reflect actual random variations to basement shear-wave velocities across a footprint. The upper range profile P3 encountered hard rock shear-wave velocities (9,285 ft/s) at a depth below the SSE control point of about 1,236 feet. The three shear wave velocity profiles are shown in Figure 2.3.2-1 and listed in Table 2.3.2-1.

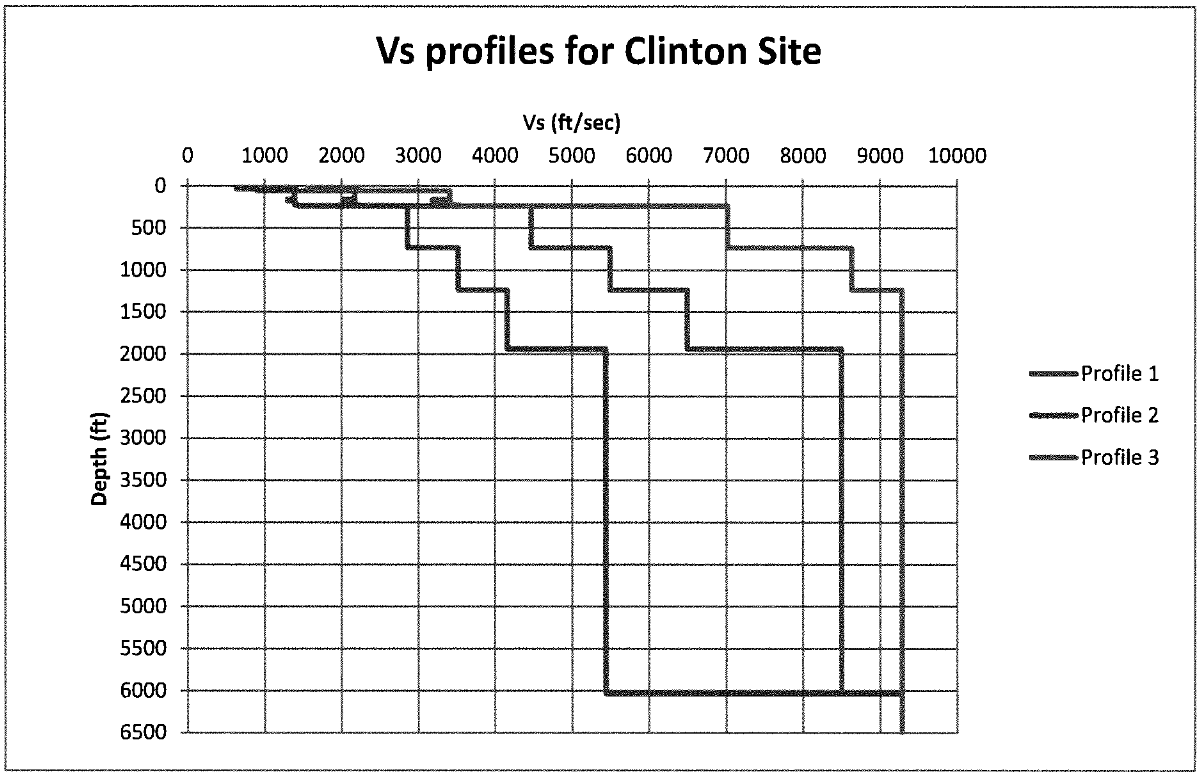

Figure 2.3.2-1: Shear-wave velocity (Vs) profiles for Clinton site. (Reference 21)

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[1] Assumptions discussed in Section 2 are provided by EPRI engineers (Reference 11) in accordance with implementation of the SPID (Reference 3) methodology.

Table 2.3.2-1: Layer thicknesses, depths, and shear-wave velocities (Vs) for 3 profiles, Clinton site (Reference 21)

Profile 1 (P1)			Profile 2 (P2)			Profile 3 (P3)		
Thickness(ft)	Depth (ft)	Vs (ft/s)	Thickness(ft)	Depth (ft)	Vs (ft/s)	Thickness(ft)	Depth (ft)	Vs (ft/s)
	0	997		0	638		0	1566
4.0	4.0	997	4.0	4.0	638	4.0	4.0	1566
5.0	9.0	997	5.0	9.0	638	5.0	9.0	1566
5.0	14.0	997	5.0	14.0	638	5.0	14.0	1566
5.0	19.0	997	5.0	19.0	638	5.0	19.0	1566
1.0	20.0	997	1.0	20.0	638	1.0	20.0	1566
4.0	24.0	997	4.0	24.0	638	4.0	24.0	1566
5.0	29.0	997	5.0	29.0	638	5.0	29.0	1566
5.0	34.0	997	5.0	34.0	638	5.0	34.0	1566
4.4	38.4	1415	4.4	38.4	906	4.4	38.4	2221
4.4	42.8	1415	4.4	42.8	906	4.4	42.8	2221
4.4	47.2	1415	4.4	47.2	906	4.4	47.2	2221
2.8	50.0	1415	2.8	50.0	906	2.8	50.0	2221
1.6	51.6	1415	1.6	51.6	906	1.6	51.6	2221
4.4	56.0	1415	4.4	56.0	906	4.4	56.0	2221
10.3	66.3	2175	10.3	66.3	1392	10.3	66.3	3415
10.3	76.6	2175	10.3	76.6	1392	10.3	76.6	3415
10.3	86.9	2175	10.3	86.9	1392	10.3	86.9	3415
10.3	97.2	2175	10.3	97.2	1392	10.3	97.2	3415
10.3	107.5	2175	10.3	107.5	1392	10.3	107.5	3415
10.3	117.8	2175	10.3	117.8	1392	10.3	117.8	3415
2.2	120.0	2175	2.2	120.0	1392	2.2	120.0	3415
8.1	128.1	2175	8.1	128.1	1392	8.1	128.1	3415
10.3	138.4	2175	10.3	138.4	1392	10.3	138.4	3415
10.3	148.7	2175	10.3	148.7	1392	10.3	148.7	3415
10.3	159.0	2175	10.3	159.0	1392	10.3	159.0	3415
8.5	167.5	2030	8.5	167.5	1299	8.5	167.5	3187
8.5	176.0	2030	8.5	176.0	1299	8.5	176.0	3187
10.0	186.0	2180	10.0	186.0	1395	10.0	186.0	3422
10.0	196.0	2180	10.0	196.0	1395	10.0	196.0	3422
10.0	206.0	2180	10.0	206.0	1395	10.0	206.0	3422
10.0	216.0	2180	10.0	216.0	1395	10.0	216.0	3422
10.0	226.0	2180	10.0	226.0	1395	10.0	226.0	3422
10.0	236.0	2250	10.0	236.0	1440	10.0	236.0	3532
14.0	250.0	4475	14.0	250.0	2864	14.0	250.0	7025
25.0	275.0	4475	25.0	275.0	2864	25.0	275.0	7025

Table 2.3.2-1: (Continued)

Profile 1 (P1)			Profile 2 (P2)			Profile 3 (P3)		
Thickness(ft)	Depth (ft)	Vs (ft/s)	Thickness(ft)	Depth (ft)	Vs (ft/s)	Thickness(ft)	Depth (ft)	Vs (ft/s)
25.0	300.0	4475	25.0	300.0	2864	25.0	300.0	7025
25.0	325.0	4475	25.0	325.0	2864	25.0	325.0	7025
25.0	350.0	4475	25.0	350.0	2864	25.0	350.0	7025
25.0	375.0	4475	25.0	375.0	2864	25.0	375.0	7025
25.0	400.0	4475	25.0	400.0	2864	25.0	400.0	7025
25.0	425.0	4475	25.0	425.0	2864	25.0	425.0	7025
25.0	450.0	4475	25.0	450.0	2864	25.0	450.0	7025
25.0	475.0	4475	25.0	475.0	2864	25.0	475.0	7025
25.0	500.0	4475	25.0	500.0	2864	25.0	500.0	7025
118.0	618.0	4475	118.0	618.0	2864	118.0	618.0	7025
118.0	736.0	4475	118.0	736.0	2864	118.0	736.0	7025
250.0	985.9	5500	250.0	985.9	3520	250.0	985.9	8635
250.0	1235.9	5500	250.0	1235.9	3520	250.0	1235.9	8635
233.3	1469.3	6500	233.3	1469.3	4160	233.3	1469.3	9285
233.3	1702.6	6500	233.3	1702.6	4160	233.3	1702.6	9285
233.3	1935.9	6500	233.3	1935.9	4160	233.3	1935.9	9285
275.0	2210.9	8500	275.0	2210.9	5440	275.0	2210.9	9285
275.0	2485.9	8500	275.0	2485.9	5440	275.0	2485.9	9285
275.0	2760.9	8500	275.0	2760.9	5440	275.0	2760.9	9285
275.0	3035.8	8500	275.0	3035.8	5440	275.0	3035.8	9285
300.0	3335.8	8500	300.0	3335.8	5440	300.0	3335.8	9285
300.0	3635.8	8500	300.0	3635.8	5440	300.0	3635.8	9285
300.0	3935.8	8500	300.0	3935.8	5440	300.0	3935.8	9285
300.0	4235.8	8500	300.0	4235.8	5440	300.0	4235.8	9285
300.0	4535.8	8500	300.0	4535.8	5440	300.0	4535.8	9285
300.0	4835.8	8500	300.0	4835.8	5440	300.0	4835.8	9285
300.0	5135.7	8500	300.0	5135.7	5440	300.0	5135.7	9285
300.0	5435.7	8500	300.0	5435.7	5440	300.0	5435.7	9285
300.0	5735.7	8500	300.0	5735.7	5440	300.0	5735.7	9285
300.0	6035.7	8500	300.0	6035.7	5440	300.0	6035.7	9285
3280.8	9316.5	9285	3280.8	9316.5	9285	3280.8	9316.5	9285

2.3.2.1 *Shear Modulus and Damping Curves*

Results of recent laboratory testing for nonlinear dynamic material properties were not available for the soils or firm rock materials for Clinton station. To reflect epistemic uncertainty in nonlinear dynamic material properties, the firm rock material at the site was assumed[1] to have behavior that could be modeled as either linear or non-linear and a realistic range in soil nonlinearity was accommodated with two sets of modulus reduction and hysteretic damping curves. Consistent with the SPID (Reference 3), the EPRI soil and rock curves (model M1) were considered to be appropriate to represent the upper range nonlinearity likely in the materials at the site; and Peninsular Range (PR) curves for soils combined with linear analyses (model M2) for rock was assumed[1] to represent an equally plausible less nonlinear alternative response across loading level. For the linear firm rock analyses, the low strain damping from the EPRI soil and rock curves were used as the constant damping values in the upper 500 feet of the profile.

2.3.2.2 *Kappa*

For the Clinton profile of about 6,000 feet of soils and firm rock over hard reference rock, the estimates of kappa were based on the low-strain damping in the hysteretic damping curves over the top 500 feet plus the assumption of a constant hysteretic damping of 1.25 (Q_S of 40) for the remaining firm rock profile in addition to a kappa value of 0.006s for hard rock (Reference 3). For base-case profiles P1, P2, and P3 the kappa contributions from the profiles was 0.025s, 0.040s, and 0.020s respectively. The total kappa values, after adding the hard reference rock value of 0.006s, were 0.031s, 0.040s (maximum kappa; Reference 3), and 0.026s respectively (Table 2.3.2-2). About the mean base-case (P1) the epistemic uncertainty in kappa is only about 20%. Additional epistemic uncertainty in profile damping (kappa) is accommodated at design loading levels through multiple sets of modulus reduction and hysteretic damping curves for the soils.

Table 2.3.2-2: Kappa values and weights used for site response analyses (Reference 11)

Velocity Profile	Kappa(s)
P1	0.031
P2	0.040
P3	0.026
	Weights
P1	0.4
P2	0.3
P3	0.3
G/G_{max} and Hysteretic Damping Curves	
M1, EPRI Soil, EPRI Rock	0.5
M2, PR Soil, Linear Rock	0.5

[1] Assumptions discussed in Section 2 are provided by EPRI engineers (Reference 11) in accordance with implementation of the SPID (Reference 3) methodology.

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[1] shear-wave velocity profiles has been incorporated in the site response calculations. For Clinton station, 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 (Reference 3), 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 (Reference 9) 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 feet and 0.15 below that depth. As specified in the SPID (Reference 3), 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[1] for the limits on random velocity fluctuations.

2.3.4 *Input Spectra*

Consistent with the guidance in Appendix B of the SPID (Reference 3), input Fourier amplitude spectra were defined for a single representative earthquake magnitude (**M** 6.5) using two different assumptions regarding the shape of the seismic source spectrum (single-corner and double-corner). A range of 11 different input amplitudes (median peak ground accelerations (PGA) ranging from 0.01g to 1.50g) were used in the site response analyses. The characteristics of the seismic source and upper crustal attenuation properties assumed[1] for the analysis of the Clinton station were the same as those identified in Tables B-4, B-5, B-6 and B-7of the SPID (Reference 3) as appropriate for typical CEUS sites.

2.3.5 *Methodology*

To perform the site response analyses for the Clinton station, 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 (Reference 3). The guidance contained in Appendix B of the SPID (Reference 3) 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 Clinton station.

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[1] Assumptions discussed in Section 2 are provided by EPRI engineers (Reference 11) in accordance with implementation of the SPID (Reference 3) methodology.

2.3.6 *Amplification Functions*

The results of the site response analysis consist of amplification factors (5% of critical damping pseudo absolute response spectra) which describe the amplification (or de-amplification) of hard reference rock motion as a function of frequency and input reference rock amplitude. The amplification factors are represented in terms of a median amplification value and an associated standard deviation (sigma) for each oscillator frequency and input rock amplitude. Consistent with the SPID a minimum median amplification value of 0.5 was employed in the present analysis. Figure 2.3.6-1 illustrates the median and +/- 1 standard deviation in the predicted amplification factors developed for the eleven loading levels parameterized by the median reference (hard rock) peak acceleration (0.01g to 1.50g) for profile P1 and EPRI soil and firm rock G/G_{max} and hysteretic damping curves (Reference 3). 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 more linear response at Clinton station, firm rock site, Figure 2.3.6-2 shows the corresponding amplification factors developed with PR curves for soil and linear site response analyses for firm rock (model M2). Between the more nonlinear and more linear analyses, Figures 2.3.6-1 and Figure 2.3.6-2 respectively show little difference across structural frequency as well as loading level. Tabulated values of amplification factors are provided in Tables A-2b1 and A-2b2 in Appendix A.

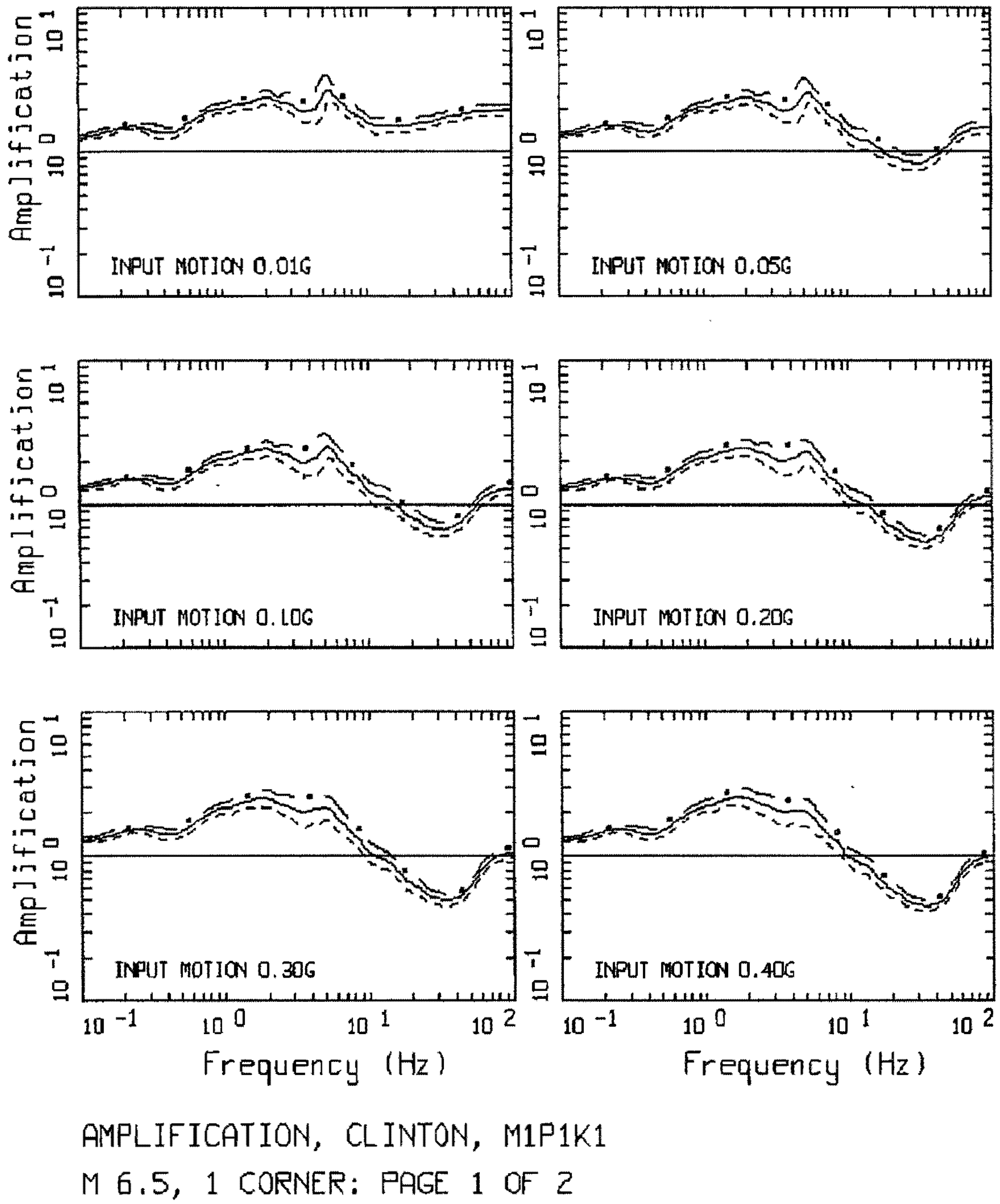

Figure 2.3.6-1: Example suite of amplification factors (5% of critical damping pseudo absolute acceleration spectra) developed for the mean base-case profile (P1), EPRI soil and rock modulus reduction and hysteretic damping curves (model M1), and base-case kappa at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g. **M** 6.5 and single-corner source model (Reference 3). (Reference 11)

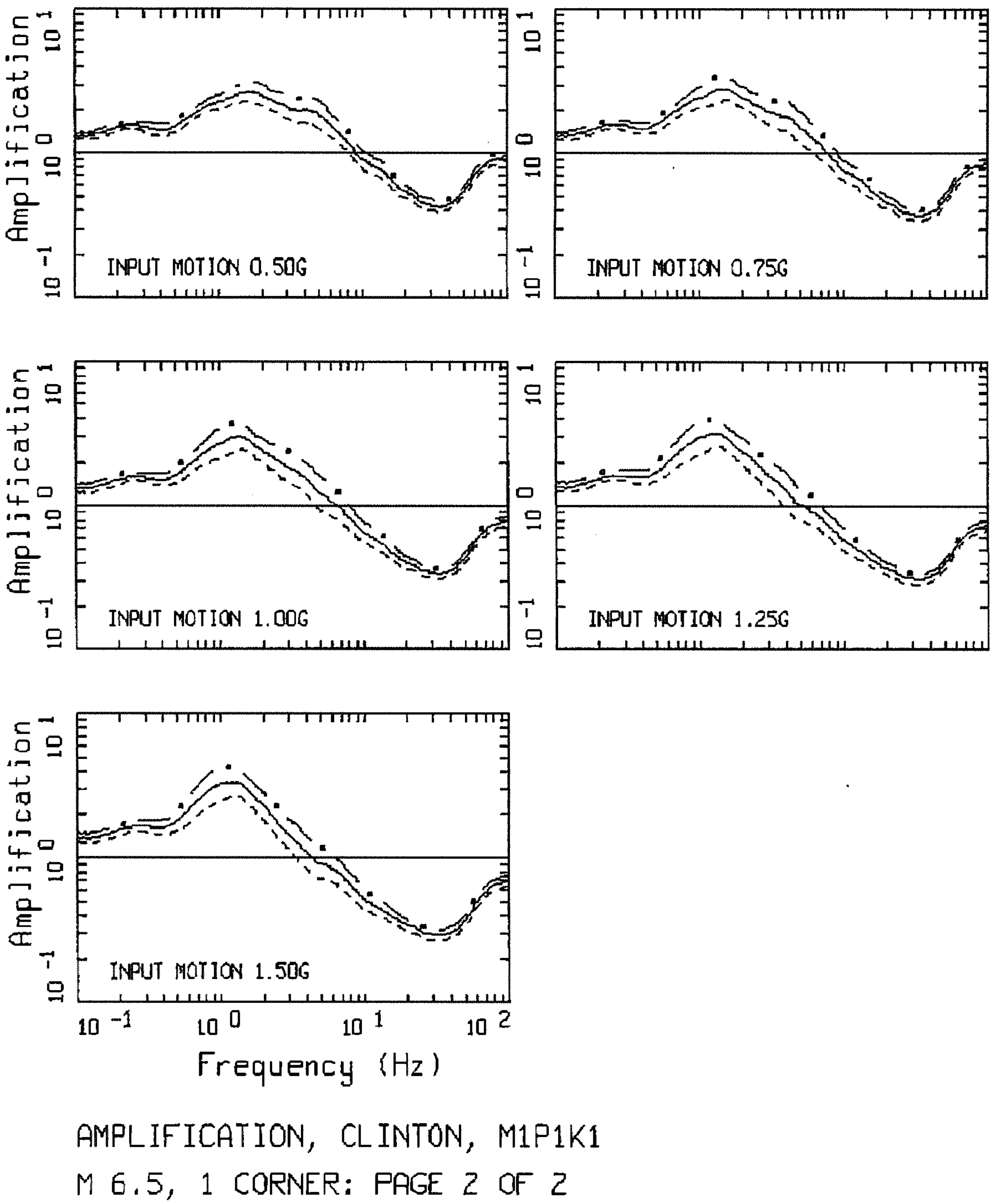

Figure 2.3.6-1. (cont.)

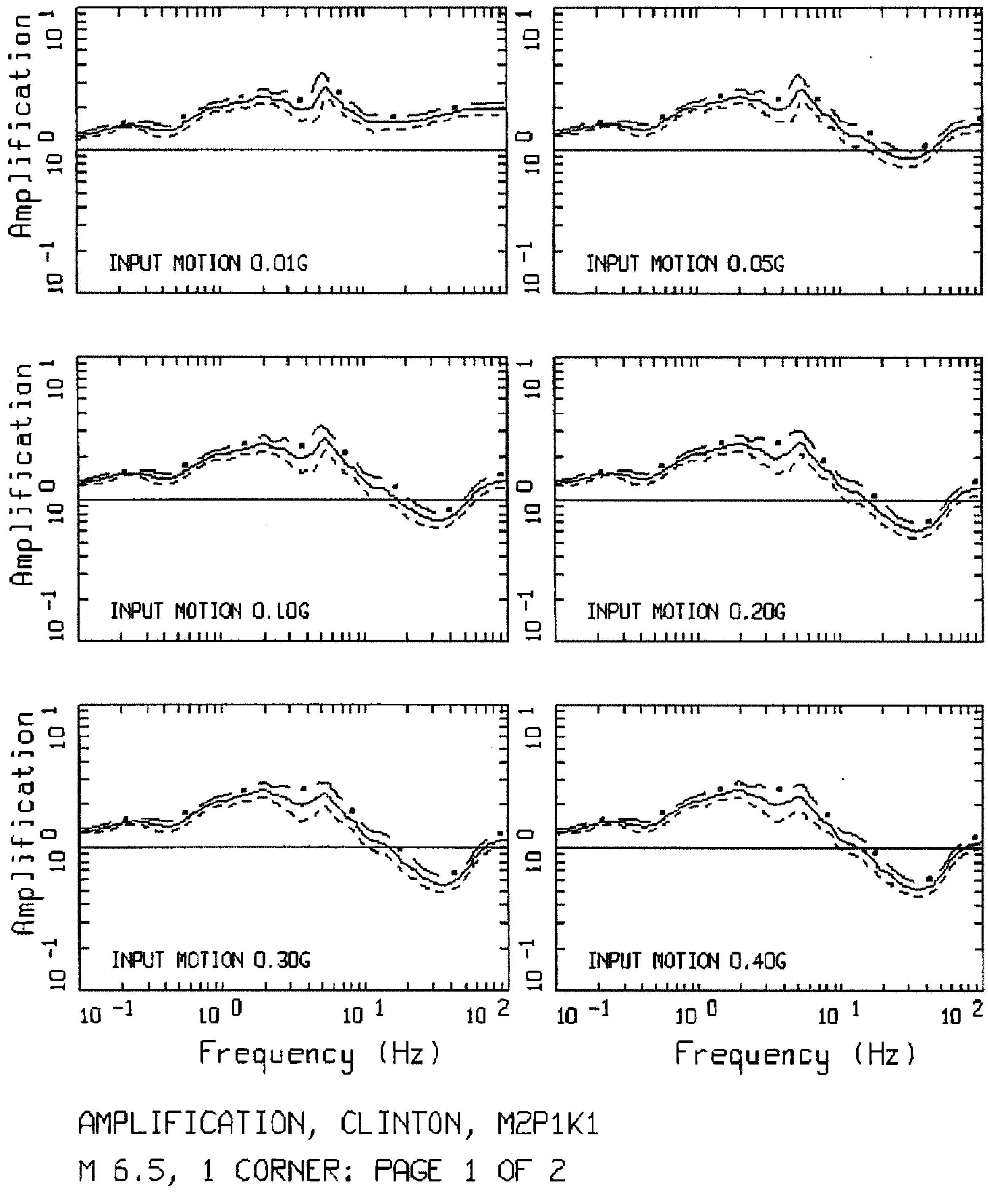

Figure 2.3.6-2: Example suite of amplification factors (5% of critical damping pseudo absolute acceleration spectra) developed for the mean base-case profile (P1), Peninsular Range curves for soil and linear site response for firm rock (model M2), and base-case kappa at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g. **M** 6.5 and single-corner source model (Reference 3). (Reference 11)

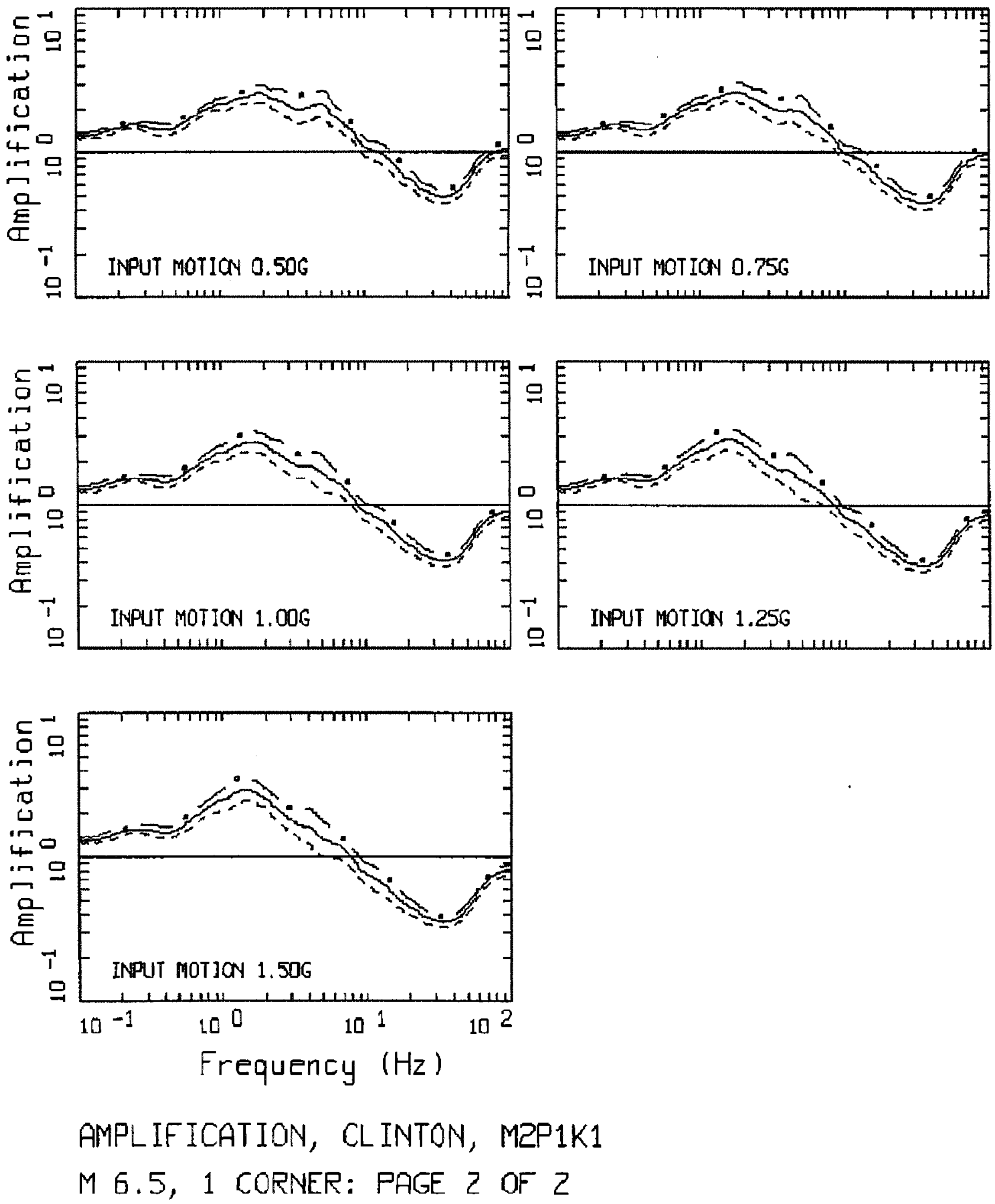

Figure 2.3.6-2. (cont.)

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 (Reference 3). 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 Clinton are shown in Figure 2.3.7-1 for the seven spectral frequencies for which ground motion equations are defined. Tabulated values of mean and fractile seismic hazard curves and site response amplification functions are provided in Appendix A.

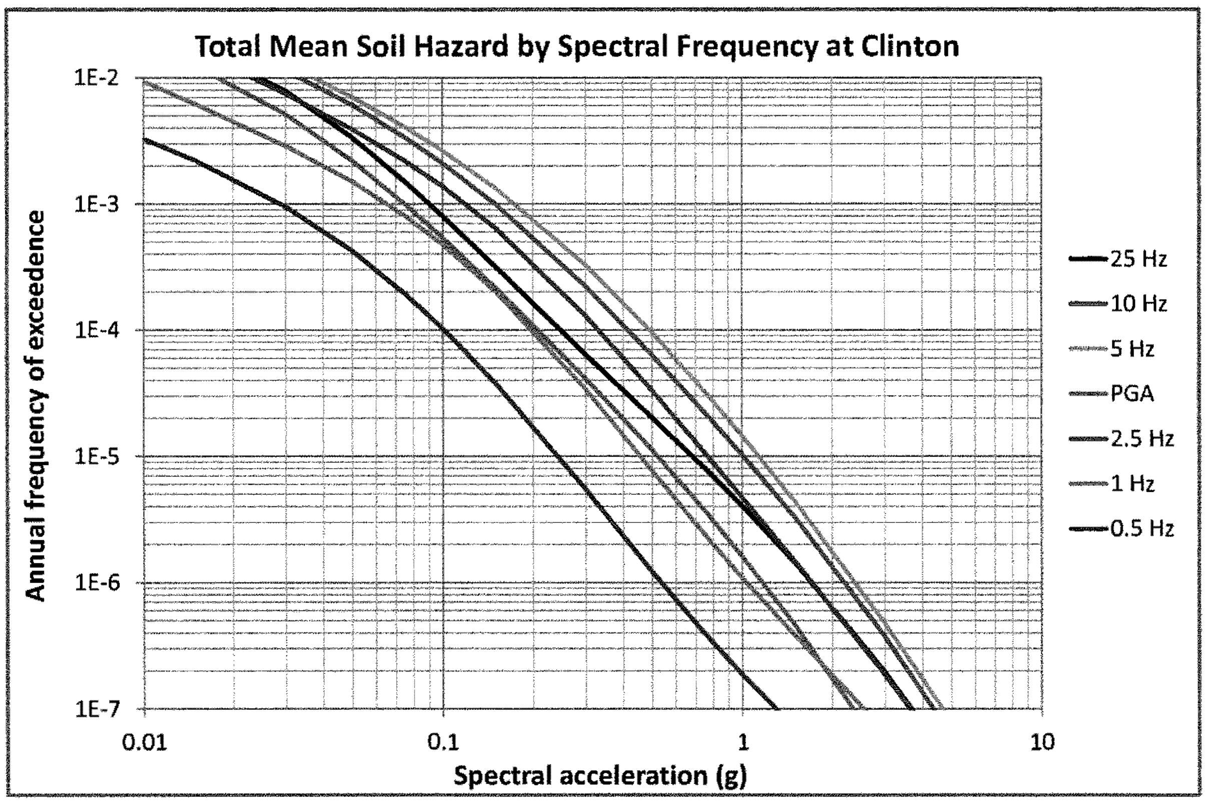

Figure 2.3.7-1: Control point mean hazard curves for spectral frequencies of 0.5, 1, 2.5, 5, 10, 25 and 100 Hz (PGA) at Clinton (5% of critical damping). (Reference 11)

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.

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 16). Table 2.4-1 shows the UHRS and GMRS spectral accelerations for a range of spectral frequencies.

Table 2.4-1: UHRS and GMRS at control point for Clinton station (5% of critical damping) (Reference 11)

Freq. (Hz)	10^{-4} UHRS (g)	10^{-5} UHRS (g)	GMRS (g)
100	2.07E-01	5.21E-01	2.60E-01
90	2.06E-01	5.23E-01	2.61E-01
80	2.05E-01	5.26E-01	2.61E-01
70	2.04E-01	5.30E-01	2.63E-01
60	2.04E-01	5.35E-01	2.65E-01
50	2.05E-01	5.47E-01	2.70E-01
40	2.11E-01	5.71E-01	2.81E-01
35	2.18E-01	5.94E-01	2.91E-01
30	2.28E-01	6.26E-01	3.07E-01
25	2.47E-01	6.80E-01	3.33E-01
20	2.78E-01	7.47E-01	3.68E-01
15	3.33E-01	8.61E-01	4.27E-01
12.5	3.61E-01	9.29E-01	4.61E-01
10	4.14E-01	1.01E+00	5.06E-01
9	4.61E-01	1.10E+00	5.54E-01
8	4.79E-01	1.16E+00	5.83E-01
7	4.58E-01	1.12E+00	5.61E-01
6	4.68E-01	1.09E+00	5.54E-01
5	4.90E-01	1.13E+00	5.75E-01
4	4.32E-01	1.02E+00	5.17E-01
3.5	4.05E-01	9.33E-01	4.74E-01
3	3.83E-01	8.59E-01	4.38E-01
2.5	3.30E-01	7.66E-01	3.89E-01
2	3.12E-01	7.31E-01	3.70E-01
1.5	2.67E-01	6.22E-01	3.15E-01
1.25	2.37E-01	5.46E-01	2.77E-01
1	1.97E-01	4.57E-01	2.32E-01

Table 2.4-1. (cont.)

Freq. (Hz)	10^{-4} UHRS (g)	10^{-5} UHRS (g)	GMRS (g)
0.9	1.79E-01	4.24E-01	2.14E-01
0.8	1.60E-01	3.82E-01	1.92E-01
0.7	1.41E-01	3.38E-01	1.70E-01
0.6	1.24E-01	2.95E-01	1.49E-01
0.5	1.01E-01	2.41E-01	1.22E-01
0.4	8.09E-02	1.93E-01	9.73E-02
0.35	7.08E-02	1.69E-01	8.51E-02
0.3	6.07E-02	1.45E-01	7.30E-02
0.25	5.06E-02	1.21E-01	6.08E-02
0.2	4.04E-02	9.65E-02	4.86E-02
0.15	3.03E-02	7.24E-02	3.65E-02
0.125	2.53E-02	6.03E-02	3.04E-02
0.1	2.02E-02	4.82E-02	2.43E-02

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.

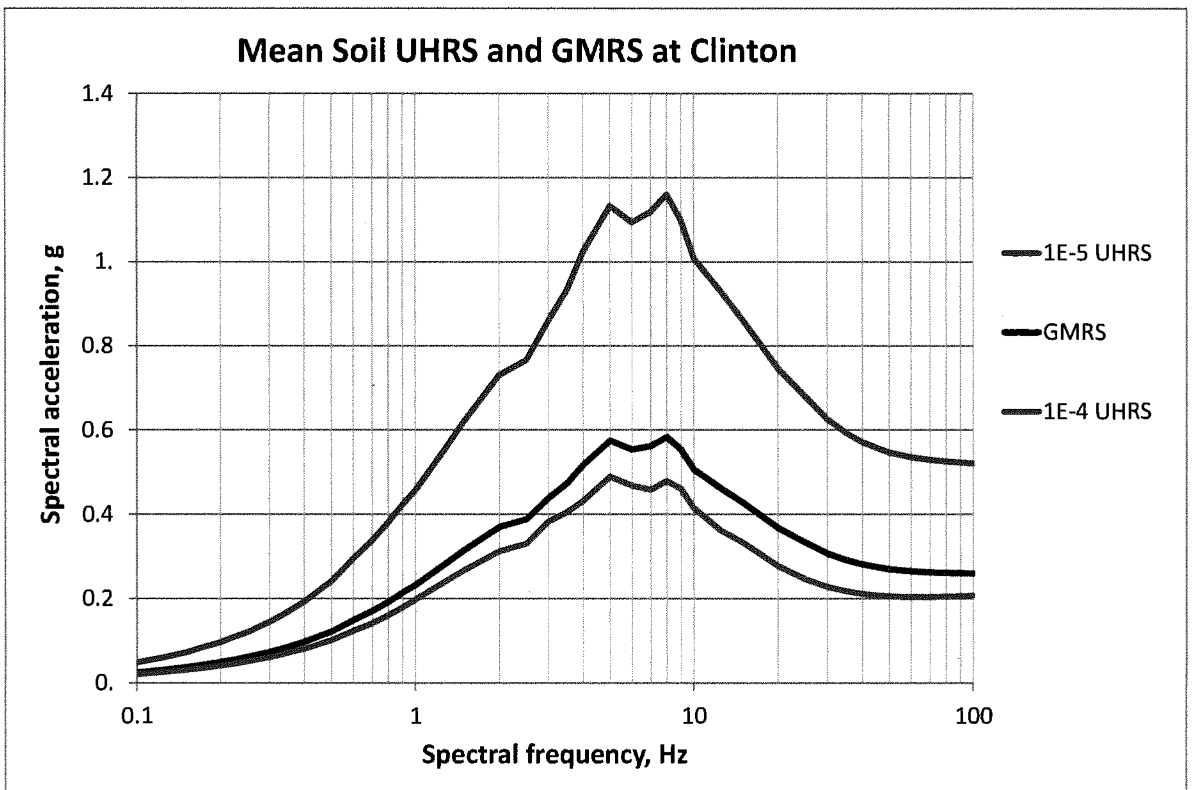

Figure 2.4-1: Plots of 1E-4 and 1E-5 UHRS spectra and GMRS at control point for Clinton station (5% of critical damping). (Reference 11)

3 Plant Design Basis Ground Motion

The recommended safe shutdown earthquake (SSE) was defined as the occurrence of an intensity MM VII event near the site. This near field event was correlated to a mean horizontal ground acceleration of 0.13g (Reference 10, Figure 2.5-295) during the initial plant design. In order to expedite licensing, the NRC staff position that the SSE be defined as intensity MM VIII event near the site was accepted for Clinton station. This resulted in a maximum horizontal ground surface acceleration at the site of 0.25g. To provide additional margin, an acceleration of 0.25g was applied at the foundation level in the free field.

Using the site subsurface properties defined in the UFSAR, in order to achieve 0.25g at the foundation level, the corresponding ground surface acceleration was determined to be 0.26g. The free field ground response spectra prepared in accordance with Reg. Guide 1.60 (Reference 13) for a horizontal peak ground acceleration of 0.26g are presented in Figure 2.5-296 of the site UFSAR. A soil structure interaction (SSI) analysis was performed using a design time history based on this response spectra as described in UFSAR Section 3.7.2.4 (Reference 10). The SSI analysis resulted in an acceleration at the foundation level of 0.25g.

3.1 SSE Description of Spectral Shape

The SSE is defined in terms of a PGA and a design response spectrum. The PGA is 0.26g at the free field surface (ground surface) with a spectral shape in accordance with Reg. Guide 1.60 (Reference 13). The 5% damped horizontal SSE for Clinton station at the control point elevation (EL. 736 feet MSL) is shown in Table 3.1-1 and plotted in Figure 3.1-1.

Table 3.1-1 Clinton station Safe Shutdown Earthquake horizontal ground response spectrum (5% of critical damping) (Reference 10)

Frequency (Hz)	5% Damped Spectral Acceleration (g)
0.35	0.161
0.50	0.216
1.00	0.383
1.25	0.461
2.00	0.677
2.50	0.814
3.0	0.794
4.0	0.761
5.0	0.737
6.0	0.719
7.0	0.703
8.0	0.690
9.0	0.679
10.0	0.628
12.0	0.549
12.5	0.532
13	0.517
15	0.465
20	0.376
25	0.319
28	0.293
30	0.279
33	0.260
35	0.260
40	0.260
50	0.260
100	0.260

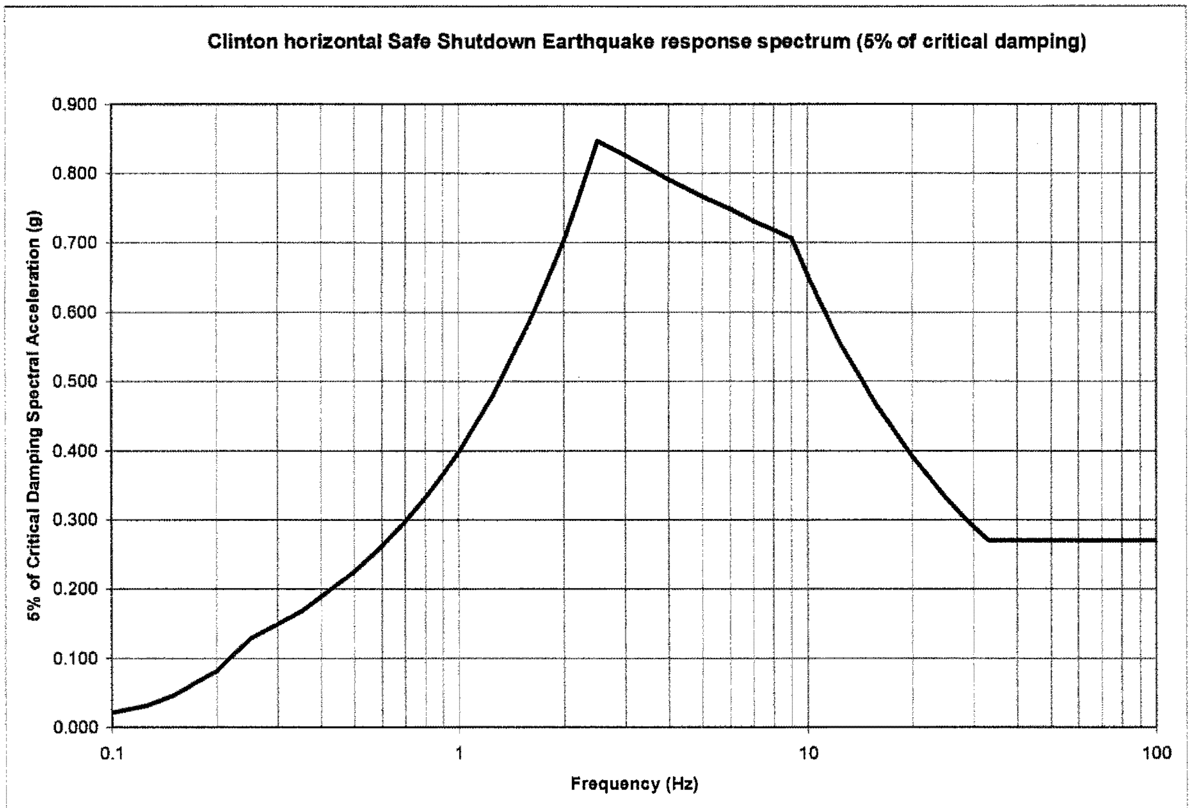

Figure 3.1-1: Clinton horizontal Safe Shutdown Earthquake response spectrum (5% of critical damping)

3.2 CONTROL POINT ELEVATION

In accordance with Section 2.4.2 of the SPID (Reference 3), the licensing design basis definition of the SSE control point for Clinton station is used to define the SSE control point. Section 2.5.2.6 of the site UFSAR (Reference 10), states that the 0.26g Reg. Guide 1.60 (Reference 13) SSE site response spectra is specified at the free field ground surface elevation. This corresponds to elevation 736 feet MSL in the vicinity of the main power block structures. The GMRS is computed at the control point elevation, 736 feet MSL, for comparison to the SSE.

4

Screening Evaluation

Following completion of the seismic hazard reevaluation, as requested in the 50.54(f) letter (Reference 1), a screening process is needed to determine if a risk evaluation is needed. The horizontal GMRS determined from the hazard reevaluation is used to characterize the amplitude of the new seismic hazard at each of the nuclear power plant sites. The screening compares the GMRS with the 5% of critical damping horizontal SSE, in accordance with the SPID Section 3 (Reference 3).

4.1 Risk Evaluation Screening (1 to 10 Hz)

In the frequency range of 1 Hz to 10 Hz, the SSE (Table 3.1-1) exceeds the GMRS (Table 2.4-1). Therefore, a risk evaluation will not be performed.

4.2 High Frequency Screening (> 10 Hz)

For a portion of the frequency range above 10 Hz, the GMRS exceeds the SSE. Therefore, a high frequency confirmation will be performed.

Section 3.4 of the SPID (Reference 3) discusses high-frequency exceedances. It discusses the impact of high-frequency ground motion on plant components and identifies the component groups that are sensitive to high-frequency vibration. A two-phase test program is described, which is currently ongoing, that will develop data to support the high-frequency confirmation.

The SPID concludes that high-frequency vibration is not damaging, in general, to components with strain- or stress-based failure modes, based on EPRI Report NP-7498 (Reference 22). But components, such as relays, subject to electrical functionality failure modes have unknown acceleration sensitivity for frequencies above 16 Hz.

EPRI Report 1015108 (Reference 23) provides evidence that supports the conclusion that high-frequency motions are not damaging to the majority of nuclear plant components, excluding relays and other electrical devices whose output signals may be affected by high-frequency vibration. EPRI Report 1015109 (Reference 24) provides guidance for identifying and evaluating potentially high-frequency sensitive components. Guidance from these documents is considered in the SPID (Reference 3) report for identifying components that are sensitive to high-frequency vibration. Component types listed in Table 2-1 of EPRI Report 3002000706 (Reference 25) will require high-frequency confirmation. Those component types are:

- Electro-mechanical relays
- Circuit breakers
- Control switches
- Process switches and sensors

- Electro-mechanical contactors
- Auxiliary contacts
- Transfer switches
- Potentiometers

4.3 SPENT FUEL POOL EVALUATION SCREENING (1 TO 10 HZ)

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

5 Interim Actions

Based on the screening evaluation outcome described in Section 4, the SSE exceeds the GMRS in the frequency range of 1 Hz to 10 Hz. Therefore, Clinton station is not required to implement interim actions. However, due to high frequency exceedances, additional testing and confirmations are required.

5.1 EXPEDITED SEISMIC EVALUATION PROCESS

Since the SSE exceeds the GMRS in the frequency range from 1 Hz to 10 Hz, the expedited seismic evaluation described in EPRI 3002000704 (Reference 4) will not be performed.

5.2 INTERIM EVALUATION OF SEISMIC HAZARD

Consistent with NRC letter dated February 20, 2014, (Reference 28) the seismic hazard reevaluations presented herein are distinct from the current design and licensing bases of Clinton station. 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" (Reference 17), and 10 CFR 50.73, "Licensee event report system" (Reference 18).

The NRC letter also requests that licensees provide an interim evaluation or actions to demonstrate that the plant can cope with the reevaluated hazard while the expedited approach and risk evaluations are conducted. In response to that request, NEI letter dated March 12, 2014 (Reference 29), 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 (Reference 30):

> 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.

Clinton station is included in the March 12, 2014 risk estimates (Reference 29). Using the methodology described in the NEI letter, all plants were shown to be below 10^{-4}/year; thus, the above conclusions apply.

5.3 SEISMIC WALKDOWN INSIGHTS

In response to NTTF Recommendation 2.3, the 50.54(f) letter (Reference 1) requested licensees to perform seismic walkdowns in order to, in the context of seismic response: 1) verify that the current plant configuration is consistent with the licensing basis, 2) verify the adequacy of current strategies, monitoring, and maintenance programs, and 3) identify degraded, nonconforming, or unanalyzed conditions. Seismic walkdown guidance (EPRI 1025286, Reference 33) was developed and endorsed by the NRC as a means for all plants to provide a uniform and acceptable industry response to NTTF 2.3 seismic walkdowns.

Seismic walkdowns in response to NTTF 2.3 for Clinton station have been performed as documented in Reference 12. Any potentially degraded, nonconforming, or unanalyzed conditions identified during the seismic walkdown program were assessed in accordance with the plant corrective action program, and were identified as being minor issues. The evaluations determined the seismic walkdowns for Clinton station resulted with no adverse anchorage conditions, no adverse seismic spatial interactions, and no other adverse seismic conditions existing for equipment examined during the walkdowns.

Plant vulnerabilities identified in the Clinton station seismic Individual Plant Examination of External Events (IPEEE) (Reference 19) were assessed as part of the seismic walkdowns (Reference 12). No anomalies, outliers, findings, or plant improvements were identified as a result of the IPEEE program and so no plant improvements were implemented (References 19 and 32).

5.4 BEYOND-DESIGN-BASIS SEISMIC INSIGHTS

A beyond-design-basis seismic margin assessment (SMA) was performed for the seismic portion of the Clinton station IPEEE using the EPRI SMA methodology, EPRI NP-6041-SL (Reference 34) with the enhancements identified in NUREG-1407 (Reference 35), where applicable (References 19). Clinton is a focused scope 0.3g peak ground acceleration (PGA) plant per NUREG-1407 (Reference 35). The review level earthquake (RLE) was a median NUREG/CR-0098 (Reference 36) spectrum anchored to 0.3g PGA (References 19).

The SMA determined that Clinton station is capable of attaining safe shutdown conditions after a review level earthquake with peak ground accelerations of 0.3g, which is a larger magnitude than the design basis earthquake. Therefore, the IHS is the same as the RLE, as defined above. The SMA did not find any potential vulnerabilities in the safe shutdown components, systems and structures in the two safe shutdown paths selected, and so no plant improvements were implemented (Reference 19).

6 Conclusions

In accordance with the 50.54(f) letter (Reference 1) request for information, a seismic hazard and screening evaluation was performed for the Clinton station. A GMRS was developed solely for the purpose of screening for additional evaluations in accordance with the SPID (Reference 3). The GMRS represents a beyond-design-basis seismic demand and does not constitute a change in the plant design or licensing basis.

The screening evaluation comparison demonstrates that the SSE exceeds the GMRS in the frequency range of 1 Hz to 10 Hz. Therefore, risk evaluations and a spent fuel pool integrity evaluation will not be performed for Clinton station.

Based on the screening requirements in the ESEP Guidance (Reference 4), Clinton station will not perform an expedited seismic evaluation (ESEP) because the SSE exceeds the GMRS in the 1 Hz to 10 Hz frequency range.

The GMRS exceeds the SSE in a portion of the frequency range beyond 10 Hz. Therefore, high frequency confirmations will be performed. The high frequency confirmations will be conducted on a schedule in accordance with the NEI letter dated April 9, 2013 (Reference 6), and as endorsed by the NRC (Reference 27).

7 References

1. NRC Letter (E. J. Leeds) to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status, *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,* March 2012

2. NRC Regulations Title 10, Code of Federal Regulations, Part 50 - Domestic Licensing of Production and Utilization Facilities

3. EPRI Technical Report 1025287, *Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic*, dated November 2012

4. EPRI Technical Report 3002000704, *Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic*, dated May 2013

5. NRC Regulations Title 10, Code of Federal Regulations, Part 100 - Reactor Site Criteria

6. NEI Letter (A. R. Pietrangelo) to the NRC, *Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations,* April 9 2013

7. EPRI Technical Report 1021097 (NUREG-2115), *Central and Eastern United States Seismic Source Characterization for Nuclear Facilities*, dated January 2012

8. EPRI Technical Report 3002000717, *EPRI (2004, 2006) Ground-Motion Model (GMM) Review Project*, dated June 2013

9. 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, Associated Universities, Inc. Upton, New York 11973, Contract No. 770573, dated 1996

10. Clinton Power Station Updated Final Safety Analysis Report (UFSAR), Revision 16

11. EPRI RSM-121313-030, LCI Report, *Clinton Seismic Hazard and Screening Report*, dated December 23, 2013

12. NRC Correspondence RS-12-165, Enclosure 1, Clinton Power Station Unit 1 Seismic Walkdown Report, November, 2012

13. U.S. Nuclear Regulatory Commission, USNRC Reg. Guide 1.60. "Design Response Spectra for Seismic Design of Nuclear Power Plants," 1973

14. *Review of Existing Site Response Parameter Data for the Exelon Nuclear Fleet—Revision 1,* Simpson Gumpertz & Heger Report. No. 128018-R-01 dated July 17, 2012, transmitted by letter from J. Clark to J. Hamel on July 18, 2012

15. Willman, H.B (1975). Handbook of Illinois Stratigraphy, Bulletin 95, 261 pp., Illinois State Geological Survey, Urbana, IL

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

17. Title 10 Code of Federal Regulations Part 50 Section 72, "Immediate notification requirements for operating nuclear power reactors"

18. Title 10 Code of Federal Regulations Part 50 Section 73, "Licensee event report system"

19. Exelon, Clinton Nuclear Power Station Unit 1, *Individual Plant Examination of External Events for Severe Accident Vulnerabilities*, September, 29, 1995

20. Exelon Generation Company letter to the NRC, *Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Seismic Aspects of Recommendation 2.1, 2.3, and 9.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident*, RS-13-102, dated April 29, 2013

21. Attachment 3 to Letter from Glen T. Kaegi of Exelon to U.S. Nuclear Regulatory Commission, dated September 12, 2013 "Clinton Power Station, Unit 1, Descriptions of Subsurface Materials and Properties and Base Case Velocity Profiles (RS-13-205, RA-13-075, and TMI-13-104)

22. EPRI NP-7498, "Industry Approach to Severe Accident Policy Implementation," November, 1991

23. EPRI Report 1015108, "Program on Technology Innovation: The Effects of High-Frequency Ground Motion on Structures, Components and Equipment in Nuclear Power Plants", June 2007

24. EPRI Report 1015109, "Program on Technology Innovation: Seismic Screening of Components Sensitive to High-Frequency Vibratory Motions", October 2007

25. EPRI Report 3002000706, "High Frequency Program, Phase 1 Seismic Test Summary", September 2013

26. NRC Letter, Endorsement of EPRI Final Draft Report 1025287, "Seismic Evaluation Guidance," dated February 15, 2013

27. NRC Letter, EPRI Final Draft Report XXXXXX, "Seismic Evaluation Guidance: Augmented Approach for the Resolution of Near-Term Task Force Recommendation 2.1: Seismic," as an Acceptable Alternative to the March 12, 2012, Information Request for Seismic Reevaluations, dated May 7, 2013

28. NRC Letter (E. J. Leeds) to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status, *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,* February 20, 2014

29. NEI Letter (A. R. Pietrangelo) to the NRC, *Seismic Risk Evaluations for Plants in the Central and Eastern United States,* March 12, 2014

30. NUREG-0933, "A Prioritization of Generic Safety Issues;" Supplement 34, "Resolution of Generic Safety Issues;" Issue 199: Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants, Revision 1, September, 2011

31. E-mail from R. Kassawaral (EPRI) to J. Clark (Exelon) dated February 27, 2014, Subject: Amp Tables

32. Staff Evaluation By The Office of Nuclear Reactor Regulation Related to Generic Letter 88-20, Supplement 4, Individual Plant Examination of External Events, Clinton Power Station, December, 6, 2000

33. EPRI Technical Report 1025286, *Seismic Walkdown Guidance for Resolution of Fukushima Near-Term Task Force Recommendation 2.3: Seismic*, June 2012

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

35. NRC NUREG-1407, *Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities*, April 1991

36. NRC NUREG/CR-0098, *Development of Criteria for Seismic Review of Selected Nuclear Power Plants*, May 1978

37. E-mail from R. Kassawaral (EPRI) to R. Boehm (S&L) dated March 4, 2014, Subject: Clinton_Appendix A-2 Tables and Figures.docx

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Additional Tables

Table A-1a: Mean and fractile seismic hazard curves for 100 Hz (PGA) at Clinton, 5% of critical damping (Reference 11)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	9.59E-02	6.26E-02	7.66E-02	9.65E-02	9.93E-02	9.93E-02
0.001	8.14E-02	4.63E-02	6.17E-02	8.23E-02	9.93E-02	9.93E-02
0.005	3.38E-02	1.42E-02	2.13E-02	3.23E-02	4.56E-02	6.00E-02
0.01	1.87E-02	7.13E-03	1.07E-02	1.72E-02	2.57E-02	3.79E-02
0.015	1.24E-02	4.31E-03	6.64E-03	1.10E-02	1.72E-02	2.72E-02
0.03	5.15E-03	1.25E-03	2.07E-03	4.13E-03	7.55E-03	1.36E-02
0.05	2.20E-03	3.57E-04	6.17E-04	1.46E-03	3.47E-03	7.23E-03
0.075	9.94E-04	1.13E-04	2.04E-04	5.50E-04	1.53E-03	3.90E-03
0.1	5.40E-04	4.98E-05	9.11E-05	2.72E-04	7.77E-04	2.25E-03
0.15	2.16E-04	1.64E-05	3.14E-05	1.02E-04	3.05E-04	8.85E-04
0.3	4.09E-05	3.01E-06	6.09E-06	1.98E-05	6.54E-05	1.51E-04
0.5	1.12E-05	7.13E-07	1.55E-06	5.35E-06	1.90E-05	4.07E-05
0.75	3.71E-06	1.64E-07	4.13E-07	1.64E-06	6.26E-06	1.38E-05
1.	1.61E-06	4.70E-08	1.38E-07	6.54E-07	2.72E-06	6.26E-06
1.5	4.61E-07	6.09E-09	2.42E-08	1.51E-07	7.55E-07	1.90E-06
3.	4.30E-08	1.84E-10	7.89E-10	8.23E-09	6.09E-08	1.92E-07
5.	5.92E-09	1.11E-10	1.44E-10	7.13E-10	6.93E-09	2.64E-08
7.5	1.02E-09	1.01E-10	1.13E-10	1.74E-10	1.08E-09	4.70E-09
10.	2.65E-10	1.01E-10	1.11E-10	1.42E-10	3.19E-10	1.32E-09

Table A-1b: Mean and fractile seismic hazard curves for 25 Hz at Clinton, 5% of critical damping (Reference 11)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	9.83E-02	6.93E-02	8.00E-02	9.93E-02	9.93E-02	9.93E-02
0.001	8.59E-02	5.50E-02	6.73E-02	8.60E-02	9.93E-02	9.93E-02
0.005	4.18E-02	2.04E-02	2.80E-02	4.01E-02	5.42E-02	6.93E-02
0.01	2.56E-02	1.13E-02	1.60E-02	2.39E-02	3.42E-02	4.77E-02
0.015	1.80E-02	7.45E-03	1.05E-02	1.64E-02	2.42E-02	3.57E-02
0.03	7.88E-03	2.53E-03	3.90E-03	6.83E-03	1.13E-02	1.77E-02
0.05	3.36E-03	7.77E-04	1.25E-03	2.60E-03	5.20E-03	8.98E-03
0.075	1.49E-03	2.49E-04	4.25E-04	9.93E-04	2.39E-03	4.77E-03
0.1	7.97E-04	1.05E-04	1.87E-04	4.77E-04	1.27E-03	2.80E-03
0.15	3.16E-04	3.23E-05	6.09E-05	1.74E-04	4.90E-04	1.11E-03
0.3	6.34E-05	5.91E-06	1.16E-05	3.57E-05	1.07E-04	2.13E-04
0.5	2.02E-05	1.95E-06	3.84E-06	1.18E-05	3.57E-05	6.54E-05
0.75	8.01E-06	7.23E-07	1.51E-06	4.70E-06	1.44E-05	2.60E-05
1.	4.04E-06	3.42E-07	7.34E-07	2.32E-06	7.34E-06	1.32E-05
1.5	1.44E-06	1.08E-07	2.46E-07	8.00E-07	2.60E-06	4.83E-06
3.	1.94E-07	9.24E-09	2.39E-08	9.24E-08	3.37E-07	7.13E-07
5.	3.56E-08	9.79E-10	2.80E-09	1.38E-08	5.91E-08	1.44E-07
7.5	8.01E-09	2.04E-10	4.77E-10	2.49E-09	1.29E-08	3.47E-08
10.	2.55E-09	1.34E-10	1.90E-10	7.23E-10	3.95E-09	1.16E-08

Table A-1c: Mean and fractile seismic hazard curves for 10 Hz at Clinton, 5% of critical damping (Reference 11)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	1.04E-01	7.89E-02	8.60E-02	9.93E-02	9.93E-02	9.93E-02
0.001	9.57E-02	6.93E-02	7.77E-02	9.65E-02	9.93E-02	9.93E-02
0.005	5.24E-02	2.96E-02	3.73E-02	5.20E-02	6.73E-02	7.89E-02
0.01	3.25E-02	1.62E-02	2.16E-02	3.14E-02	4.31E-02	5.27E-02
0.015	2.31E-02	1.08E-02	1.49E-02	2.19E-02	3.09E-02	3.95E-02
0.03	1.14E-02	4.77E-03	6.73E-03	1.07E-02	1.57E-02	2.10E-02
0.05	6.07E-03	2.13E-03	3.14E-03	5.42E-03	8.72E-03	1.23E-02
0.075	3.36E-03	9.37E-04	1.46E-03	2.84E-03	5.20E-03	7.77E-03
0.1	2.10E-03	4.83E-04	7.77E-04	1.62E-03	3.37E-03	5.42E-03
0.15	9.92E-04	1.69E-04	2.92E-04	6.83E-04	1.62E-03	2.92E-03
0.3	2.21E-04	2.32E-05	4.56E-05	1.29E-04	3.52E-04	7.13E-04
0.5	6.29E-05	4.83E-06	1.04E-05	3.42E-05	1.05E-04	2.16E-04
0.75	2.21E-05	1.23E-06	2.92E-06	1.11E-05	3.84E-05	7.89E-05
1.	1.02E-05	4.43E-07	1.13E-06	4.77E-06	1.82E-05	3.79E-05
1.5	3.27E-06	9.79E-08	2.76E-07	1.36E-06	5.75E-06	1.31E-05
3.	3.70E-07	6.09E-09	2.04E-08	1.16E-07	6.09E-07	1.62E-06
5.	6.06E-08	5.83E-10	2.10E-09	1.46E-08	9.37E-08	2.68E-07
7.5	1.29E-08	1.55E-10	3.47E-10	2.42E-09	1.84E-08	5.66E-08
10.	4.10E-09	1.16E-10	1.60E-10	6.83E-10	5.27E-09	1.82E-08

Table A-1d: Mean and fractile seismic hazard curves for 5 Hz at Clinton, 5% of critical damping (Reference 11)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	1.06E-01	8.00E-02	8.85E-02	9.93E-02	9.93E-02	9.93E-02
0.001	9.94E-02	7.23E-02	8.12E-02	9.93E-02	9.93E-02	9.93E-02
0.005	5.94E-02	3.14E-02	4.13E-02	5.83E-02	7.77E-02	8.98E-02
0.01	3.74E-02	1.74E-02	2.35E-02	3.57E-02	5.12E-02	6.17E-02
0.015	2.64E-02	1.15E-02	1.60E-02	2.53E-02	3.68E-02	4.56E-02
0.03	1.30E-02	5.20E-03	7.45E-03	1.21E-02	1.84E-02	2.35E-02
0.05	7.03E-03	2.46E-03	3.73E-03	6.45E-03	1.04E-02	1.34E-02
0.075	4.07E-03	1.18E-03	1.90E-03	3.63E-03	6.26E-03	8.47E-03
0.1	2.64E-03	6.45E-04	1.08E-03	2.22E-03	4.19E-03	6.00E-03
0.15	1.33E-03	2.53E-04	4.43E-04	1.01E-03	2.19E-03	3.52E-03
0.3	3.25E-04	4.01E-05	7.66E-05	2.01E-04	5.27E-04	1.02E-03
0.5	9.51E-05	9.11E-06	1.84E-05	5.42E-05	1.55E-04	3.09E-04
0.75	3.24E-05	2.57E-06	5.50E-06	1.77E-05	5.50E-05	1.10E-04
1.	1.44E-05	9.79E-07	2.19E-06	7.66E-06	2.49E-05	5.05E-05
1.5	4.36E-06	2.10E-07	5.20E-07	2.10E-06	7.77E-06	1.62E-05
3.	4.71E-07	7.34E-09	2.39E-08	1.62E-07	8.12E-07	1.98E-06
5.	7.84E-08	4.13E-10	1.60E-09	1.82E-08	1.25E-07	3.52E-07
7.5	1.74E-08	1.42E-10	2.42E-10	2.68E-09	2.42E-08	8.00E-08
10.	5.71E-09	1.11E-10	1.42E-10	6.83E-10	6.93E-09	2.60E-08

Table A-1e: Mean and fractile seismic hazard curves for 2.5 Hz at Clinton, 5% of critical damping (Reference 11)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	1.04E-01	7.89E-02	8.60E-02	9.93E-02	9.93E-02	9.93E-02
0.001	9.43E-02	6.54E-02	7.66E-02	9.37E-02	9.93E-02	9.93E-02
0.005	4.62E-02	2.25E-02	3.01E-02	4.43E-02	6.26E-02	7.55E-02
0.01	2.55E-02	1.13E-02	1.55E-02	2.39E-02	3.57E-02	4.50E-02
0.015	1.67E-02	7.13E-03	9.93E-03	1.55E-02	2.39E-02	3.01E-02
0.03	7.47E-03	2.84E-03	4.19E-03	6.93E-03	1.08E-02	1.38E-02
0.05	3.91E-03	1.20E-03	1.90E-03	3.52E-03	5.91E-03	7.89E-03
0.075	2.20E-03	5.20E-04	8.72E-04	1.84E-03	3.52E-03	5.05E-03
0.1	1.38E-03	2.64E-04	4.63E-04	1.05E-03	2.32E-03	3.57E-03
0.15	6.42E-04	9.11E-05	1.69E-04	4.25E-04	1.08E-03	1.95E-03
0.3	1.29E-04	1.18E-05	2.39E-05	7.03E-05	2.07E-04	4.50E-04
0.5	3.30E-05	2.39E-06	5.12E-06	1.69E-05	5.42E-05	1.15E-04
0.75	1.06E-05	6.54E-07	1.49E-06	5.35E-06	1.79E-05	3.68E-05
1.	4.71E-06	2.57E-07	6.17E-07	2.32E-06	8.00E-06	1.69E-05
1.5	1.48E-06	6.26E-08	1.62E-07	6.73E-07	2.53E-06	5.58E-06
3.	1.86E-07	3.63E-09	1.10E-08	6.00E-08	3.01E-07	7.66E-07
5.	3.63E-08	3.47E-10	1.01E-09	7.55E-09	5.27E-08	1.62E-07
7.5	9.08E-09	1.42E-10	2.04E-10	1.27E-09	1.16E-08	4.07E-08
10.	3.19E-09	1.11E-10	1.42E-10	3.79E-10	3.52E-09	1.40E-08

Table A-1f: Mean and fractile seismic hazard curves for 1 Hz at Clinton, 5% of critical damping (Reference 11)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	8.18E-02	4.50E-02	5.91E-02	8.23E-02	9.93E-02	9.93E-02
0.001	6.14E-02	2.72E-02	3.90E-02	6.00E-02	8.47E-02	9.79E-02
0.005	1.86E-02	6.00E-03	9.11E-03	1.69E-02	2.84E-02	3.68E-02
0.01	9.40E-03	2.68E-03	4.37E-03	8.35E-03	1.44E-02	1.95E-02
0.015	6.17E-03	1.51E-03	2.68E-03	5.50E-03	9.51E-03	1.31E-02
0.03	2.89E-03	4.31E-04	9.11E-04	2.42E-03	4.83E-03	6.93E-03
0.05	1.51E-03	1.34E-04	3.14E-04	1.08E-03	2.76E-03	4.25E-03
0.075	8.07E-04	4.43E-05	1.15E-04	4.77E-04	1.51E-03	2.68E-03
0.1	4.78E-04	1.87E-05	5.12E-05	2.39E-04	8.85E-04	1.77E-03
0.15	2.02E-04	4.98E-06	1.51E-05	8.23E-05	3.57E-04	8.00E-04
0.3	3.38E-05	4.63E-07	1.51E-06	1.04E-05	5.42E-05	1.36E-04
0.5	7.70E-06	7.89E-08	2.76E-07	2.04E-06	1.15E-05	3.23E-05
0.75	2.39E-06	1.90E-08	7.77E-08	6.00E-07	3.47E-06	1.05E-05
1.	1.09E-06	7.13E-09	3.19E-08	2.60E-07	1.60E-06	4.77E-06
1.5	3.83E-07	1.74E-09	8.35E-09	7.89E-08	5.42E-07	1.69E-06
3.	6.62E-08	2.16E-10	8.00E-10	9.11E-09	8.00E-08	2.96E-07
5.	1.63E-08	1.34E-10	2.01E-10	1.51E-09	1.62E-08	7.03E-08
7.5	4.79E-09	1.11E-10	1.42E-10	3.90E-10	4.01E-09	1.95E-08
10.	1.87E-09	1.04E-10	1.21E-10	1.95E-10	1.40E-09	7.13E-09

Table A-1g: Mean and fractile seismic hazard curves for 0.5 Hz at Clinton, 5% of critical damping (Reference 11)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.10E-02	1.82E-02	2.49E-02	3.95E-02	5.66E-02	6.93E-02
0.001	2.47E-02	9.51E-03	1.36E-02	2.32E-02	3.52E-02	4.50E-02
0.005	6.19E-03	1.60E-03	2.84E-03	5.58E-03	9.37E-03	1.31E-02
0.01	3.28E-03	5.20E-04	1.13E-03	2.84E-03	5.42E-03	7.55E-03
0.015	2.19E-03	2.29E-04	5.58E-04	1.74E-03	3.84E-03	5.66E-03
0.03	9.50E-04	4.07E-05	1.18E-04	5.50E-04	1.84E-03	3.19E-03
0.05	4.24E-04	8.60E-06	2.80E-05	1.67E-04	7.89E-04	1.74E-03
0.075	1.94E-04	2.16E-06	7.66E-06	5.50E-05	3.23E-04	8.60E-04
0.1	1.03E-04	7.66E-07	2.84E-06	2.32E-05	1.57E-04	4.70E-04
0.15	3.78E-05	1.57E-07	6.45E-07	6.26E-06	5.12E-05	1.67E-04
0.3	5.43E-06	8.00E-09	4.01E-08	5.91E-07	5.66E-06	2.32E-05
0.5	1.21E-06	7.45E-10	4.25E-09	1.02E-07	1.08E-06	5.50E-06
0.75	3.93E-07	1.79E-10	7.55E-10	2.72E-08	3.37E-07	1.77E-06
1.	1.88E-07	1.42E-10	2.76E-10	1.07E-08	1.53E-07	8.35E-07
1.5	7.05E-08	1.11E-10	1.42E-10	2.80E-09	5.05E-08	3.05E-07
3.	1.33E-08	1.05E-10	1.42E-10	3.28E-10	6.64E-09	5.05E-08
5.	3.44E-09	1.01E-10	1.11E-10	1.49E-10	1.38E-09	1.13E-08
7.5	1.04E-09	1.01E-10	1.11E-10	1.42E-10	3.95E-10	3.05E-09
10.	4.10E-10	1.01E-10	1.11E-10	1.42E-10	2.10E-10	1.16E-09

Table A-2a: Amplification functions for Clinton, 5% of critical damping (Reference 11)

100 Hz (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	1.88E+00	9.93E-02	1.30E-02	1.50E+00	1.05E-01	1.90E-02	1.64E+00	1.24E-01	2.09E-02	2.16E+00	2.60E-01
4.95E-02	1.40E+00	1.08E-01	1.02E-01	8.26E-01	1.42E-01	9.99E-02	1.43E+00	1.53E-01	8.24E-02	2.10E+00	2.43E-01
9.64E-02	1.23E+00	1.10E-01	2.13E-01	6.99E-01	1.54E-01	1.85E-01	1.34E+00	1.60E-01	1.44E-01	2.05E+00	2.24E-01
1.94E-01	1.09E+00	1.10E-01	4.43E-01	6.04E-01	1.58E-01	3.56E-01	1.22E+00	1.67E-01	2.65E-01	1.96E+00	2.03E-01
2.92E-01	1.01E+00	1.09E-01	6.76E-01	5.51E-01	1.58E-01	5.23E-01	1.13E+00	1.72E-01	3.84E-01	1.88E+00	2.01E-01
3.91E-01	9.53E-01	1.07E-01	9.09E-01	5.13E-01	1.55E-01	6.90E-01	1.06E+00	1.76E-01	5.02E-01	1.80E+00	2.11E-01
4.93E-01	9.08E-01	1.06E-01	1.15E+00	5.00E-01	1.53E-01	8.61E-01	1.00E+00	1.78E-01	6.22E-01	1.72E+00	2.23E-01
7.41E-01	8.28E-01	1.06E-01	1.73E+00	5.00E-01	1.49E-01	1.27E+00	8.90E-01	1.84E-01	9.13E-01	1.55E+00	2.47E-01
1.01E+00	7.68E-01	1.07E-01	2.36E+00	5.00E-01	1.45E-01	1.72E+00	8.04E-01	1.89E-01	1.22E+00	1.40E+00	2.57E-01
1.28E+00	7.21E-01	1.07E-01	3.01E+00	5.00E-01	1.41E-01	2.17E+00	7.36E-01	1.93E-01	1.54E+00	1.28E+00	2.58E-01
1.55E+00	6.85E-01	1.07E-01	3.63E+00	5.00E-01	1.39E-01	2.61E+00	6.84E-01	1.99E-01	1.85E+00	1.20E+00	2.52E-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	2.08E+00	1.48E-01	1.27E-02	2.10E+00	1.33E-01	8.25E-03	1.60E+00	1.11E-01			
7.05E-02	2.10E+00	1.61E-01	3.43E-02	2.15E+00	1.34E-01	1.96E-02	1.62E+00	1.10E-01			
1.18E-01	2.12E+00	1.65E-01	5.51E-02	2.18E+00	1.36E-01	3.02E-02	1.64E+00	1.12E-01			
2.12E-01	2.13E+00	1.70E-01	9.63E-02	2.25E+00	1.50E-01	5.11E-02	1.68E+00	1.21E-01			
3.04E-01	2.10E+00	1.78E-01	1.36E-01	2.32E+00	1.68E-01	7.10E-02	1.72E+00	1.35E-01			
3.94E-01	2.07E+00	1.92E-01	1.75E-01	2.36E+00	1.73E-01	9.06E-02	1.76E+00	1.52E-01			
4.86E-01	2.03E+00	1.93E-01	2.14E-01	2.40E+00	1.73E-01	1.10E-01	1.78E+00	1.65E-01			
7.09E-01	1.91E+00	2.01E-01	3.10E-01	2.46E+00	1.87E-01	1.58E-01	1.83E+00	2.03E-01			
9.47E-01	1.82E+00	2.14E-01	4.12E-01	2.50E+00	1.98E-01	2.09E-01	1.89E+00	2.21E-01			
1.19E+00	1.76E+00	2.25E-01	5.18E-01	2.53E+00	2.03E-01	2.62E-01	1.95E+00	2.31E-01			
1.43E+00	1.72E+00	2.27E-01	6.19E-01	2.55E+00	2.06E-01	3.12E-01	2.00E+00	2.29E-01			

Tables A-2b1 and A-2b2 are tabular versions of the typical amplification factors provided in Figures 2.3.6-1 and 2.3.6-2. Values are provided for two input motion levels at approximately 10^{-4} and 10^{-5} mean annual frequency of exceedance. These tables concentrate on the frequency range of 0.5 Hz to 25 Hz, with values up to 100 Hz included, with a single value at 0.1 Hz included for completeness. These factors are unverified and are provided for information only. The figures should be considered the governing information.

Table A-2b1. Median AFs and sigmas for Model 1, Profile 1, for 2 PGA levels (Reference 31)

M1P1K1	Rock PGA=0.194			M1P1K1	PGA=0.493		
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
100.0	0.224	1.156	0.092	100.0	0.469	0.952	0.077
87.1	0.225	1.129	0.092	87.1	0.469	0.924	0.077
75.9	0.225	1.082	0.093	75.9	0.470	0.876	0.077
66.1	0.226	0.995	0.093	66.1	0.471	0.791	0.077
57.5	0.227	0.855	0.094	57.5	0.472	0.663	0.077
50.1	0.229	0.718	0.095	50.1	0.475	0.547	0.077
43.7	0.232	0.616	0.097	43.7	0.478	0.466	0.078
38.0	0.237	0.572	0.102	38.0	0.484	0.434	0.080
33.1	0.244	0.556	0.105	33.1	0.493	0.423	0.083
28.8	0.253	0.576	0.107	28.8	0.507	0.439	0.086
25.1	0.268	0.604	0.117	25.1	0.524	0.456	0.087
21.9	0.283	0.669	0.126	21.9	0.549	0.508	0.096
19.1	0.301	0.723	0.137	19.1	0.578	0.548	0.111
16.6	0.331	0.827	0.146	16.6	0.616	0.615	0.116
14.5	0.361	0.941	0.139	14.5	0.674	0.711	0.138
12.6	0.382	1.023	0.158	12.6	0.724	0.791	0.135
11.0	0.390	1.071	0.161	11.0	0.750	0.847	0.144
9.5	0.417	1.200	0.146	9.5	0.785	0.935	0.144
8.3	0.461	1.436	0.157	8.3	0.859	1.117	0.160
7.2	0.481	1.598	0.164	7.2	0.915	1.278	0.166
6.3	0.529	1.873	0.186	6.3	0.984	1.472	0.171
5.5	0.593	2.195	0.190	5.5	1.069	1.684	0.212
4.8	0.595	2.252	0.224	4.8	1.161	1.878	0.224
4.2	0.542	2.113	0.251	4.2	1.172	1.966	0.214
3.6	0.498	1.996	0.241	3.6	1.133	1.961	0.200
3.2	0.478	2.032	0.187	3.2	1.092	2.015	0.200
2.8	0.490	2.196	0.175	2.8	1.101	2.150	0.187
2.4	0.471	2.287	0.130	2.4	1.075	2.282	0.168
2.1	0.453	2.418	0.128	2.1	1.041	2.440	0.179
1.8	0.412	2.462	0.129	1.8	0.984	2.589	0.178
1.6	0.348	2.398	0.119	1.6	0.865	2.634	0.155
1.4	0.289	2.312	0.089	1.4	0.718	2.550	0.133
1.2	0.244	2.215	0.110	1.2	0.596	2.415	0.132
1.0	0.211	2.122	0.101	1.0	0.505	2.276	0.117

Table A-2b1: (cont.)

M1P1K1	Rock PGA=0.194			M1P1K1	PGA=0.493		
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
0.91	0.188	2.081	0.083	0.91	0.442	2.204	0.105
0.79	0.160	1.954	0.076	0.79	0.371	2.053	0.089
0.69	0.132	1.811	0.073	0.69	0.302	1.889	0.085
0.60	0.106	1.670	0.099	0.60	0.240	1.732	0.108
0.52	0.082	1.519	0.095	0.52	0.184	1.567	0.100
0.46	0.064	1.423	0.081	0.46	0.142	1.462	0.081
0.10	0.002	1.316	0.040	0.10	0.005	1.324	0.046

Table A-2b2. Median AFs and sigmas for Model 2, Profile 1, for 2 PGA levels (Reference 37)

M2P1K1	PGA=0.194			M2P1K1	PGA=0.493		
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
100.0	0.238	1.227	0.107	100.0	0.522	1.059	0.097
87.1	0.239	1.199	0.107	87.1	0.522	1.028	0.098
75.9	0.239	1.150	0.107	75.9	0.524	0.976	0.098
66.1	0.240	1.059	0.108	66.1	0.526	0.883	0.098
57.5	0.242	0.912	0.109	57.5	0.529	0.741	0.099
50.1	0.245	0.768	0.112	50.1	0.534	0.615	0.101
43.7	0.250	0.663	0.116	43.7	0.542	0.529	0.105
38.0	0.257	0.620	0.123	38.0	0.555	0.498	0.109
33.1	0.267	0.607	0.128	33.1	0.574	0.492	0.116
28.8	0.280	0.637	0.127	28.8	0.598	0.519	0.118
25.1	0.300	0.676	0.142	25.1	0.632	0.550	0.121
21.9	0.319	0.754	0.156	21.9	0.674	0.624	0.140
19.1	0.344	0.826	0.160	19.1	0.717	0.681	0.147
16.6	0.383	0.954	0.168	16.6	0.793	0.792	0.166
14.5	0.410	1.070	0.158	14.5	0.863	0.911	0.168
12.6	0.427	1.144	0.170	12.6	0.907	0.991	0.152
11.0	0.430	1.183	0.159	11.0	0.923	1.043	0.136
9.5	0.470	1.352	0.155	9.5	0.966	1.151	0.145
8.3	0.513	1.599	0.145	8.3	1.077	1.401	0.146
7.2	0.523	1.741	0.166	7.2	1.101	1.538	0.159
6.3	0.581	2.055	0.194	6.3	1.164	1.742	0.193
5.5	0.658	2.438	0.184	5.5	1.287	2.027	0.236
4.8	0.616	2.331	0.251	4.8	1.322	2.140	0.210
4.2	0.535	2.086	0.262	4.2	1.234	2.070	0.206
3.6	0.488	1.955	0.235	3.6	1.146	1.984	0.240
3.2	0.479	2.039	0.188	3.2	1.104	2.038	0.223
2.8	0.500	2.241	0.188	2.8	1.135	2.217	0.207
2.4	0.474	2.303	0.116	2.4	1.100	2.336	0.167

Table A-2b2: (cont.)

M2P1K1		PGA=0.194		M2P1K1		PGA=0.493	
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
2.1	0.457	2.441	0.124	2.1	1.062	2.489	0.138
1.8	0.408	2.439	0.122	1.8	0.970	2.553	0.139
1.6	0.340	2.341	0.114	1.6	0.812	2.473	0.116
1.4	0.282	2.258	0.081	1.4	0.669	2.378	0.091
1.2	0.239	2.170	0.104	1.2	0.559	2.263	0.111
1.0	0.207	2.086	0.098	1.0	0.478	2.157	0.105
0.91	0.186	2.053	0.074	0.91	0.423	2.108	0.079
0.79	0.158	1.931	0.070	0.79	0.357	1.975	0.071
0.69	0.131	1.793	0.071	0.69	0.292	1.829	0.073
0.60	0.105	1.657	0.096	0.60	0.233	1.686	0.097
0.52	0.082	1.509	0.093	0.52	0.180	1.533	0.092

Enclosure 2

SUMMARY OF REGULATORY COMMITMENTS

The following table identifies commitments made in this document. (Any other actions discussed in the submittal represent intended or planned actions. They are described to the NRC for the NRC's information and are not regulatory commitments.)

COMMITMENT	COMMITTED DATE OR "OUTAGE"	COMMITMENT TYPE	
		ONE-TIME ACTION (Yes/No)	PROGRAMMATIC (Yes/No)
Clinton Power Station, Unit 1, will perform a High Frequency Confirmation evaluation in accordance with EPRI Report 1025287, Section 3.4.	As determined by NRC prioritization following submittal of all nuclear power plant Seismic Hazard Re-evaluations, but no later than December 31, 2019.	Yes	No