Exelon Generation.

RS-14-073
TMI-14-026

10 CFR 50.54(f)

March 31, 2014

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

Three Mile Island Nuclear Station, Unit 1
Renewed Facility Operating License No. DPR-50
NRC Docket No. 50-289

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 Three Mile Island Nuclear 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 Three Mile Island Nuclear 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, Three Mile Island Nuclear Station, Unit 1, does not meet the requirements of SPID Sections 3.2 and 7 (Reference 5) and therefore screens in and a Risk Evaluation and Spent Fuel Pool evaluation will be performed as determined by NRC prioritization following submittal of all nuclear power plant Seismic Hazard Re-evaluations per Reference 1. Additionally, Three Mile Island Nuclear Station, Unit 1, will prepare an Expedited Seismic Evaluation Process (ESEP) Report in accordance with Reference 7, by December 31, 2014.

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,

James Barstow
Director - Licensing & Regulatory Affairs
Exelon Generation Company, LLC

Enclosures:

1. Three Mile Island Nuclear Station, Unit 1, Seismic Hazard and Screening Report
2. Summary of Regulatory Commitments

cc: Director, Office of Nuclear Reactor Regulation
Regional Administrator - NRC Region I
NRC Senior Resident Inspector – Three Mile Island Nuclear Station
NRC Project Manager, NRR – Three Mile Island Nuclear 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
Director, Bureau of Radiation Protection - Pennsylvania Department of Environmental Resources
Chairman, Board of County Commissioners of Dauphin County, PA
Chairman, Board of Supervisors of Londonderry Township, PA
R. R. Janati, Chief, Division of Nuclear Safety, Pennsylvania Department of Environmental Protection, Bureau of Radiation Protection

Enclosure 1

Three Mile Island Nuclear Station, Unit 1

Seismic Hazard and Screening Report

(49 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

THREE MILE ISLAND NUCLEAR STATION UNIT 1

Route 441 South, P.O. Box 480, Middletown, PA 17057

Facility Operating License No. DPR-50

NRC Docket No. 50-289

Correspondence No.: RS-14-073, TMI-14-026

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Report Number: EXLNTM039-PR-001, Revision 1

	Printed Name	Signature	Date
Preparer:	Shana Gibbs		3/25/2014
Reviewer:	Mitchell McKay		3/25/2014
Approver:	Paul Hansen		3/25/14
Lead Responsible Engineer:	Patrick Mullens		3/26/14
Risk Management Engineer (Section 5.4 only)	Larry Lee		3/25/2014
Branch Manager:	Patrick Bennett		3/26/14
Senior Manager Design Engineering:	John Piazza		3/26/14
Corporate Acceptance:	Jeffrey Clark		3/26/14

RECORD OF REVISIONS

Revision	Affected Pages	Description
0	All	Initial issue.
1	All	Revised text to align with final NEI Seismic Hazard and Screening Report example submittal for CEUS site.

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Purpose

Following the accident at the Fukushima Dai-ichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the Nuclear Regulatory Commission (NRC) 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 using updated seismic hazard information and present-day regulatory guidance and methodologies. This report provides the information requested in items (1) through (7) of the "Requested Information" in Enclosure 1 of the 50.54(f) letter (Reference 1), pertaining to NTTF Recommendation 2.1: Seismic for Three Mile Island Nuclear Station Unit 1 (TMI) in accordance with the documented intention of Exelon Generation Company, LLC transmitted to the NRC via letter dated April 29, 2013 (Reference 15).

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 TMI was performed to develop a Ground Motion Response Spectrum (GMRS) for comparison with the plant-level seismic capacity. The new GMRS represents an alternative seismic demand determined using recently developed techniques. The new GMRS does not constitute a change in the plant design or licensing basis as described in the NRC letter February 20, 2014 (Reference 13). Section 1 provides an introduction. Section 2 provides a summary of the TMI regional and local geology and seismicity, other major inputs to the seismic hazard reevaluation, and detailed seismic hazard results including definition of the GMRS. Seismic hazard analysis for TMI, including 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 (Reference 16). A more in-depth discussion of the calculation methods used in the seismic hazard reevaluation can be found in References 3, 6, 7, 9, and 18. Section 3 describes the characteristics of the plant design basis ground motion for TMI. Section 4 provides a GMRS screening evaluation for TMI. Sections 5 and 6 discuss interim actions and conclusions, respectively, for TMI.

Conclusions

For TMI, the GMRS spectral acceleration exceeds that of the Safe Shutdown Earthquake (SSE) at spectral frequencies above approximately 8.0 Hz. As a result, TMI screens in for a risk evaluation and a Spent Fuel Pool Integrity evaluation in accordance with the SPID, Sections 3 and 7 (Reference 3). Since the GMRS spectral acceleration exceeds that of the SSE in the frequency range above 10 Hz, high-frequency

exceedances can be addressed as part of the risk evaluation for TMI. As an interim action/assessment prior to completion of the risk evaluation, an Expedited Seismic Evaluation Process (ESEP) will be performed for TMI in conformance with the "Augmented Approach" guidance document (Reference 4). Actions to address NTTF 2.1: Seismic for central and eastern United States nuclear plants are outlined in the schedule provided in the April 9, 2013 letter from the industry to the NRC (Reference 5), as agreed to by the NRC in the May 7, 2013 letter to the industry (Reference 20).

1 Introduction

Following the accident at the Fukushima Dai-ichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the Nuclear Regulatory Commission (NRC) established a Near Term Task Force (NTTF). The NTTF was tasked with conducting a systematic review of NRC processes and regulations to determine if the agency should make additional improvements to its regulatory system. The NTTF developed a set of recommendations intended to clarify and strengthen the regulatory framework for protection against natural phenomena. Subsequently, the NRC issued a 50.54(f) letter requesting information to assure these recommendations would be 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 Title 10 Code of Federal Regulations Part 50 (Reference 2) reevaluate the seismic hazards at their sites using updated seismic hazard information and present-day regulatory guidance and methodologies. Depending on the outcome of the comparison between the reevaluated seismic hazard and the current site-specific design basis, performance of a seismic risk assessment may be necessary. Risk assessment approaches acceptable to the NRC 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 to provide additional protection against the updated hazards.

This report provides the information requested in items (1) through (7) of the "Requested Information" in Enclosure 1 of the 50.54(f) letter (Reference 1), pertaining to NTTF Recommendation 2.1: Seismic for Three Mile Island Nuclear Station Unit 1 (TMI), located in Dauphin County, Pennsylvania in accordance with the documented intention of Exelon Generation Company, LLC (Exelon) transmitted to the NRC via letter dated April 29, 2013 (Reference 15). In providing this information, Exelon followed the Screening, Prioritization, and Implementation Details (SPID) industry guidance document (Reference 3). The "Augmented Approach" guidance document (Reference 4) defines interim actions/evaluations for addressing a higher seismic hazard relative to the plant's current design/licensing basis prior to completion of the risk evaluations to demonstrate additional seismic margin. This short term aspect of the Augmented Approach is referred to as the Expedited Seismic Evaluation Process (ESEP). In response to NTTF Recommendation 2.3, seismic walkdowns for TMI have been completed as initially documented and supplemented in Exelon Correspondence Numbers RS-12-175 and RS-14-032 (References 12 and 25) respectively, to satisfy the 50.54(f) letter (Reference 1).

Geological and seismic investigations for TMI were performed for the original plant construction. TMI structures, systems, and components (SSCs) which are essential to the prevention of accidents which could affect the public health and safety or to the mitigation of accident consequences are designed to withstand the most severe natural phenomena specific to the site, with an appropriate margin to account for uncertainties in the historical data, or upon the most severe conditions which are susceptible to synthetic

analyses, including earthquakes, in accordance with the General Design Criteria proposed by the Atomic Energy Commission in July 1967 (Reference 10, Section 1.4). All Class I SSCs are analyzed under the loading conditions of the Design Earthquake (OBE) and the Maximum Hypothetical Earthquake (MHE), equivalent to the Safe Shutdown Earthquake (SSE) (Reference 10, Section 5.1.2). See Section 3 of this report for further discussion on the development of the TMI SSE.

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

2 Seismic Hazard Reevaluation

TMI is located on the northern most section of Three Mile Island near the east shore of the Susquehanna River about 10 miles southeast of Harrisburg in Dauphin County, Pennsylvania (Reference 10, Sections 1.1 and 1.2.1). The site is located in the Triassic lowland of Pennsylvania, within the Gettysburg Basin section of the physiographic division known as the Piedmont Province (Reference 10, Sections 2.7.3.1 and 2.7.3.2). The island on which the site is located is basically composed of fluvially deposited sand and gravel of adequate density to support moderately heavy loads. The underlying rock is a sedimentary sequence of interbedded sandstone, shaley siltstone, and shaley claystone which belongs to the Gettysburg Formation of Triassic Age. Below the weathered surface, bedrock is capable of safely bearing loads imposed by the heaviest structures. The site is not considered to be deleteriously affected by faulting, and it is concluded that regional tectonic elements are inactive and present no threat to the structural integrity of local geology. (Reference 10, Section 2.7.1)

Historically, earthquakes in Pennsylvania have been infrequent and of low intensity (Reference 10, Section 2.7.1). Earthquakes in the greater Pennsylvania area, which have or might have affected the site, were nearly always felt over very limited areas, and had high attenuation, indicating foci close to the earth's surface (Reference 10, Section 2.8.1). The original investigation of historical seismic activity in the region indicated that a low intensity VI (Modified Mercalli Scale) is an adequately conservative design intensity for the site. TMI determined that a low intensity VI corresponds to a ground acceleration of 0.04g (Reference 10, Section 2.8.1); for conservatism, a peak ground acceleration (PGA) of 0.06g is used for the OBE and a PGA of 0.12g is used for the SSE (Reference 10, Section 5.1.2.1.1).

2.1 Regional and Local Geology

The site is located in the Triassic lowland of Pennsylvania, within the Gettysburg Basin section of the physiographic division known as the Piedmont Province (Reference 10, Sections 2.7.3.1 and 2.7.3.2). The Triassic lowland of Pennsylvania is one of a series of long narrow basins of Triassic deposits which extend in broken patches from Connecticut to North Carolina (Reference 10, Section 2.7.3.2). The site is underlain by the sedimentary rocks of the Gettysburg shale, a part of the Newark group of Triassic Age (Reference 10, Section 2.7.3.4). The Newark group is believed to have a thickness of approximately 16,000 ft. and tilts toward the northwest due to subsidence and faulting along the northwest border (Reference 10, Section 2.7.3.2).

Three Mile Island is located approximately 2.5 miles south of Middletown, Pennsylvania. It is one of the largest of a group of several islands in the Susquehanna River and is situated about 900 ft. from the east bank (Reference 10, Section 2.7.1). All Class I structures were founded on bedrock which was excavated to sound rock, with the exception of Storage Tanks and the Diesel Generator Building, which were founded on

compacted backfill (Reference 10, Section 2.7.5.2 and Table 2.7-1). At the Reactor Building and other main structures, the top of the rock varies from El. 275.0 ft. to 279.5 ft. (Reference 10, Section 2.7.5.2). The bedrock underlying the general area is composed of shales, sandstones, and siltstones belonging to the Gettysburg shale of Triassic Age (Reference 10, Section 2.7.4.2). There is a high degree of uniformity of density and of soil types at the plant location, within the upper silty sand layer and the lower sand and gravel layer (Reference 10, Section 2.7.5.1). The tectonic history of the area indicates that the region has been extremely stable for at least the last 10,000 to one million years, and that studies did not establish the existence of minor faults or fractures at the site (Reference 10, Section 2.7.3.2).

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 6) together with the updated Electric Power Research Institute (EPRI) Ground-Motion Model (GMM) for the central and eastern United States (CEUS) (Reference 7). 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 sources out to a distance of 400 miles (640 km) around TMI were included. This distance exceeds the 200 mile (320 km) recommendation contained in NRC Reg. Guide 1.208 (Reference 18) and was chosen for completeness. Background sources included in this site analysis are the following:

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

For sources of large magnitude earthquakes, designated Repeated Large Magnitude Earthquake (RLME) sources in CEUS-SSC (Reference 6), the following sources lie within 1,000 km of the site and were included in the analysis:

1. Charleston
2. Charlevoix
3. 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, Section 2.5.3 (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 Enclosure 1 of the 50.54(f) letter (Reference 1) and the SPID, Section 2.4 (Reference 3) for nuclear power plant sites that are not founded on hard rock (considered as having a shear-wave velocity of at least 9285 fps), a site response analysis was performed for TMI.

2.3.1 Description of Subsurface Material

TMI is located on Three Mile Island in the Lower Susquehanna River Valley near Harrisburg Pennsylvania. The general site conditions consist of about 25 ft. (8.0 m) of soils (silts, sands, and gravels with some boulders and cobbles) over about 16,000 ft. (4,877 m) of sound Triassic sedimentary rocks with a basement of hard crystalline rocks (Reference 17). The SSE control point is at an elevation of 280 ft. at the top of the Gettysburg Formation.

The following description of the general geology is taken directly from the SGH Review of Existing Site Response Parameter Data (Reference 17):

> "Three Mile Island Nuclear Station is located on Three Mile Island, a low relief land mass situated in the Lower Susquehanna River Valley, upstream from York Haven Dam, approximately 10 miles southeast of Harrisburg in Londonderry Township of Dauphin County, Pennsylvania, about 2.5 miles north of the southern tip of Dauphin County. The island is about 300 yards from the east bank of the river, and over one mile from the western York County shore.
>
> "Three Mile Island formed as a result of fluvial deposition by the Susquehanna River. Boulders carried by the glacial meltwater or transported downstream by ice rafts were first deposited in this wide-channel, low-velocity section of the river and became the nuclei for subsequent deposition of smaller material. This gradual accretion of river sediment resulted in the growth of most of the islands in this area. Three Mile Island is made up of two such nuclei which eventually merged. This area between the two nuclei is presently represented by find-grained deposits.

"The topography of the area immediately surrounding Three Mile Island is of a slightly undulating nature with maximum relief of about 200 ft and highest elevation seldom above 500 ft. Three Mile Island has very little relief, with elevations ranging from about 280 ft at the water's edge to slightly more than 300 ft in the north central portion.

"The site is located in the Triassic lowland of Pennsylvania, one of a series of long narrow basins of Triassic deposits which extend in broken patches from Connecticut to North Carolina. The Triassic lowland in the vicinity of the site is referred to as the Gettysburg basin. The site lies within the Gettysburg Basin section of the physiographic division known as the Piedmont Province.

"The bedrock surface at the site is essentially flat and lies at approximately El. 277 ft. Lithologic types vary from red to brown, interbedded, fine-to medium-grained sandstone, shaley siltstone, and shaley claystone, which range from medium-hard to hard, possessing compressional wave velocities in a range from 8,500 to 11,500 ft/sec. There is 1 to 3 ft of weathered rock at the overburden-bedrock interface. All Class I structures founded on bedrock were excavated to sound rock. Wherever necessary, concrete fill was placed on top of the rock to the base elevation.

"There is a high degree of uniformity of density and of soil types at the plant location within the upper silty sand layer and the lower sand and gravel layer. The island, as a whole, consists of fluvially stratified subrounded to rounded sand and gravel containing varying amounts of silt, clay, and occasional lenses of clean sand. Density values range from loose to very dense. Boulders are presented at depth and are mainly confined to the lower portions of the soil zone on the north end of the island. Soil depths vary from approximately 6 ft at the south end of the island to a max of 30 ft near the axial intersection of the island. Depth of soil is relatively constant at about 20 ft in the vicinity of the plant site.

"The overburden is made up primarily of two units. The top layer is loose to medium dense, fine-grained granular material (alluvial deposits consisting primarily of sands and gravels) which varies from a fine silty sand and gravel to a very stiff (north), clayey silt (south). Directly overlying the sedimentary rocks is a layer of coarse sand and gravel, which at the north end of the island contains numerous boulders and cobbles and ranges from medium dense to very dense (layer of coarse cobbles).

"The bedrock surface at the site is of the Gettysburg shale, a part of the Newark group of the Triassic Age described as reddish-brown shale, and soft, red-brown, medium-to-fine-grained sandstone with minor amounts of yellowish-brown shale and sandstone; it may be metamorphosed by intrusive diabase to dark-purple to black argillite. The Newark Group is believed to have a thickness of approx. 16,000 ft and tilts toward the northwest."

Table 2.3.1-1 shows the recommended geotechnical properties for TMI (reproduced from Reference 17).

Table 2.3.1-1 Summary of site geotechnical profile for TMI (Reference 17)

Elevations of Layer Boundaries Under Reactor Buildings (ft., MSL)	Range in Thickness Across Site (ft.)	Soil/Rock Description and Age	Density (pcf)	Shear-wave Velocity (fps)	Compressional Wave Velocity (fps)	Poisson's ratio
304[a] to 298	6	Loose to medium dense fine silty sand and gravel to very stiff clayey silt	125-147	N/A	1000-2300	N/A
298 to 280	18	Medium dense to very dense coarse sand and gravel with some boulders and cobbles	125-147	N/A	2300-3800	N/A
280[b] to -15700[c]	16000	Triassic Gettysburg Formation, sandstone, medium-hard to hard shaley siltstone, and shaley claystone	N/A	N/A	8000-12000[d]	N/A
-15700 and below	N/A	Basement rock	N/A	N/A	N/A	N/A

[a] Finish grade elevation is nominally 304 ft. MSL.

[b] The SSE control point elevation is at the top of bedrock at El. 280 ft. MSL.

[c] Bottom of the deepest foundation is at El. 268 ft. MSL, near the surface of the Gettysburg Formation.

[d] Gettysburg Formation wave velocities were measured near the surface of the bedrock. The wave velocities are expected to increase with depth, but the degree and rate at which they do so is undetermined.

2.3.2 Development of Base Case Profiles and Nonlinear Material Properties

Based on Table 2.3.1-1 and the location of the SSE control point at an elevation of 280 ft. MSL (Reference 17) (see Section 3.2 for further discussion of the control point elevation), the profile consists of about 16,000 ft. (4,877 m) of firm rock overlying hard crystalline basement rock.

Shear-wave velocities for the profile were unspecified with compressional-wave velocities listed between 8,000 and 12,000 fps (2,438 m/s and 3,657 m/s respectively), likely based on shallow refraction surveys. To develop a mean base-case shear-wave velocity profile, a shallow velocity of 5,000 fps (1,524 m/s), which reflects a reasonable Poisson ratio of 0.35, was assumed for the top of the Triassic Gettysburg Formation.

Provided the materials to basement depth reflect similar sedimentary rocks and age, the shear-wave velocity gradient for sedimentary rock of 0.5 m/s/m (Reference 3) was assumed to be appropriate for the site. The shallow shear-wave velocity of 5,000 fps (1,524 m/s) was taken at the surface of the profile with the velocity gradient applied at

that point, resulting in a base-case shear-wave velocity of about 8,200 ft/s (2,500 m/s) at a depth of 6,562 ft. (2,000 m). The mean or best estimate base-case profile is shown as profile P1 in Figure 2.3.2-1.

Based on the uncertainty in shear-wave velocities due to the lack of measurements, a scale factor of 1.57 was adopted to reflect upper and lower range base-cases. The scale factor of 1.57 reflects a $\sigma_{\mu ln}$ of about 0.35 based on the SPID (Reference 3) 10^{th} and 90^{th} fractiles which implies a 1.28 scale factor on σ_{μ}. (Reference 16)

Using the best estimate or mean base-case profile (P1), the depth independent scale factor of 1.57 was applied to develop lower and upper range base-cases profiles P2 and P3 respectively with the stiffest profile (P3) reaching reference rock velocities at a depth of about 1,800 ft. (548 m). Base-case profiles P1 and P2 have a mean depth below the SSE control point of 6,562 ft. (2,000 m) to hard reference rock, randomized ± 1,969 ft. (± 600 m). The base-case profiles (P1, P2, and P3) are shown in Figure 2.3.2-1 and listed in Table 2.3.2-2. The depth randomization reflects ± 30% of the depth to provide a realistic broadening of the fundamental resonance rather than reflect actual random variations to basement shear-wave velocities across a footprint.

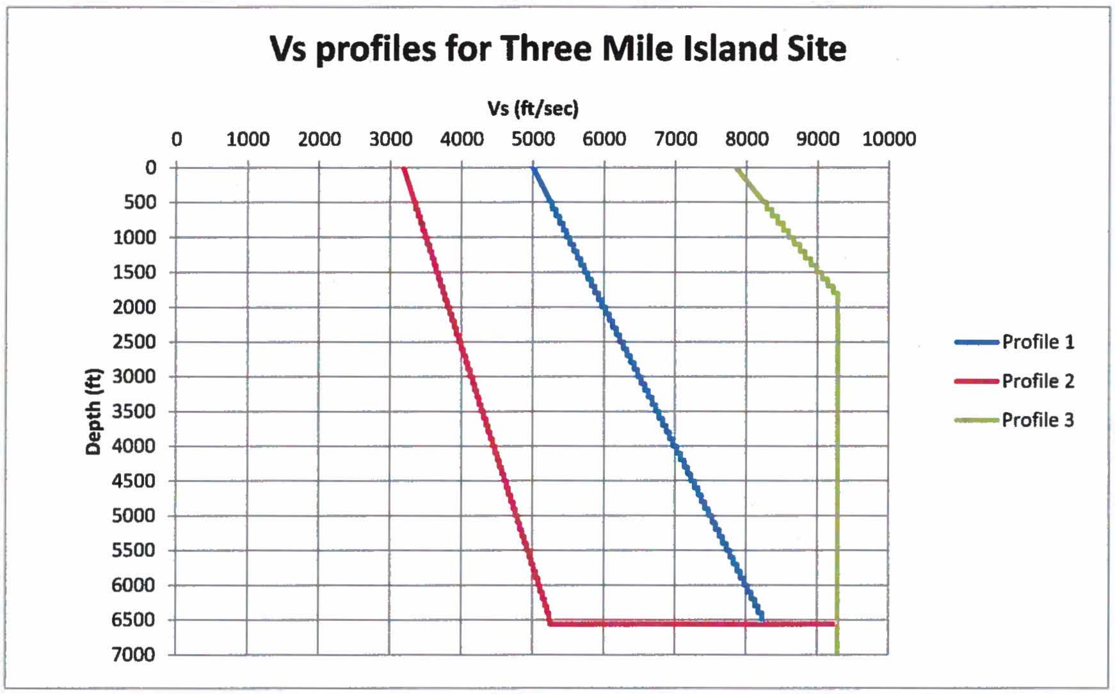


Figure 2.3.2-1 Shear-wave velocity profiles for the Three Mile Island site

Table 2.3.2-2 Layer thicknesses, depths, and shear-wave velocities (V_s) for three profiles, the Three Mile Island site

Profile 1			Profile 2			Profile 3		
Thickness (ft.)	Depth (ft.)	V_s (fps)	Thickness (ft.)	Depth (ft.)	V_s (fps)	Thickness (ft.)	Depth (ft.)	V_s (fps)
	0	5002		0	3186		0	7854
10.0	10.0	5002	10.0	10.0	3186	10.0	10.0	7854
10.0	20.0	5007	10.0	20.0	3190	10.0	20.0	7861
10.0	30.0	5012	10.0	30.0	3193	10.0	30.0	7869
10.0	40.0	5017	10.0	40.0	3196	10.0	40.0	7877
10.0	50.0	5022	10.0	50.0	3199	10.0	50.0	7885
10.0	60.0	5027	10.0	60.0	3202	10.0	60.0	7893
10.0	70.0	5032	10.0	70.0	3206	10.0	70.0	7901
10.0	80.0	5037	10.0	80.0	3209	10.0	80.0	7908
10.0	90.0	5042	10.0	90.0	3212	10.0	90.0	7916
10.0	100.0	5047	10.0	100.0	3215	10.0	100.0	7924
10.0	110.0	5052	10.0	110.0	3218	10.0	110.0	7932
10.0	120.0	5057	10.0	120.0	3221	10.0	120.0	7940
10.0	130.0	5062	10.0	130.0	3225	10.0	130.0	7948
10.0	140.0	5067	10.0	140.0	3228	10.0	140.0	7956
10.0	150.0	5072	10.0	150.0	3231	10.0	150.0	7963
10.0	160.0	5077	10.0	160.0	3234	10.0	160.0	7971
10.0	170.0	5082	10.0	170.0	3237	10.0	170.0	7979
10.0	180.0	5087	10.0	180.0	3241	10.0	180.0	7987
10.0	190.0	5092	10.0	190.0	3244	10.0	190.0	7995
10.0	200.0	5097	10.0	200.0	3247	10.0	200.0	8003
10.0	210.0	5102	10.0	210.0	3250	10.0	210.0	8011
10.0	220.0	5107	10.0	220.0	3253	10.0	220.0	8018
10.0	230.0	5112	10.0	230.0	3256	10.0	230.0	8026
10.0	240.0	5117	10.0	240.0	3260	10.0	240.0	8034
10.0	250.0	5122	10.0	250.0	3263	10.0	250.0	8042
10.0	260.0	5127	10.0	260.0	3266	10.0	260.0	8050
10.0	270.0	5132	10.0	270.0	3269	10.0	270.0	8058
10.0	280.0	5137	10.0	280.0	3272	10.0	280.0	8065
10.0	290.0	5142	10.0	290.0	3276	10.0	290.0	8073
10.0	300.0	5147	10.0	300.0	3279	10.0	300.0	8081
10.0	310.0	5152	10.0	310.0	3282	10.0	310.0	8089
10.0	320.0	5157	10.0	320.0	3285	10.0	320.0	8097
10.0	330.0	5162	10.0	330.0	3288	10.0	330.0	8105
10.0	340.0	5167	10.0	340.0	3292	10.0	340.0	8113
10.0	350.0	5172	10.0	350.0	3295	10.0	350.0	8120
10.0	360.0	5177	10.0	360.0	3298	10.0	360.0	8128

Profile 1			Profile 2			Profile 3		
Thickness (ft.)	Depth (ft.)	V_s (fps)	Thickness (ft.)	Depth (ft.)	V_s (fps)	Thickness (ft.)	Depth (ft.)	V_s (fps)
10.0	370.0	5182	10.0	370.0	3301	10.0	370.0	8136
10.0	380.0	5187	10.0	380.0	3304	10.0	380.0	8144
10.0	390.0	5192	10.0	390.0	3307	10.0	390.0	8152
10.0	400.0	5197	10.0	400.0	3311	10.0	400.0	8160
10.0	410.0	5202	10.0	410.0	3314	10.0	410.0	8168
10.0	420.0	5207	10.0	420.0	3317	10.0	420.0	8175
10.0	430.0	5212	10.0	430.0	3320	10.0	430.0	8183
10.0	440.0	5217	10.0	440.0	3323	10.0	440.0	8191
10.0	450.0	5222	10.0	450.0	3327	10.0	450.0	8199
10.0	460.0	5227	10.0	460.0	3330	10.0	460.0	8207
10.0	470.0	5232	10.0	470.0	3333	10.0	470.0	8215
10.0	480.0	5237	10.0	480.0	3336	10.0	480.0	8222
10.0	490.0	5242	10.0	490.0	3339	10.0	490.0	8230
10.0	500.0	5247	10.0	500.0	3342	10.0	500.0	8238
100.0	600.0	5274	100.0	600.0	3360	100.0	600.0	8281
100.0	700.0	5324	100.0	700.0	3392	100.0	700.0	8359
100.0	800.0	5374	100.0	800.0	3423	100.0	800.0	8438
100.0	900.0	5424	100.0	900.0	3455	100.0	900.0	8516
100.0	1000.0	5474	100.0	1000.0	3487	100.0	1000.0	8595
100.0	1100.0	5524	100.0	1100.0	3519	100.0	1100.0	8673
100.0	1200.0	5574	100.0	1200.0	3551	100.0	1200.0	8752
100.0	1300.0	5624	100.0	1300.0	3583	100.0	1300.0	8830
100.0	1400.0	5674	100.0	1400.0	3615	100.0	1400.0	8909
100.0	1499.9	5724	100.0	1499.9	3646	100.0	1499.9	8987
100.0	1599.9	5774	100.0	1599.9	3678	100.0	1599.9	9066
100.0	1699.9	5824	100.0	1699.9	3710	100.0	1699.9	9144
100.0	1799.9	5874	100.0	1799.9	3742	100.0	1799.9	9223
100.0	1899.9	5924	100.0	1899.9	3774	100.0	1899.9	9285
100.0	1999.9	5974	100.0	1999.9	3806	100.0	1999.9	9285
100.0	2099.9	6024	100.0	2099.9	3838	100.0	2099.9	9285
100.0	2199.9	6074	100.0	2199.9	3869	100.0	2199.9	9285
100.0	2299.9	6124	100.0	2299.9	3901	100.0	2299.9	9285
100.0	2399.9	6174	100.0	2399.9	3933	100.0	2399.9	9285
100.0	2499.9	6224	100.0	2499.9	3965	100.0	2499.9	9285
100.0	2599.9	6274	100.0	2599.9	3997	100.0	2599.9	9285
100.0	2699.9	6324	100.0	2699.9	4029	100.0	2699.9	9285
100.0	2799.9	6374	100.0	2799.9	4060	100.0	2799.9	9285
100.0	2899.9	6424	100.0	2899.9	4092	100.0	2899.9	9285
100.0	2999.9	6474	100.0	2999.9	4124	100.0	2999.9	9285

Profile 1			Profile 2			Profile 3		
Thickness (ft.)	Depth (ft.)	V_s (fps)	Thickness (ft.)	Depth (ft.)	V_s (fps)	Thickness (ft.)	Depth (ft.)	V_s (fps)
100.0	3099.9	6524	100.0	3099.9	4156	100.0	3099.9	9285
100.0	3199.9	6574	100.0	3199.9	4188	100.0	3199.9	9285
100.0	3299.9	6624	100.0	3299.9	4220	100.0	3299.9	9285
100.0	3399.9	6674	100.0	3399.9	4252	100.0	3399.9	9285
100.0	3499.9	6724	100.0	3499.9	4283	100.0	3499.9	9285
100.0	3599.9	6774	100.0	3599.9	4315	100.0	3599.9	9285
100.0	3699.9	6824	100.0	3699.9	4347	100.0	3699.9	9285
100.0	3799.9	6874	100.0	3799.9	4379	100.0	3799.9	9285
100.0	3899.9	6924	100.0	3899.9	4411	100.0	3899.9	9285
100.0	3999.9	6974	100.0	3999.9	4443	100.0	3999.9	9285
100.0	4099.9	7024	100.0	4099.9	4475	100.0	4099.9	9285
100.0	4199.9	7074	100.0	4199.9	4506	100.0	4199.9	9285
100.0	4299.9	7124	100.0	4299.9	4538	100.0	4299.9	9285
100.0	4399.8	7174	100.0	4399.8	4570	100.0	4399.8	9285
100.0	4499.8	7224	100.0	4499.8	4602	100.0	4499.8	9285
100.0	4599.8	7274	100.0	4599.8	4634	100.0	4599.8	9285
100.0	4699.8	7324	100.0	4699.8	4666	100.0	4699.8	9285
100.0	4799.8	7374	100.0	4799.8	4698	100.0	4799.8	9285
100.0	4899.8	7424	100.0	4899.8	4729	100.0	4899.8	9285
100.0	4999.8	7474	100.0	4999.8	4761	100.0	4999.8	9285
100.0	5099.8	7524	100.0	5099.8	4793	100.0	5099.8	9285
100.0	5199.8	7574	100.0	5199.8	4825	100.0	5199.8	9285
100.0	5299.8	7624	100.0	5299.8	4857	100.0	5299.8	9285
100.0	5399.8	7674	100.0	5399.8	4889	100.0	5399.8	9285
100.0	5499.8	7724	100.0	5499.8	4920	100.0	5499.8	9285
100.0	5599.8	7774	100.0	5599.8	4952	100.0	5599.8	9285
100.0	5699.8	7824	100.0	5699.8	4984	100.0	5699.8	9285
100.0	5799.8	7874	100.0	5799.8	5016	100.0	5799.8	9285
100.0	5899.8	7924	100.0	5899.8	5048	100.0	5899.8	9285
100.0	5999.8	7975	100.0	5999.8	5080	100.0	5999.8	9285
100.0	6099.8	8025	100.0	6099.8	5112	100.0	6099.8	9285
100.0	6199.8	8075	100.0	6199.8	5143	100.0	6199.8	9285
100.0	6299.8	8125	100.0	6299.8	5175	100.0	6299.8	9285
100.0	6399.8	8175	100.0	6399.8	5207	100.0	6399.8	9285
100.0	6499.8	8225	100.0	6499.8	5239	100.0	6499.8	9285
61.4	6561.2	8235	61.4	6561.2	5246	61.4	6561.2	9285
3280.8	9842.0	9285	3280.8	9842.0	9285	3280.8	9842.0	9285

2.3.2.1 Shear Modulus and Damping Curves

No site-specific nonlinear dynamic material properties were determined in the initial siting of TMI 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 Three Mile Island site, two sets of shear modulus reduction and hysteretic damping curves were used. Consistent with the SPID (Reference 3), 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. (150 m).

2.3.2.2 Kappa

For the Three Mile Island site, kappa estimates were determined using Section B-5.1.3.1 of the SPID (Reference 3) 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. For the Three Mile Island site, with about 6,500 ft. (1,969 m) of firm sedimentary rock below the SSE control point elevation, kappa estimates were based on the average shear-wave velocity over the top 100 ft. (30 m) of the three base-case profiles P1, P2, and P3. For the three profiles the corresponding average (100 ft., 30 m) shear-wave velocities were: 5,026 fps (1,532 m/s), 3,201 fps (976 m/s), and 7,980 fps (2,432 m/s) with corresponding kappa estimates of 0.015 s, 0.024 s, and 0.009 s. While profile P3 reached hard reference rock shear-wave velocities at a depth of 1,800 ft. (548 m), significantly less than 3,000 ft. (914 m), the profile reflects very firm sedimentary rock at the surface (about 7,800 fps, 2,393 m/s) and would be expected to increase to hard rock values above a depth of 3,000 ft. (914 m). For these conditions the kappa estimate based on the average shear-wave velocity over the top 100 ft. (30 m) would be appropriate as assigning a Q_S below 500 ft. would result in too high a kappa estimate, depending on depth to hard reference rock velocities. The range in kappa about the best estimate base-case value of 0.015 s (profile P1) is roughly 1.6 and is considered to adequately reflect epistemic uncertainty in low strain damping (kappa) for the profile.

Table 2.3.2-3 Kappa values and weights used for site response analyses

Velocity Profile	Kappa (s)	Weights
P1	0.015	0.4
P2	0.024	0.3
P3	0.009	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 Three Mile Island 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 (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 Reference 9 for United States Geological Survey (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 a natural log standard deviation of 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 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 PGAs ranging from 0.01g to 1.5g) were used in the site response analyses. The characteristics of the seismic source and upper crustal attenuation properties assumed for the analysis of the Three Mile Island site were the same as those identified in Tables B-4, B-5, B-6 and B-7 of the SPID (Reference 3) as appropriate for typical CEUS sites.

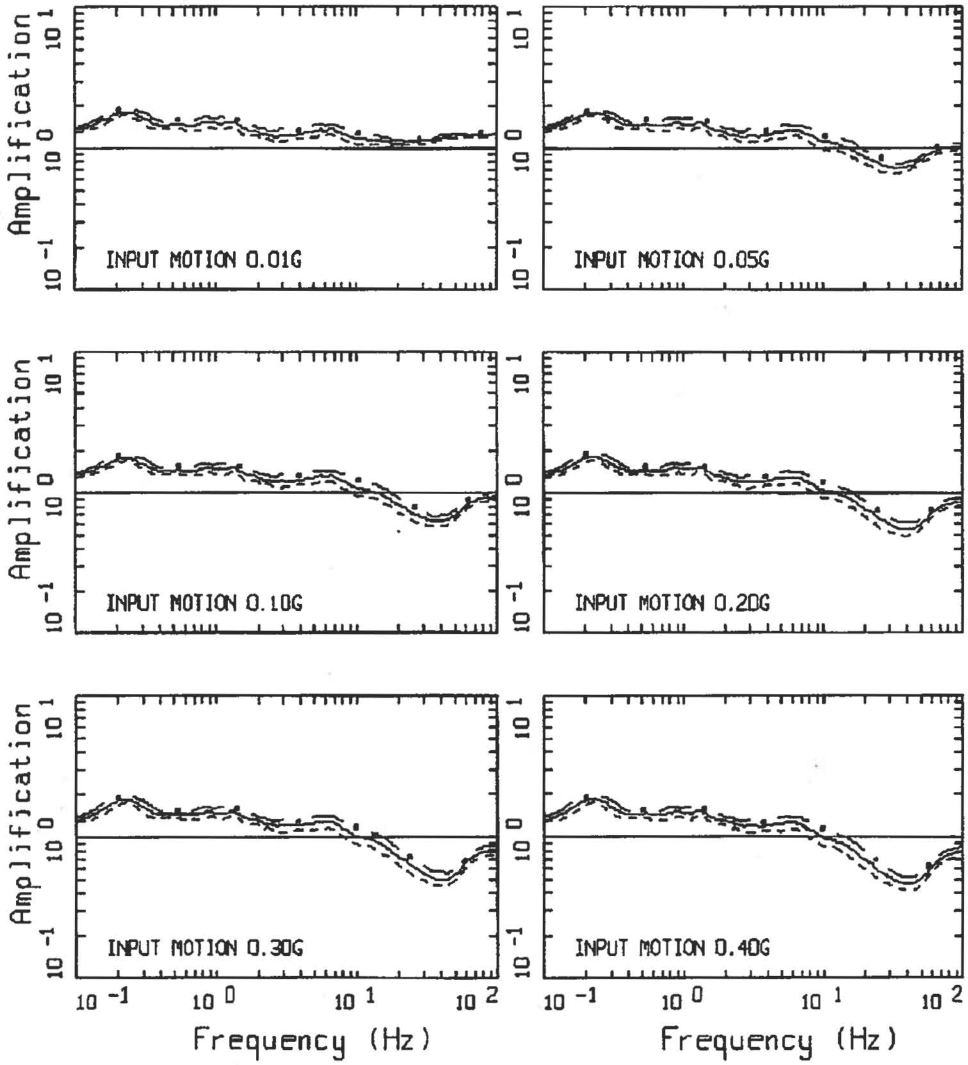
2.3.5 *Methodology*

To perform the site response analyses for the Three Mile Island 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 (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 Three Mile Island site.

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 (Reference 3) 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

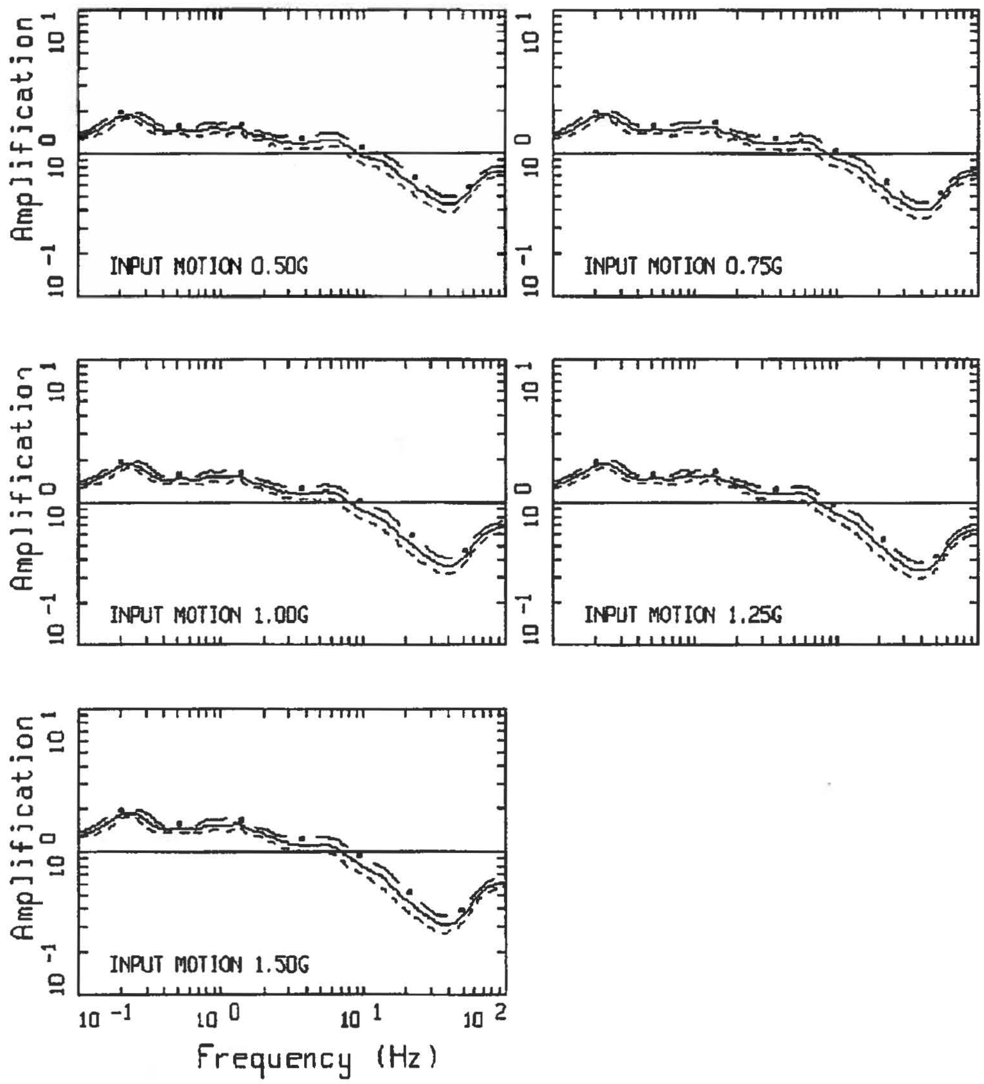
amplification factors developed for the eleven loading levels parameterized by the median reference (hard rock) peak acceleration (0.01g to 1.50g) for profile P1 and EPRI rock G/G_{max} and hysteretic damping curves. The variability in the amplification factors results from variability in shear-wave velocity, depth to hard rock, and modulus reduction and hysteretic damping curves. To illustrate the effects of nonlinearity at the Three Mile Island site, Figure 2.3.6-2 shows the corresponding amplification factors developed with linear analyses (model M2). Tabulated values of the amplification factors are provided in Appendix A.



AMPLIFICATION, THREE MILE ISLAND, M1P1K1

M 6.5, 1 CORNER: PAGE 1 OF 2

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 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)



AMPLIFICATION, THREE MILE ISLAND, M1P1K1
M 6.5, 1 CORNER: PAGE 2 OF 2

Figure 2.3.6-1 continued

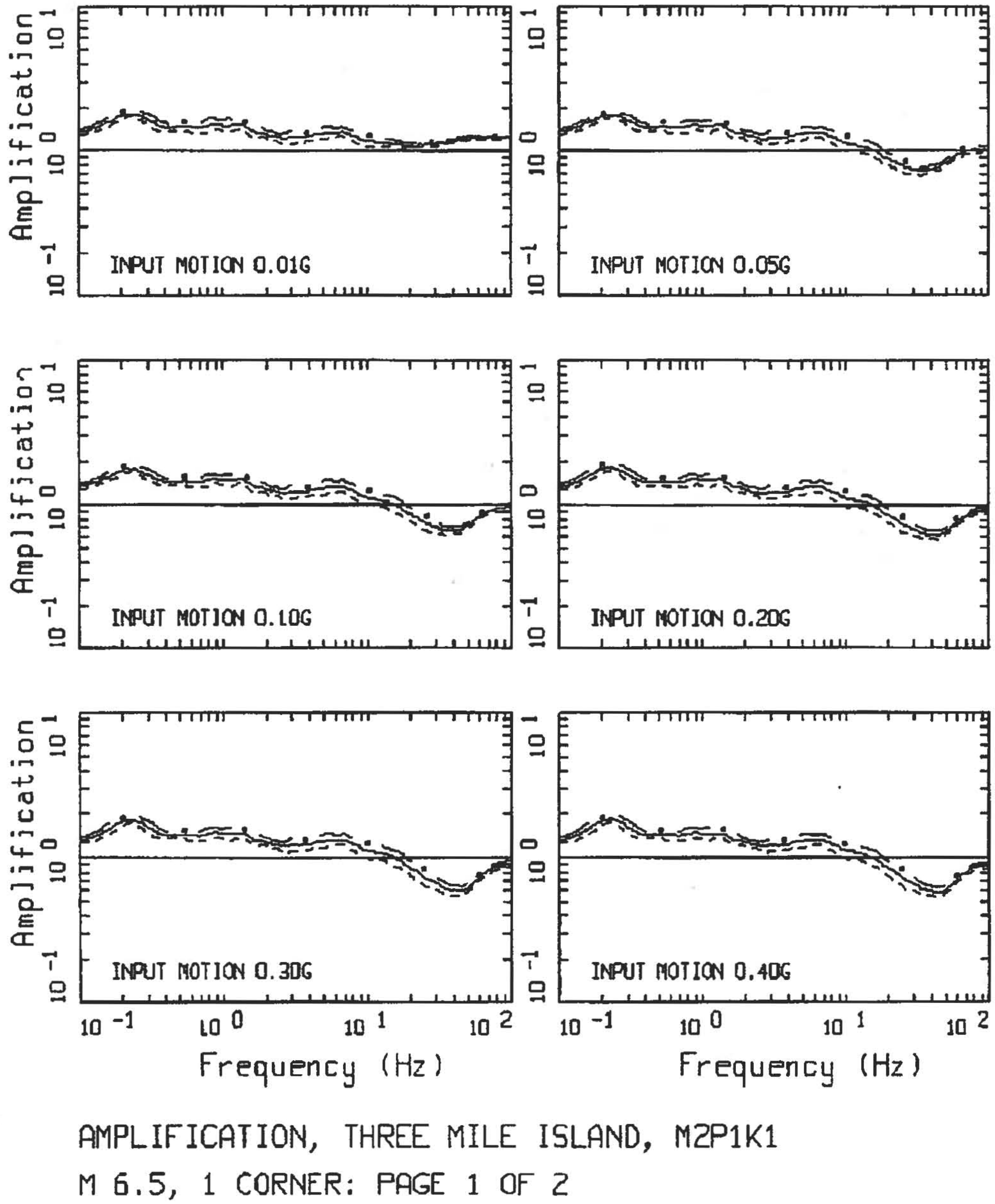


Figure 2.3.6-2 Example suite of amplification factors (5% of critical damping pseudo absolute acceleration spectra) developed for the mean base-case profile (P1), linear analyses (model M2), and base-case kappa at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g;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

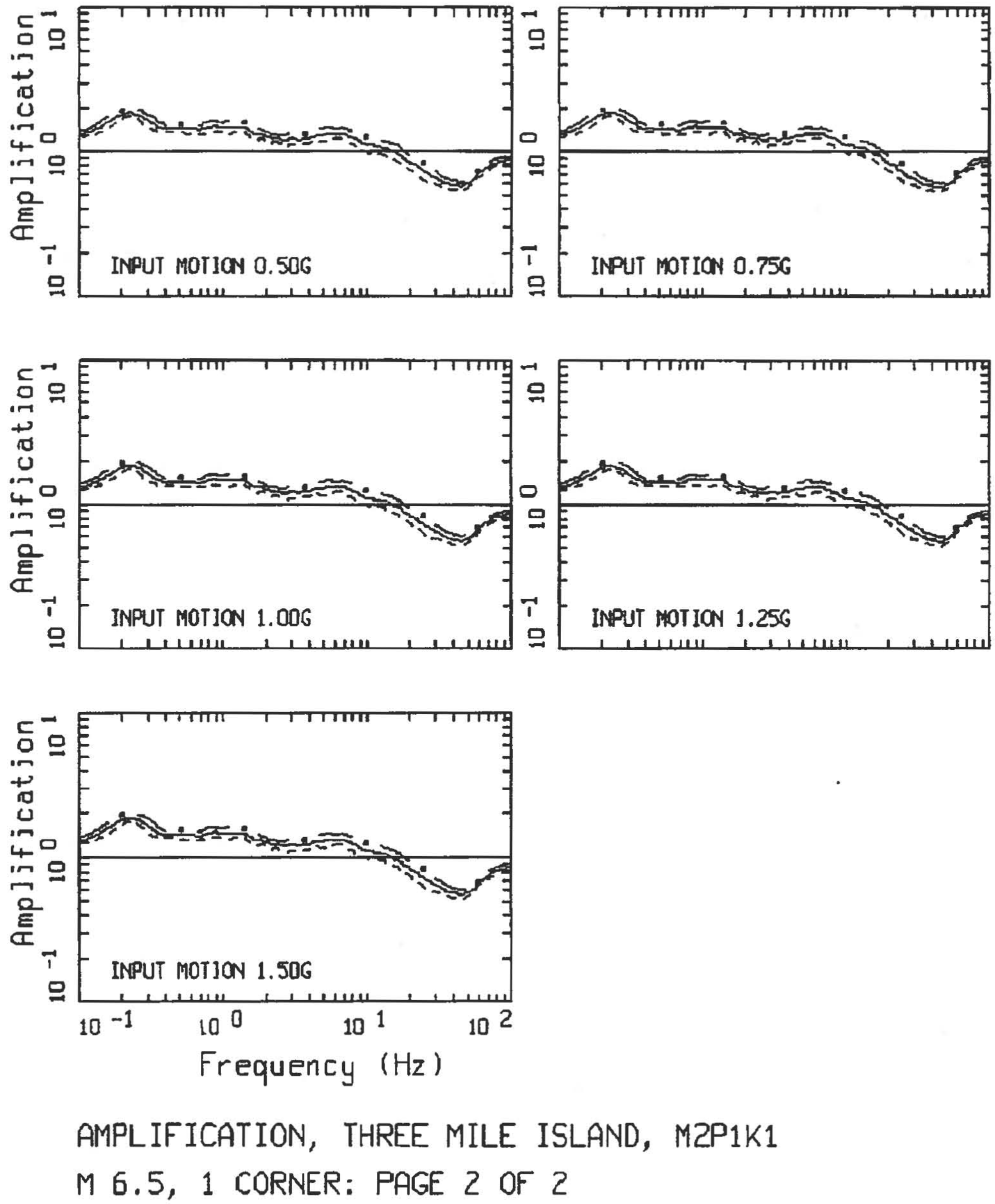


Figure 2.3.6-2 continued

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 TMI 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.

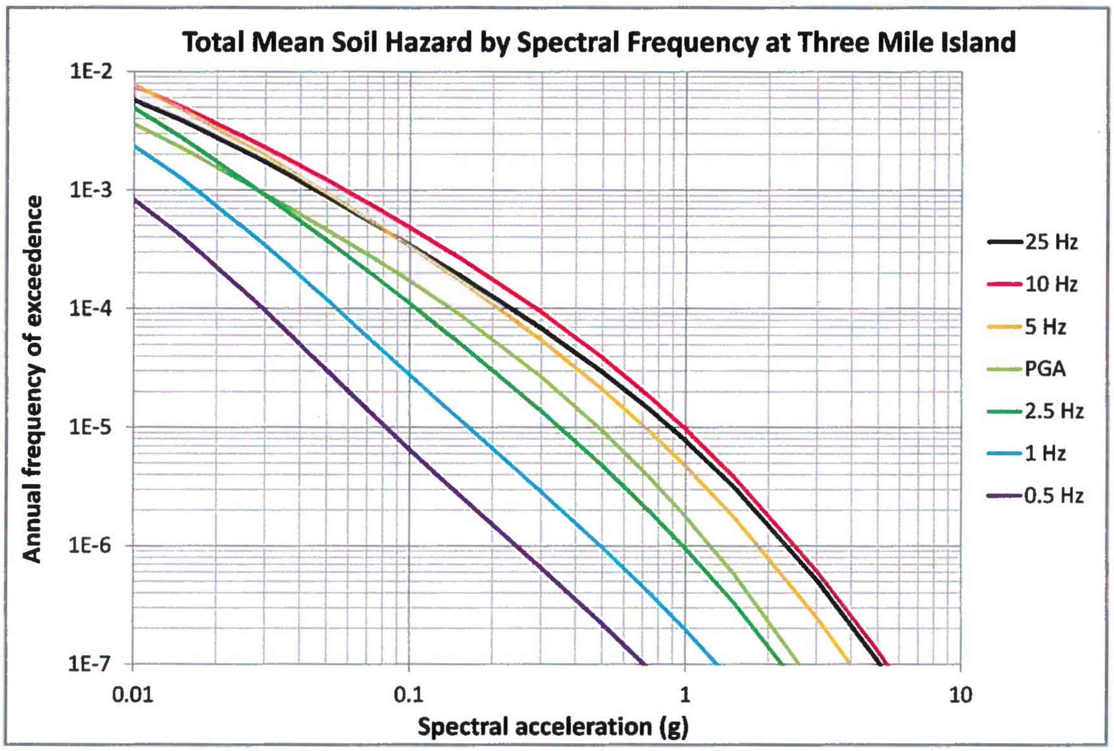


Figure 2.3.7-1 Control point mean hazard curves for spectral frequencies of 0.5, 1, 2.5, 5, 10, 25 and 100 Hz (PGA) at TMI (5% of critical damping)

2.4 CONTROL POINT RESPONSE SPECTRA (UHRS & GMRS)

The control point hazard curves described in Section 2.3.7 have been used to develop geometric mean horizontal uniform hazard response spectra (UHRS) and the GMRS. The UHRS were obtained through linear interpolation in log-log space to estimate the spectral acceleration at each spectral frequency for the 1E-4 and 1E-5 per year hazard levels. The 1E-4 and 1E-5 UHRS, along with a design factor (DF) are used to compute the GMRS at the control point using the criteria in NRC Reg. Guide 1.208 (Reference 18). The GMRS developed herein represents an alternative seismic demand for TMI determined using recently developed techniques. Table 2.4-1 shows the UHRS and GMRS accelerations for a range of spectral frequencies. Figure 2.4-1 shows the UHRS and GMRS at the control point.

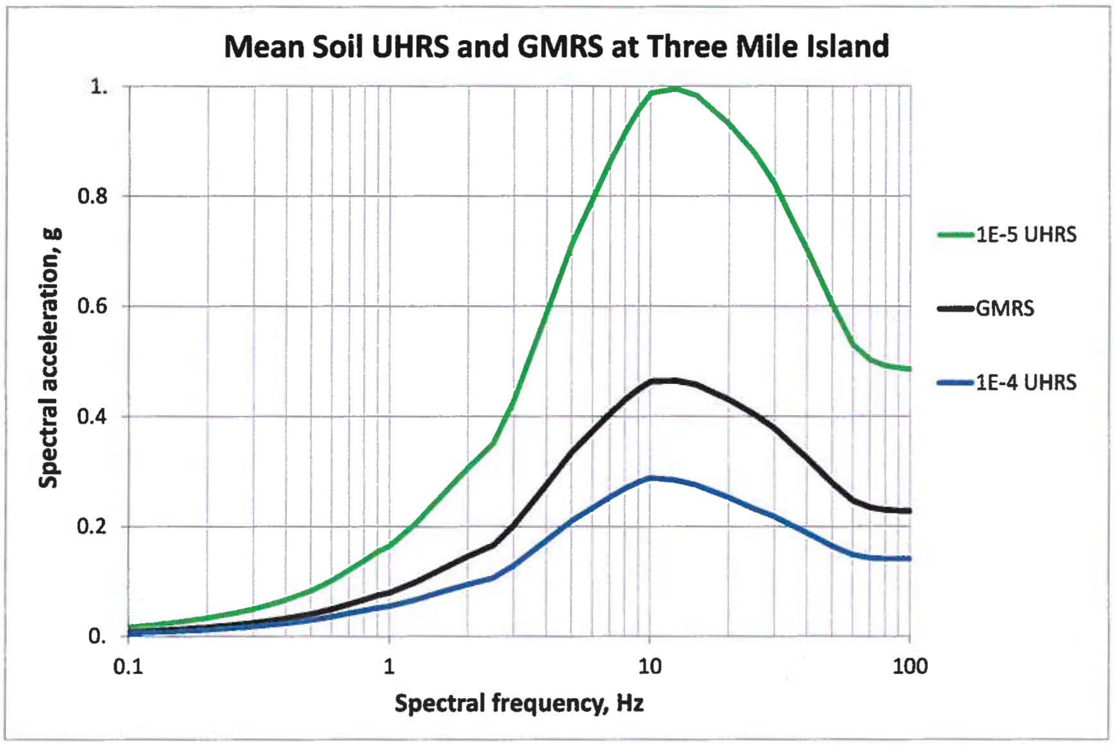


Figure 2.4-1 Plots of 1E-4 and 1E-5 UHRS and GMRS at control point for TMI (5% of critical damping response spectra)

Table 2.4-1 UHRS and GMRS at control point for TMI (5% of critical damping response spectra)

Freq (Hz)	1E-4 UHRS (g)	1E-5 UHRS (g)	GMRS (g)
100	1.41E-01	4.85E-01	2.27E-01
90	1.41E-01	4.87E-01	2.28E-01
80	1.41E-01	4.92E-01	2.30E-01
70	1.42E-01	5.02E-01	2.34E-01
60	1.48E-01	5.30E-01	2.46E-01
50	1.64E-01	6.02E-01	2.79E-01
40	1.88E-01	7.02E-01	3.24E-01
35	2.01E-01	7.56E-01	3.48E-01
30	2.18E-01	8.21E-01	3.78E-01
25	2.32E-01	8.79E-01	4.04E-01
20	2.53E-01	9.31E-01	4.30E-01
15	2.75E-01	9.83E-01	4.57E-01
12.5	2.84E-01	9.96E-01	4.65E-01
10	2.88E-01	9.87E-01	4.63E-01
9	2.80E-01	9.58E-01	4.49E-01
8	2.69E-01	9.17E-01	4.30E-01
7	2.53E-01	8.63E-01	4.05E-01
6	2.33E-01	7.95E-01	3.73E-01
5	2.10E-01	7.14E-01	3.35E-01
4	1.74E-01	5.87E-01	2.76E-01
3.5	1.52E-01	5.13E-01	2.42E-01
3	1.28E-01	4.28E-01	2.02E-01
2.5	1.06E-01	3.50E-01	1.65E-01
2	9.42E-02	3.06E-01	1.45E-01
1.5	7.69E-02	2.43E-01	1.16E-01
1.25	6.56E-02	2.03E-01	9.73E-02
1	5.44E-02	1.64E-01	7.89E-02
0.9	5.14E-02	1.53E-01	7.39E-02
0.8	4.65E-02	1.37E-01	6.62E-02
0.7	4.14E-02	1.20E-01	5.82E-02
0.6	3.53E-02	1.01E-01	4.90E-02
0.5	2.94E-02	8.23E-02	4.02E-02
0.4	2.36E-02	6.58E-02	3.21E-02
0.35	2.06E-02	5.76E-02	2.81E-02
0.3	1.77E-02	4.94E-02	2.41E-02
0.25	1.47E-02	4.11E-02	2.01E-02
0.2	1.18E-02	3.29E-02	1.61E-02
0.15	8.83E-03	2.47E-02	1.21E-02
0.125	7.36E-03	2.06E-02	1.00E-02
0.1	5.89E-03	1.65E-02	8.04E-03

3 Plant Design Basis Ground Motion

The design basis for TMI is identified in the TMI Updated Final Safety Analysis Report (UFSAR) (Reference 10). The current licensing basis maximum hypothetical earthquake (MHE), equivalent to the SSE, is based on an evaluation of the maximum earthquake potential considering regional and local geology, seismology, tectonic history, and specific characteristics of local subsurface material. An estimate of the maximum expected intensity of an earthquake is predicted on the assumption that the activity which would affect the site would originate along the border fault of the Triassic Lowland, five to six miles north of the site. The highest recorded intensity within a 50 mile radius of the site was modified Mercalli VI, which would attenuate to an intensity of V at the site if the earthquake originated at the assumed location. Due to the uncertainty associated with epicenter focal depth and ground motion attenuation, the maximum earthquake intensity is conservatively equated to a low intensity VI. The SSE acceleration response spectrum is based on data recorded from the March 1957 San Francisco and 1940 El Centro earthquakes. (Reference 10, Section 2.7.1)

3.1 SSE Description of Spectral Shape

The SSE is defined in terms of a PGA and a design response spectrum. Considering a site design intensity of VI, the maximum horizontal ground acceleration is defined with 12% of gravity (0.12g) as the anchor point for the SSE (Reference 10, Section 5.1.2.1.1). The site design response spectrum, shown in Figure 2.7-1, is derived from the ground motions of the 1957 Golden Gate Park, San Francisco earthquake together with the revised acceleration spectra reflecting the greater response at lower frequencies based upon the 1940 El Centro spectra (Reference 10, Section 2.8.2).

Table 3.1-1 shows the spectral acceleration values as a function of frequency for horizontal SSE (5% of critical damping). The SSE acceleration values are based on digitized data from UFSAR Figure 2.7-1 (Reference 10) normalized to the SSE PGA of 0.12g. The horizontal SSE (5% of critical damping) for TMI is shown in Figure 3.1-1.

Table 3.1-1 Horizontal SSE for TMI (5% of critical damping response spectrum)

Frequency (Hz)	Spectral Acceleration (g)
1	0.17
1.25	0.18
1.5	0.23
2	0.27
2.5	0.30
3	0.32
4	0.36
5	0.40
6	0.42
7	0.43
8	0.43
9	0.42
10	0.41
12.5	0.36
15	0.29
20	0.21
25	0.18
30	0.17
35	0.15
40	0.15
50	0.14
60	0.14
70	0.13
80	0.13
90	0.12
100/PGA	0.12

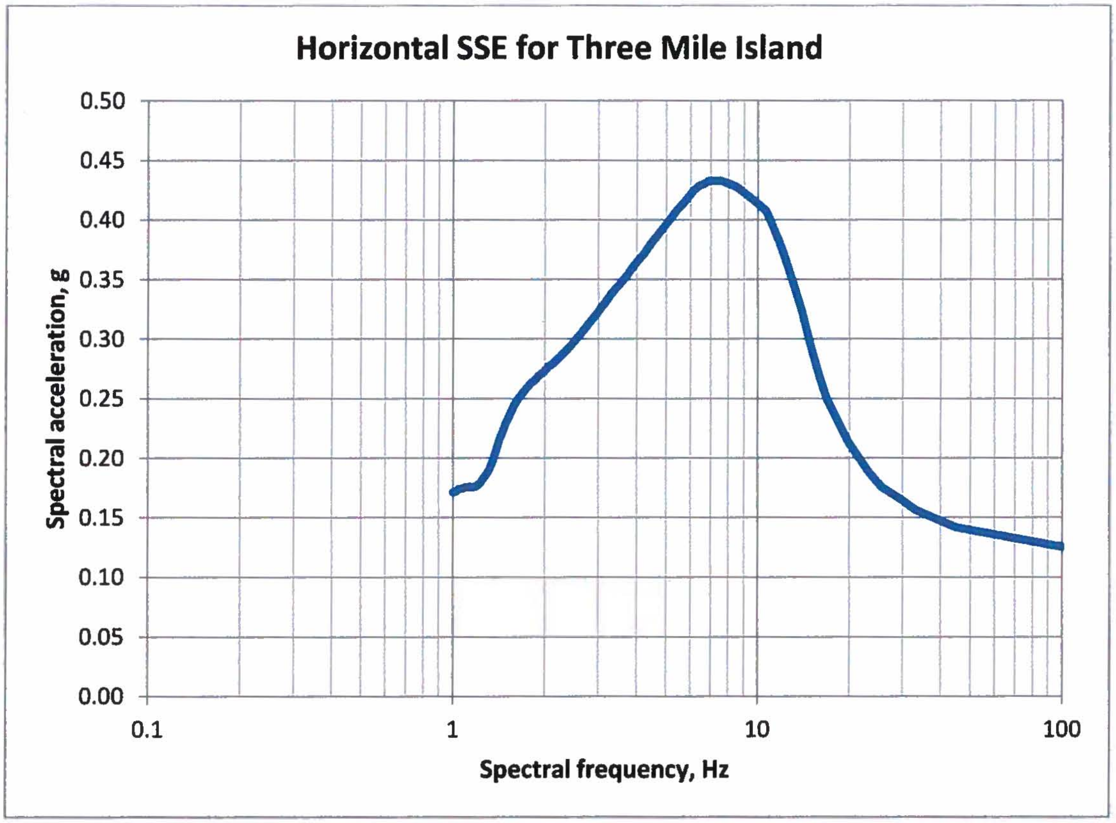


Figure 3.1-1 Horizontal SSE for TMI (5% of critical damping response spectrum)

3.2 CONTROL POINT ELEVATION

The TMI UFSAR (Reference 10) does not define an SSE control point. The site is layered with approximately 20 ft. of soil (Reference 10, Section 2.7.3.6) over underlying rock composed of a sedimentary sequence of interbedded sandstone, shaley siltstone, and shaley claystone which belongs to the Gettysburg Formation of the Triassic Age (Reference 10, Section 2.7.1). TMI is identified as a rock site (Reference 17) with the top of rock varying from El. 275.0 to 279.5 ft. (Reference 10, Section 2.7.5.2) directly underlying the main power block building foundations. Based on estimation from subsurface sections and seismic refraction survey results (Reference 10, Figures 2.7-3 and 2.7-4), the SSE control point elevation is taken to be at the approximate top of the rock surface at El. 280 ft. MSL. This definition of the control point is consistent with the approach described in the SPID (Reference 3, Section 2.4.2).

4 Screening Evaluation

Following completion of the seismic hazard reevaluation, as requested in the 50.54(f) letter (Reference 1), a screening evaluation is performed in accordance with the SPID, Section 3 (Reference 3). The horizontal GMRS determined from the hazard reevaluation is used to characterize the amplitude of the alternative seismic hazard at each of the nuclear power plant sites. The screening evaluation is based upon a comparison of the GMRS with the established plant-level seismic capacity (either the SSE or IPEEE HCLPF Spectrum (IHS), where IPEEE is defined as Individual Plant Examination of External Events and HCLPF is defined as high-confidence-of-low-probability-of-failure), in accordance with the SPID (Reference 3). For TMI, the plant-level seismic capacity is based on the SSE.

4.1 Risk Evaluation Screening (1 to 10 Hz)

In the frequency range of 1 to 10 Hz, the TMI GMRS spectral acceleration exceeds that of the SSE at spectral frequencies above approximately 8.0 Hz. As a result, TMI screens in for a risk evaluation in accordance with the SPID, Section 3.2 (Reference 3). Section 6.2 of the SPID (Reference 3) provides guidance as to whether an NRC SMA, as described in NRC Interim Staff Guidance JLD-ISG-2012-04 (Reference 8), or an SPRA is the appropriate approach for the risk evaluation. As the re-evaluated seismic hazard is not considerably higher than the design basis seismic hazard, since the GMRS is less than 1.3 times the SSE, an SMA and an SPRA are both acceptable risk evaluation approaches for TMI.

Further, in accordance with the screening requirements in Section 2.2 of the "Augmented Approach" guidance document (Reference 4), TMI will perform an ESEP as an interim action/assessment.

4.2 High Frequency Screening (> 10 Hz)

In the frequency range above 10 Hz, the GMRS spectral acceleration exceeds that of the SSE. The high frequency exceedances can be addressed in the risk evaluation discussed in Section 4.1

Section 3.4 of the SPID (Reference 3) discusses the impact of high-frequency ground motion on plant components and identifies the component groups that are sensitive to high-frequency vibration. As summarized in the SPID (Reference 3), EPRI Report NP-7498 (Reference 21) concludes that high-frequency vibration is not damaging, in general, to components with strain- or stress-based failure modes. However, components, such as relays, subject to electrical functionality failure modes have unknown acceleration sensitivity for frequencies above 16 Hz.

EPRI Report 1015108 (Reference 22) 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 23) provides guidance for identifying and evaluating potentially high-frequency sensitive components. Guidance from these documents is considered in the SPID (Reference 3) for identifying components that are sensitive to high-frequency vibration. Component types listed in Table 3-3 of the SPID (Reference 3) provide examples of components that are potentially sensitive to high-frequency vibrations. 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)

As the GMRS spectral acceleration exceeds that of the SSE in the frequency range of 1 to 10 HZ, a Spent Fuel Pool Integrity evaluation is needed for TMI in accordance with the SPID, Section 7 (Reference 3).

5 Interim Actions

Based on the screening results described in Section 4 of this report, the GMRS spectral acceleration exceeds that of the SSE at all spectral frequencies above approximately 8.0 Hz at TMI. Therefore, TMI screens in for a risk evaluation in response to the 50.54(f) letter (Reference 1). Additionally, the "Augmented Approach" guidance document (Reference 4) prescribes expedited seismic evaluations of key components be performed.

5.1 Expedited Seismic Evaluation Process

Based on the screening results, the ESEP will be performed for TMI as proposed in the April 9, 2013 letter from the industry to the NRC (Reference 5) and agreed to by the NRC in a letter dated May 7, 2013 (Reference 20).

Exelon has committed to follow the "Augmented Approach" guidance document (Reference 4), which introduces the ESEP as an interim action to augment the response to the NRC request for information. The ESEP addresses the part of the 50.54(f) letter (Reference 1) that requests "interim evaluation and actions taken or planned to address the higher seismic hazard relative to the design basis, as appropriate, prior to completion of the risk evaluation." Specifically, the ESEP focuses initial industry efforts on short term evaluations that will lead to prompt modifications to some of the most important components that could improve plant seismic safety.

5.2 Interim Evaluation of Seismic Hazard

Consistent with the NRC letter dated February 20, 2014 (Reference 13), the seismic hazard reevaluations presented herein are distinct from the current design and licensing bases of TMI. Therefore, the results do not call into question the operability or functionality of SSCs and are not reportable pursuant to 10CFR50.72, "Immediate notification requirements for operating nuclear power reactors" (Reference 2, Section 50.72) and 10CFR50.73, "Licensee event report system" (Reference 2, Section 50.73).

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, the Nuclear Energy Institute (NEI) letter dated March 12, 2014 (Reference 24) provides seismic core damage risk estimates using the updated seismic hazards for the operating nuclear plants in the CEUS. These risk estimates continue to support the following conclusions of the NRC GI-199 Safety/Risk Assessment (Reference 19):

> "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."

TMI is included in the March 12, 2014 NEI letter risk estimates (Reference 24). Using the methodology described in the NEI letter, the seismic core damage risk estimates for all plants were shown to be below 1E-4/year; thus, the above conclusions apply.

5.3 Seismic Walkdown Insights

In response to NTTF 2.3, the 50.54(f) letter (Reference 1) also 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. Exelon committed to and performed seismic walkdowns in accordance with the seismic walkdown guidance (Reference 14) as initially documented and supplemented in Exelon Correspondence Numbers RS-12-175 and RS-14-032 (References 12 and 25) respectively.

Based on the successful completion of seismic walkdowns in response to NTTF 2.3, and the lack of identified adverse seismic conditions resulting in an operability concern, Exelon has directly concluded that the TMI current plant configuration is consistent with the plant licensing basis and can safely shut down the reactor and maintain containment integrity following the design basis SSE event. Additionally, the findings of the seismic walkdown program indirectly verify that the current TMI strategies, monitoring, and maintenance programs are adequate for ensuring seismic safety consistent with the licensing basis.

Plant vulnerabilities and commitments identified in the TMI IPEEE (Reference 11) were reviewed as part of the NTTF 2.3 seismic walkdowns (References 12 and 25). The TMI seismic walkdown reports verified the IPEEE report did not identify any vulnerabilities and confirmed all previously identified IPEEE commitments have been resolved (References 12 and 25).

5.4 Beyond-Design-Basis Seismic Insights

An evaluation of beyond-design-basis ground motions was performed for TMI as part of the IPEEE program. The TMI IPEEE (Reference 11) analyzed seismic risk quantitatively via an SPRA. The IPEEE seismic evaluation included plant walkdowns, earthquake induced soil liquefaction analysis, review of relay chatter effects, evaluation of containment performance, and examination of seismic core damage frequency (SCDF) sensitivity to changes in input assumptions and model characteristics. The results of the TMI IPEEE showed there were no vulnerabilities to severe accident risk from external events, including seismic events (Reference 11). The final SCDF for TMI was found to be 3.21E-5/year (Reference 11), which is less than the Commission's Safety Goal subsidiary objective of 1E-4/year (Reference 19). Based on the SCDF value, it may be qualitatively concluded that the plant has adequate seismic margin beyond the design basis. Additionally, improvements were made to TMI based on the TMI IPEEE seismic

evaluation, as confirmed in the NTTF 2.3 seismic walkdown reports (References 12 and 25), to further enhance the TMI seismic margin.

6 Conclusions

In accordance with the 50.54(f) letter (Reference 1), a seismic hazard and screening evaluation was performed for TMI. This evaluation followed the SPID guidance (Reference 3) in order to develop a site GMRS for the purpose of screening the plant in accordance with the SPID. The new GMRS does not constitute a change in the plant design or licensing basis as described in the NRC letter dated February 20, 2014 (Reference 13).

The screening evaluation comparison demonstrates that the GMRS spectral acceleration exceeds that of the SSE at spectral frequencies above approximately 8.0 Hz. Based on the screening evaluation, TMI screens in for a risk evaluation and a Spent Fuel Pool Integrity evaluation in accordance with the SPID, Sections 3 and 7 (Reference 3). Since the GMRS spectral acceleration exceeds that of the SSE in the frequency range above 10 Hz, high-frequency exceedances can be addressed as part of the risk evaluation for TMI. As an interim action/assessment, an ESEP will be performed for TMI in conformance with the "Augmented Approach" guidance document (Reference 4). This is an interim action to establish beyond-design-basis safety margin prior to completion of the risk evaluation. Actions to address NTTF 2.1: Seismic for CEUS nuclear plants are outlined in the schedule provided in the April 9, 2013 letter from the industry to the NRC (Reference 5), as agreed to by the NRC in the May 7, 2013 letter to the industry (Reference 20).

7 References

1. NRC (E. Leeds and M. Johnson) Letter to All Power Reactor Licensees et al., *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. Title 10 Code of Federal Regulations Part 50, *Domestic Licensing of Production and Utilization Facilities.*

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

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

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

6. EPRI 1021097 (NUREG-2115), *Central and Eastern United States Seismic Source Characterization for Nuclear Facilities*, Palo Alto, CA, January 2012.

7. EPRI 3002000717, *EPRI (2004, 2006) Ground-Motion Model (GMM) Review Project*, Palo Alto, CA, June 2013.

8. NRC Japan Lessons-Learned Project Directorate Interim Staff Guidance JLD-ISG-2012-04, Revision 0, *Guidance on Performing a Seismic Margin Assessment in Response to the March 2012 Request for Information Letter*, November 2012.

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, 1997.

10. Exelon Generation Company, *Three Mile Island Nuclear Station, Unit 1, Updated Final Safety Analysis Report (UFSAR)*, Revision 22.

11. GPU Nuclear Corporation, *Three Mile Island Nuclear Station, Unit 1, Individual Plant Examination for External Events (IPEEE)*, December 1994.

12. Exelon Generation Company Letter to the NRC, *Exelon Generation Company, LLC's 180-day Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Seismic Aspects of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident*, RS-12-175, dated November 19, 2012.

13. NRC (E. Leeds) Letter to All Power Reactor Licensees et al., ML14030A046, *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.

14. EPRI 1025286, *Seismic Walkdown Guidance for Resolution of Fukushima Near-Term Task Force Recommendation 2.3: Seismic*, Palo Alto, CA, June 2012.

15. 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 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident*, RS-13-102, dated April 29, 2013.

16. EPRI RSM-112013-027, *Three Mile Island Seismic Hazard and Screening Report*, dated November 27, 2013.

17. SGH Report No. 128018-R-01, Revision 1, *Review of Existing Site Response Parameter Data for the Exelon Nuclear Fleet*, dated July 17, 2012.

18. NRC Regulatory Guide 1.208, *A performance-based approach to define the site-specific earthquake ground motion*, 2007.

19. NRC Memorandum (from P. Hiland to B. Sheron), ML100270582, "Safety/Risk Assessment Results for Generic Issue 199, Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants," dated September 2, 2010.

20. NRC (E. Leeds) Letter to NEI (J. Pollock), ML13106A331, *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.

21. EPRI NP-7498, *Industry Approach to Seismic Severe Accident Policy Implementation,* Palo Alto, CA, November 1991.

22. EPRI 1015108, *Program on Technology Innovation: The Effects of High-Frequency Ground Motion on Structures, Components, and Equipment in Nuclear Power Plants,* Palo Alto, CA, June 2007.

23. EPRI 1015109, *Program on Technology Innovation: Seismic Screening of Components Sensitive to High-Frequency Vibratory Motions,* Palo Alto, CA, October 2007.

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

25. Exelon Generation Company, *Seismic Walkdown Report In Response to the 50.54(f) Information Request Regarding Fukushima Near-Term Task Force Recommendation 2.3: Seismic, Updated Transmittal #1 (Annex A) for the Three Mile Island Generating Station Unit 1*, RS-14-032, February 2014.

A

Additional Tables

Table A-1a Mean and fractile seismic hazard curves for PGA at TMI, 5% of critical damping

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.87E-02	1.67E-02	3.05E-02	3.95E-02	4.77E-02	5.35E-02
0.001	2.76E-02	1.05E-02	2.04E-02	2.72E-02	3.63E-02	4.19E-02
0.005	7.43E-03	3.05E-03	4.70E-03	6.73E-03	9.51E-03	1.57E-02
0.01	3.60E-03	1.51E-03	2.10E-03	3.19E-03	4.50E-03	8.72E-03
0.015	2.24E-03	8.72E-04	1.23E-03	1.92E-03	2.88E-03	5.83E-03
0.03	9.20E-04	2.72E-04	4.01E-04	7.34E-04	1.32E-03	2.64E-03
0.05	4.60E-04	1.02E-04	1.67E-04	3.47E-04	7.13E-04	1.36E-03
0.075	2.60E-04	4.98E-05	8.47E-05	1.90E-04	4.19E-04	7.55E-04
0.1	1.71E-04	3.05E-05	5.35E-05	1.23E-04	2.76E-04	4.90E-04
0.15	9.09E-05	1.49E-05	2.72E-05	6.45E-05	1.49E-04	2.60E-04
0.3	2.69E-05	3.47E-06	7.03E-06	1.82E-05	4.43E-05	7.77E-05
0.5	9.40E-06	8.60E-07	2.01E-06	5.91E-06	1.60E-05	2.92E-05
0.75	3.67E-06	2.19E-07	6.00E-07	2.13E-06	6.45E-06	1.23E-05
1.	1.77E-06	6.93E-08	2.19E-07	9.11E-07	3.09E-06	6.26E-06
1.5	5.76E-07	1.05E-08	4.31E-08	2.42E-07	9.93E-07	2.22E-06
3.	6.26E-08	2.35E-10	1.46E-09	1.53E-08	9.65E-08	2.64E-07
5.	9.03E-09	7.45E-11	1.40E-10	1.38E-09	1.18E-08	4.01E-08
7.5	1.57E-09	5.05E-11	9.93E-11	2.04E-10	1.79E-09	7.23E-09
10.	4.00E-10	5.05E-11	6.09E-11	1.11E-10	4.63E-10	1.90E-09

Table A-1b Mean and fractile seismic hazard curves for 25 Hz at TMI, 5% of critical damping

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.19E-02	2.19E-02	3.52E-02	4.19E-02	4.98E-02	5.58E-02
0.001	3.17E-02	1.46E-02	2.49E-02	3.14E-02	3.95E-02	4.63E-02
0.005	1.05E-02	4.77E-03	7.13E-03	9.65E-03	1.31E-02	2.13E-02
0.01	5.73E-03	2.64E-03	3.68E-03	5.20E-03	7.03E-03	1.27E-02
0.015	3.83E-03	1.77E-03	2.39E-03	3.47E-03	4.77E-03	8.60E-03
0.03	1.72E-03	6.83E-04	9.65E-04	1.51E-03	2.29E-03	3.90E-03
0.05	8.84E-04	2.80E-04	4.25E-04	7.55E-04	1.27E-03	2.04E-03
0.075	5.08E-04	1.31E-04	2.13E-04	4.19E-04	7.77E-04	1.20E-03
0.1	3.41E-04	7.66E-05	1.31E-04	2.76E-04	5.35E-04	8.35E-04
0.15	1.92E-04	3.79E-05	6.73E-05	1.51E-04	3.14E-04	4.90E-04
0.3	6.83E-05	1.15E-05	2.19E-05	5.20E-05	1.15E-04	1.79E-04
0.5	2.92E-05	4.37E-06	8.72E-06	2.16E-05	4.98E-05	8.00E-05
0.75	1.38E-05	1.77E-06	3.73E-06	9.93E-06	2.35E-05	3.90E-05
1.	7.70E-06	8.60E-07	1.90E-06	5.27E-06	1.32E-05	2.25E-05
1.5	3.12E-06	2.72E-07	6.45E-07	1.98E-06	5.50E-06	9.65E-06
3.	5.13E-07	2.35E-08	6.73E-08	2.64E-07	8.98E-07	1.82E-06
5.	1.07E-07	2.53E-09	8.60E-09	4.31E-08	1.84E-07	4.13E-07
7.5	2.61E-08	3.73E-10	1.38E-09	8.00E-09	4.37E-08	1.08E-07
10.	8.78E-09	1.32E-10	3.57E-10	2.16E-09	1.40E-08	3.73E-08

Table A-1c Mean and fractile seismic hazard curves for 10 Hz at TMI, 5% of critical damping

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.78E-02	3.57E-02	4.13E-02	4.77E-02	5.50E-02	6.00E-02
0.001	3.91E-02	2.49E-02	3.23E-02	3.90E-02	4.63E-02	5.20E-02
0.005	1.42E-02	7.03E-03	1.01E-02	1.36E-02	1.82E-02	2.35E-02
0.01	7.53E-03	3.68E-03	5.05E-03	7.13E-03	9.65E-03	1.36E-02
0.015	4.98E-03	2.42E-03	3.28E-03	4.70E-03	6.36E-03	9.37E-03
0.03	2.29E-03	1.07E-03	1.44E-03	2.13E-03	2.96E-03	4.50E-03
0.05	1.22E-03	4.98E-04	7.03E-04	1.11E-03	1.67E-03	2.42E-03
0.075	7.14E-04	2.53E-04	3.73E-04	6.36E-04	1.04E-03	1.46E-03
0.1	4.82E-04	1.51E-04	2.32E-04	4.19E-04	7.23E-04	1.01E-03
0.15	2.72E-04	7.13E-05	1.16E-04	2.32E-04	4.25E-04	6.00E-04
0.3	9.39E-05	1.98E-05	3.52E-05	7.66E-05	1.55E-04	2.25E-04
0.5	3.90E-05	7.03E-06	1.32E-05	3.05E-05	6.54E-05	9.79E-05
0.75	1.78E-05	2.76E-06	5.50E-06	1.36E-05	3.05E-05	4.70E-05
1.	9.73E-06	1.27E-06	2.68E-06	7.13E-06	1.69E-05	2.68E-05
1.5	3.82E-06	3.57E-07	8.47E-07	2.57E-06	6.83E-06	1.15E-05
3.	6.16E-07	2.10E-08	6.83E-08	3.14E-07	1.10E-06	2.22E-06
5.	1.31E-07	1.44E-09	6.64E-09	5.05E-08	2.29E-07	5.20E-07
7.5	3.32E-08	1.74E-10	8.47E-10	9.65E-09	5.66E-08	1.42E-07
10.	1.15E-08	1.01E-10	2.13E-10	2.64E-09	1.87E-08	5.12E-08

Table A-1d Mean and fractile seismic hazard curves for 5 Hz at TMI, 5% of critical damping

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.94E-02	3.79E-02	4.25E-02	4.90E-02	5.66E-02	6.17E-02
0.001	4.18E-02	2.72E-02	3.37E-02	4.19E-02	4.98E-02	5.50E-02
0.005	1.56E-02	7.13E-03	1.07E-02	1.51E-02	2.10E-02	2.49E-02
0.01	7.70E-03	3.42E-03	4.98E-03	7.23E-03	1.07E-02	1.29E-02
0.015	4.77E-03	2.16E-03	3.05E-03	4.50E-03	6.64E-03	8.23E-03
0.03	1.93E-03	8.72E-04	1.21E-03	1.82E-03	2.64E-03	3.42E-03
0.05	9.37E-04	3.84E-04	5.50E-04	8.72E-04	1.31E-03	1.74E-03
0.075	5.15E-04	1.82E-04	2.72E-04	4.70E-04	7.55E-04	1.01E-03
0.1	3.33E-04	1.04E-04	1.62E-04	2.96E-04	5.05E-04	6.83E-04
0.15	1.76E-04	4.63E-05	7.66E-05	1.53E-04	2.80E-04	3.84E-04
0.3	5.47E-05	1.13E-05	2.04E-05	4.50E-05	8.98E-05	1.31E-04
0.5	2.09E-05	3.68E-06	7.03E-06	1.64E-05	3.52E-05	5.27E-05
0.75	9.02E-06	1.32E-06	2.68E-06	6.73E-06	1.53E-05	2.46E-05
1.	4.71E-06	5.91E-07	1.27E-06	3.37E-06	8.00E-06	1.34E-05
1.5	1.74E-06	1.64E-07	3.90E-07	1.16E-06	3.01E-06	5.35E-06
3.	2.49E-07	1.10E-08	3.28E-08	1.32E-07	4.37E-07	8.85E-07
5.	4.78E-08	9.79E-10	3.42E-09	1.90E-08	8.23E-08	1.90E-07
7.5	1.11E-08	1.62E-10	4.90E-10	3.23E-09	1.79E-08	4.77E-08
10.	3.63E-09	9.37E-11	1.55E-10	8.60E-10	5.50E-09	1.62E-08

Table A-1e Mean and fractile seismic hazard curves for 2.5 Hz at TMI, 5% of critical damping

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.65E-02	3.42E-02	3.90E-02	4.63E-02	5.42E-02	5.91E-02
0.001	3.71E-02	2.32E-02	2.84E-02	3.68E-02	4.63E-02	5.20E-02
0.005	1.14E-02	5.05E-03	7.13E-03	1.08E-02	1.60E-02	1.95E-02
0.01	4.90E-03	2.04E-03	2.88E-03	4.50E-03	7.03E-03	9.11E-03
0.015	2.73E-03	1.10E-03	1.55E-03	2.49E-03	3.90E-03	5.27E-03
0.03	8.98E-04	3.33E-04	4.83E-04	8.12E-04	1.31E-03	1.79E-03
0.05	3.76E-04	1.20E-04	1.84E-04	3.33E-04	5.66E-04	7.89E-04
0.075	1.84E-04	4.98E-05	8.12E-05	1.57E-04	2.88E-04	4.13E-04
0.1	1.10E-04	2.60E-05	4.43E-05	9.11E-05	1.74E-04	2.60E-04
0.15	5.26E-05	1.04E-05	1.87E-05	4.13E-05	8.60E-05	1.34E-04
0.3	1.38E-05	1.90E-06	3.90E-06	9.93E-06	2.32E-05	3.95E-05
0.5	4.75E-06	4.70E-07	1.08E-06	3.14E-06	8.12E-06	1.49E-05
0.75	1.90E-06	1.34E-07	3.42E-07	1.15E-06	3.33E-06	6.36E-06
1.	9.49E-07	5.05E-08	1.42E-07	5.27E-07	1.67E-06	3.33E-06
1.5	3.30E-07	1.10E-08	3.57E-08	1.60E-07	5.83E-07	1.23E-06
3.	4.22E-08	5.50E-10	2.16E-09	1.38E-08	7.13E-08	1.79E-07
5.	7.25E-09	1.11E-10	2.42E-10	1.60E-09	1.08E-08	3.28E-08
7.5	1.52E-09	6.09E-11	1.11E-10	2.84E-10	1.98E-09	6.93E-09
10.	4.54E-10	5.05E-11	6.64E-11	1.23E-10	5.66E-10	2.07E-09

Table A-1f Mean and fractile seismic hazard curves for 1 Hz at TMI, 5% of critical damping

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.45E-02	1.84E-02	2.46E-02	3.47E-02	4.37E-02	4.98E-02
0.001	2.37E-02	1.08E-02	1.57E-02	2.35E-02	3.14E-02	3.73E-02
0.005	5.81E-03	1.84E-03	3.05E-03	5.35E-03	8.60E-03	1.13E-02
0.01	2.35E-03	6.00E-04	1.04E-03	2.01E-03	3.63E-03	5.35E-03
0.015	1.23E-03	2.84E-04	4.98E-04	1.01E-03	1.92E-03	3.05E-03
0.03	3.41E-04	6.45E-05	1.18E-04	2.60E-04	5.50E-04	9.24E-04
0.05	1.19E-04	1.92E-05	3.63E-05	8.60E-05	1.98E-04	3.37E-04
0.075	5.07E-05	7.03E-06	1.36E-05	3.47E-05	8.60E-05	1.51E-04
0.1	2.78E-05	3.33E-06	6.73E-06	1.79E-05	4.70E-05	8.60E-05
0.15	1.20E-05	1.13E-06	2.46E-06	7.13E-06	2.04E-05	3.95E-05
0.3	2.88E-06	1.57E-07	4.07E-07	1.44E-06	4.83E-06	1.07E-05
0.5	9.71E-07	3.01E-08	9.24E-08	4.07E-07	1.62E-06	3.90E-06
0.75	3.90E-07	6.93E-09	2.49E-08	1.34E-07	6.45E-07	1.67E-06
1.	1.97E-07	2.22E-09	8.98E-09	5.66E-08	3.14E-07	8.72E-07
1.5	7.02E-08	4.37E-10	1.84E-09	1.49E-08	1.04E-07	3.23E-07
3.	9.61E-09	9.24E-11	1.51E-10	1.11E-09	1.10E-08	4.43E-08
5.	1.79E-09	5.05E-11	8.98E-11	1.72E-10	1.57E-09	7.77E-09
7.5	4.05E-10	5.05E-11	6.09E-11	1.11E-10	3.28E-10	1.64E-09
10.	1.30E-10	5.05E-11	5.12E-11	1.11E-10	1.42E-10	5.27E-10

Table A-1g Mean and fractile seismic hazard curves for 0.5 Hz at TMI, 5% of critical damping

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	1.84E-02	9.24E-03	1.29E-02	1.79E-02	2.39E-02	2.88E-02
0.001	1.12E-02	4.83E-03	7.13E-03	1.07E-02	1.51E-02	1.90E-02
0.005	2.29E-03	4.70E-04	8.85E-04	1.92E-03	3.68E-03	5.42E-03
0.01	8.27E-04	1.13E-04	2.35E-04	6.09E-04	1.40E-03	2.35E-03
0.015	4.02E-04	4.43E-05	9.51E-05	2.68E-04	6.93E-04	1.25E-03
0.03	9.62E-05	7.77E-06	1.74E-05	5.50E-05	1.69E-04	3.28E-04
0.05	3.05E-05	1.98E-06	4.56E-06	1.53E-05	5.50E-05	1.11E-04
0.075	1.22E-05	6.45E-07	1.55E-06	5.58E-06	2.16E-05	4.70E-05
0.1	6.52E-06	2.80E-07	7.13E-07	2.72E-06	1.11E-05	2.64E-05
0.15	2.76E-06	8.12E-08	2.35E-07	9.93E-07	4.50E-06	1.21E-05
0.3	6.55E-07	7.89E-09	2.96E-08	1.67E-07	9.37E-07	3.19E-06
0.5	2.20E-07	1.15E-09	5.27E-09	3.84E-08	2.80E-07	1.13E-06
0.75	8.82E-08	2.57E-10	1.18E-09	1.04E-08	9.65E-08	4.63E-07
1.	4.45E-08	1.23E-10	3.95E-10	3.79E-09	4.25E-08	2.32E-07
1.5	1.60E-08	7.45E-11	1.27E-10	8.35E-10	1.16E-08	7.89E-08
3.	2.24E-09	5.05E-11	6.09E-11	1.16E-10	9.93E-10	9.37E-09
5.	4.29E-10	5.05E-11	5.35E-11	1.11E-10	1.77E-10	1.49E-09
7.5	1.00E-10	5.05E-11	5.05E-11	1.01E-10	1.11E-10	3.28E-10
10.	3.28E-11	5.05E-11	5.05E-11	1.01E-10	1.11E-10	1.51E-10

Table A-2 Amplification functions for TMI, 5% of critical damping

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	1.18E+00	4.08E-02	1.30E-02	1.02E+00	4.81E-02	1.90E-02	1.13E+00	8.84E-02	2.09E-02	1.28E+00	9.44E-02
4.95E-02	9.83E-01	5.22E-02	1.02E-01	7.59E-01	9.54E-02	9.99E-02	1.08E+00	1.05E-01	8.24E-02	1.26E+00	9.88E-02
9.64E-02	9.13E-01	5.65E-02	2.13E-01	7.13E-01	1.07E-01	1.85E-01	1.07E+00	1.08E-01	1.44E-01	1.25E+00	9.99E-02
1.94E-01	8.56E-01	6.08E-02	4.43E-01	6.77E-01	1.15E-01	3.56E-01	1.04E+00	1.11E-01	2.65E-01	1.23E+00	1.02E-01
2.92E-01	8.26E-01	6.33E-02	6.76E-01	6.57E-01	1.19E-01	5.23E-01	1.03E+00	1.13E-01	3.84E-01	1.22E+00	1.03E-01
3.91E-01	8.05E-01	6.51E-02	9.09E-01	6.41E-01	1.21E-01	6.90E-01	1.01E+00	1.15E-01	5.02E-01	1.21E+00	1.04E-01
4.93E-01	7.89E-01	6.64E-02	1.15E+00	6.29E-01	1.23E-01	8.61E-01	1.00E+00	1.16E-01	6.22E-01	1.20E+00	1.05E-01
7.41E-01	7.61E-01	6.82E-02	1.73E+00	6.05E-01	1.26E-01	1.27E+00	9.74E-01	1.17E-01	9.13E-01	1.19E+00	1.07E-01
1.01E+00	7.40E-01	6.96E-02	2.36E+00	5.86E-01	1.29E-01	1.72E+00	9.52E-01	1.18E-01	1.22E+00	1.17E+00	1.08E-01
1.28E+00	7.24E-01	7.03E-02	3.01E+00	5.70E-01	1.31E-01	2.17E+00	9.31E-01	1.18E-01	1.54E+00	1.16E+00	1.10E-01
1.55E+00	7.10E-01	7.08E-02	3.63E+00	5.57E-01	1.32E-01	2.61E+00	9.14E-01	1.19E-01	1.85E+00	1.14E+00	1.11E-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	1.20E+00	8.27E-02	1.27E-02	1.48E+00	9.94E-02	8.25E-03	1.41E+00	9.51E-02
7.05E-02	1.19E+00	8.34E-02	3.43E-02	1.47E+00	9.67E-02	1.96E-02	1.40E+00	9.18E-02
1.18E-01	1.18E+00	8.39E-02	5.51E-02	1.46E+00	9.56E-02	3.02E-02	1.40E+00	9.07E-02
2.12E-01	1.18E+00	8.49E-02	9.63E-02	1.46E+00	9.47E-02	5.11E-02	1.40E+00	9.00E-02
3.04E-01	1.17E+00	8.57E-02	1.36E-01	1.46E+00	9.45E-02	7.10E-02	1.40E+00	8.97E-02
3.94E-01	1.17E+00	8.62E-02	1.75E-01	1.47E+00	9.45E-02	9.06E-02	1.40E+00	8.97E-02
4.86E-01	1.17E+00	8.67E-02	2.14E-01	1.47E+00	9.46E-02	1.10E-01	1.40E+00	8.97E-02
7.09E-01	1.16E+00	8.73E-02	3.10E-01	1.47E+00	9.51E-02	1.58E-01	1.41E+00	8.98E-02
9.47E-01	1.16E+00	8.81E-02	4.12E-01	1.48E+00	9.54E-02	2.09E-01	1.41E+00	9.01E-02
1.19E+00	1.15E+00	8.90E-02	5.18E-01	1.48E+00	9.58E-02	2.62E-01	1.41E+00	9.05E-02
1.43E+00	1.15E+00	9.05E-02	6.19E-01	1.48E+00	9.59E-02	3.12E-01	1.41E+00	9.14E-02

Tables A2-b1 and A2-b2 are tabular versions of the typical amplification factors provided in Figures 2.3.6-1 and 2.3.6-2. Values are provided for two input motion levels at approximately 1E-4 and 1E-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, and 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 A2-b1. Median AFs and sigmas for Model 1, Profile 1, for 2 PGA levels

M1P1K1	Rock PGA=0.194			M1P1K1	PGA=0.741		
Freq (Hz)	Soil SA	Median AF	Sigma ln(AF)	Freq (Hz)	Soil SA	Median AF	Sigma ln(AF)
100.0	0.169	0.869	0.066	100.0	0.532	0.719	0.082
87.1	0.170	0.853	0.067	87.1	0.535	0.700	0.083
75.9	0.171	0.824	0.068	75.9	0.539	0.666	0.084
66.1	0.174	0.769	0.069	66.1	0.546	0.605	0.087
57.5	0.181	0.681	0.074	57.5	0.560	0.515	0.093
50.1	0.192	0.601	0.085	50.1	0.587	0.442	0.105
43.7	0.208	0.551	0.101	43.7	0.624	0.397	0.122
38.0	0.228	0.549	0.105	38.0	0.673	0.395	0.133
33.1	0.248	0.564	0.105	33.1	0.728	0.411	0.132
28.8	0.269	0.611	0.121	28.8	0.791	0.453	0.145
25.1	0.289	0.652	0.136	25.1	0.856	0.493	0.158
21.9	0.307	0.727	0.137	21.9	0.912	0.561	0.161
19.1	0.329	0.788	0.132	19.1	0.978	0.619	0.162
16.6	0.350	0.874	0.131	16.6	1.051	0.702	0.158
14.5	0.361	0.943	0.124	14.5	1.110	0.785	0.151
12.6	0.371	0.994	0.110	12.6	1.145	0.842	0.130
11.0	0.374	1.026	0.112	11.0	1.170	0.891	0.124
9.5	0.371	1.066	0.125	9.5	1.164	0.937	0.132
8.3	0.369	1.151	0.126	8.3	1.157	1.019	0.138
7.2	0.368	1.223	0.109	7.2	1.164	1.103	0.120
6.3	0.362	1.282	0.090	6.3	1.173	1.192	0.106
5.5	0.349	1.291	0.095	5.5	1.135	1.217	0.100
4.8	0.331	1.252	0.101	4.8	1.069	1.179	0.111
4.2	0.315	1.228	0.082	4.2	1.025	1.173	0.093
3.6	0.299	1.199	0.073	3.6	0.980	1.160	0.080
3.2	0.282	1.199	0.090	3.2	0.927	1.171	0.083
2.8	0.265	1.188	0.098	2.8	0.885	1.184	0.100
2.4	0.252	1.224	0.068	2.4	0.845	1.231	0.076
2.1	0.233	1.246	0.079	2.1	0.787	1.266	0.088
1.8	0.221	1.319	0.077	1.8	0.744	1.345	0.072
1.6	0.198	1.361	0.098	1.6	0.663	1.389	0.099
1.4	0.185	1.478	0.074	1.4	0.615	1.505	0.070
1.2	0.163	1.481	0.081	1.2	0.539	1.506	0.080
1.0	0.146	1.469	0.100	1.0	0.478	1.489	0.100
0.91	0.135	1.492	0.076	0.91	0.437	1.507	0.074
0.79	0.120	1.471	0.095	0.79	0.386	1.483	0.092
0.69	0.103	1.416	0.076	0.69	0.328	1.426	0.076
0.60	0.091	1.431	0.071	0.60	0.286	1.438	0.071
0.52	0.078	1.449	0.075	0.52	0.245	1.455	0.075
0.46	0.065	1.429	0.058	0.46	0.200	1.433	0.059
0.10	0.003	1.346	0.037	0.10	0.008	1.337	0.039

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

M2P1K1	PGA=0.194			M2P1K1	PGA=0.741		
Freq (Hz)	Soil SA	Median AF	Sigma ln(AF)	Freq (Hz)	Soil SA	Median AF	Sigma ln(AF)
100.0	0.179	0.925	0.050	100.0	0.646	0.872	0.053
87.1	0.181	0.909	0.050	87.1	0.652	0.853	0.053
75.9	0.183	0.880	0.050	75.9	0.662	0.818	0.053
66.1	0.187	0.825	0.050	66.1	0.681	0.754	0.053
57.5	0.195	0.737	0.050	57.5	0.720	0.661	0.054
50.1	0.210	0.659	0.054	50.1	0.789	0.594	0.061
43.7	0.232	0.615	0.067	43.7	0.886	0.564	0.077
38.0	0.257	0.620	0.070	38.0	0.995	0.584	0.079
33.1	0.281	0.640	0.081	33.1	1.087	0.613	0.089
28.8	0.303	0.690	0.110	28.8	1.168	0.669	0.119
25.1	0.325	0.733	0.131	25.1	1.241	0.716	0.139
21.9	0.342	0.811	0.126	21.9	1.295	0.797	0.132
19.1	0.365	0.875	0.111	19.1	1.367	0.865	0.115
16.6	0.385	0.961	0.119	16.6	1.429	0.955	0.122
14.5	0.393	1.024	0.113	14.5	1.440	1.019	0.116
12.6	0.399	1.070	0.103	12.6	1.448	1.065	0.104
11.0	0.400	1.100	0.109	11.0	1.439	1.096	0.110
9.5	0.395	1.135	0.120	9.5	1.406	1.131	0.121
8.3	0.391	1.218	0.114	8.3	1.379	1.214	0.115
7.2	0.386	1.283	0.101	7.2	1.350	1.280	0.101
6.3	0.376	1.331	0.081	6.3	1.306	1.328	0.081
5.5	0.360	1.334	0.092	5.5	1.242	1.332	0.092
4.8	0.342	1.293	0.100	4.8	1.170	1.290	0.100
4.2	0.323	1.258	0.078	4.2	1.098	1.256	0.078
3.6	0.305	1.222	0.075	3.6	1.031	1.220	0.075
3.2	0.285	1.214	0.089	3.2	0.960	1.212	0.088
2.8	0.267	1.196	0.096	2.8	0.893	1.194	0.095
2.4	0.253	1.228	0.062	2.4	0.842	1.226	0.062
2.1	0.233	1.245	0.073	2.1	0.773	1.243	0.072
1.8	0.221	1.318	0.078	1.8	0.728	1.315	0.078
1.6	0.197	1.357	0.096	1.6	0.647	1.355	0.095
1.4	0.184	1.474	0.076	1.4	0.601	1.470	0.075
1.2	0.163	1.477	0.081	1.2	0.527	1.473	0.080
1.0	0.146	1.466	0.100	1.0	0.469	1.462	0.099
0.91	0.135	1.490	0.077	0.91	0.431	1.485	0.076
0.79	0.120	1.469	0.095	0.79	0.382	1.465	0.094
0.69	0.103	1.415	0.076	0.69	0.325	1.412	0.075
0.60	0.091	1.430	0.071	0.60	0.284	1.427	0.070
0.52	0.078	1.448	0.075	0.52	0.243	1.445	0.074
0.46	0.065	1.428	0.058	0.46	0.199	1.426	0.058
0.10	0.003	1.347	0.037	0.10	0.008	1.334	0.040

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)
1. Three Mile Island Nuclear Station, Unit 1, will perform a Risk Evaluation including a High Frequency Confirmation evaluation.	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
2. Three Mile Island Nuclear Station, Unit 1, will perform a Spent Fuel Pool evaluation in accordance with EPRI Report 1025287, Section 7.	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
3. Three Mile Island Nuclear Station, Unit 1, will prepare an Expedited Seismic Evaluation Process (ESEP) Report in accordance with EPRI Report 3002000704.	December 31, 2014	Yes	No