UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

April 20, 2015

Mr. John A. Dent, Jr.
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Pilgrim Nuclear Power Station
600 Rocky Hill Road
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SUBJECT: PILGRIM NUCLEAR POWER STATION - STAFF ASSESSMENT OF INFORMATION PROVIDED PURSUANT TO TITLE 10 OF THE *CODE OF FEDERAL REGULATIONS* PART 50, SECTION 50.54(f), SEISMIC HAZARD REEVALUATIONS RELATING TO RECOMMENDATION 2.1 OF THE NEAR-TERM TASK FORCE REVIEW OF INSIGHTS FROM THE FUKUSHIMA DAI-ICHI ACCIDENT (TAC NO. MF3967)

Dear Mr. Dent:

By letter dated March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued a request for information pursuant to Title 10 of the *Code of Federal Regulations*, Part 50, Section 50.54(f) (hereafter referred to as the 50.54(f) letter). The purpose of that request was to gather information concerning, in part, seismic hazards at each operating reactor site and to enable the NRC staff, using present-day NRC requirements and guidance, to determine whether licenses should be modified, suspended, or revoked.

By letter dated March 31, 2014, Entergy Nuclear Generation Company (Entergy) responded to this request for Pilgrim Nuclear Power Station (PNPS).

The NRC staff has reviewed the information provided related to the reevaluated seismic hazards for PNPS and, as documented in the enclosed staff assessment, determined that you provided sufficient information in response to Requested Information Items (1) – (3), (5), (7), and a partial response to Item (4), identified in Enclosure 1 of the 50.54(f) letter. Further, the staff concludes that the licensee's reevaluated seismic hazard for PNPS is suitable for other activities associated with NRC Near-Term Task Force Recommendation 2.1, "Seismic."

Contingent upon the NRC's review and acceptance of Entergy's expedited seismic evaluation process, and seismic risk evaluation including the high frequency and spent fuel pool evaluations (i.e., Items (4), (6), (8), and (9)) for PNPS, the sesimc hazard evaluation identified in Enclosure 1 of the 50.54(f) letter will be complete.

If you have any questions, please contact me at (301) 415-6197 or via e-mail at Tekia.Govan@nrc.gov.

Sincerely,

Tekia Govan, Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket No. 50-293

Enclosure:
Staff Assessment of Seismic
Hazard Evaluation and Screening Report

cc w/encl: Distribution via Listserv

STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO SEISMIC HAZARD AND SCREENING REPORT

PILGRIM NUCLEAR POWER STATION

DOCKET NO. 50-293

1.0 INTRODUCTION

By letter dated March 12, 2012 (NRC, 2012a), the U.S. Nuclear Regulatory Commission (NRC or Commission) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f) "Conditions of license" (hereafter referred to as the "50.54(f) letter"). The request and other regulatory actions were issued in connection with implementing lessons-learned from the 2011 accident at the Fukushima Dai-ichi nuclear power plant, as documented in the "Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident" (NRC, 2011b).[1] In particular, the NRC Near-Term Task Force (NTTF) Recommendation 2.1, and subsequent Staff Requirements Memoranda associated with Commission Papers SECY-11-0124 (NRC, 2011c) and SECY-11-0137 (NRC, 2011d), instructed the NRC staff to issue requests for information to licensees pursuant to 10 CFR 50.54(f).

Enclosure 1 to the 50.54(f) letter requests that addressees perform a reevaluation of the seismic hazards at their sites using present-day NRC requirements and guidance to develop a ground motion response spectrum (GMRS).

The required response section of Enclosure 1 requests that each addressee provide the following information:

(1) Site-specific hazard curves (common fractiles and mean) over a range of spectral frequencies and annual exceedance frequencies,

(2) Site-specific, performance-based GMRS developed from the new site-specific seismic hazard curves at the control point elevation,

(3) Safe Shutdown Earthquake (SSE) ground motion values including specification of the control point elevation,

(4) Comparison of the GMRS and SSE (If the GMRS is completely bounded by the SSE, an interim action plan or risk evaluation is not necessary. However if the GMRS exceeds the

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[1] Issued as an enclosure to Commission Paper SECY-11-0093 (NRC, 2011a).

SSE only at higher frequencies, information related to the functionality of high-frequency sensitive SSCs is requested),

(5) Additional information such as insights from NTTF Recommendation 2.3 walkdown and estimates of plant seismic capacity developed from previous risk assessments to inform NRC screening and prioritization,

(6) 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 (if necessary),

(7) Statement if a seismic risk evaluation is necessary,

(8) Seismic risk evaluation (if necessary), and

(9) Spent fuel pool (SFP) evaluation (if necessary).

Present-day NRC requirements and guidance with respect to characterizing seismic hazards use a probabilistic approach in order to develop a risk-informed performance-based GMRS for the site. Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion," describes this approach. As described in the 50.54(f) letter, if the reevaluated seismic hazard, as characterized by the GMRS, is not bounded by the current plant design-basis SSE, further seismic risk evaluation of the plant is merited.

By letter dated November 27, 2012 (Keithline, 2012), the Nuclear Energy Institute (NEI) submitted Electric Power Research Institute (EPRI) report "Seismic Evaluation Guidance: Screening, Prioritization, and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1 Seismic" (EPRI, 2012), hereafter called the SPID. The SPID supplements the 50.54(f) letter with guidance necessary to perform seismic reevaluations and report the results to the NRC in a manner that will address the Requested Information Items in Enclosure 1 of the 50.54(f) letter. By letter dated February 15, 2013 (NRC, 2013b), the NRC staff endorsed the SPID.

The required response section of Enclosure 1 to the 50.54(f) letter specifies that Central and Eastern United States (CEUS) licensees provide their Seismic Hazard and Screening Report (SHSR) by 1.5 years after issuance of the 50.54(f) letter. However, in order to complete its update of the EPRI seismic ground motion models (GMM) for the CEUS (EPRI, 2013), industry proposed a six-month extension to March 31, 2014, for submitting the SHSR. Industry also proposed that licensees perform an expedited assessment, referred to as the Augmented Approach, for addressing the requested interim evaluation (Item 6 above), which would use a simplified assessment to demonstrate that certain key pieces of plant equipment for core cooling and containment functions, given a loss of all alternating current power, would be able to withstand a seismic hazard up to two times the design-basis. Attachment 2 to the April 9, 2013, letter (Pietrangelo, 2013) provides a revised schedule for plants needing to perform (1) the Augmented Approach by implementing the Expedited Seismic Evaluation Process (ESEP) and (2) a seismic risk evaluation. By letter dated May 7, 2013 (NRC, 2013a), the NRC determined that the modified schedule was acceptable and by letter dated August 28, 2013 (NRC, 2013c), the NRC determined that the updated GMM (EPRI, 2013) is an acceptable ground motion model for use by CEUS plants in developing a plant-specific GMRS.

By letter dated April 9, 2013 (Pietrangelo, 2013), industry committed to following the SPID to develop the Seismic Hazard and Screening Report (SHSR) for existing nuclear power plants. By letter dated September 12, 2013 (Dent, 2013), Entergy Nuclear Operations, Inc. (Entergy, the licensee) submitted partial site response information for the Pilgrim Nuclear Power Station (Pilgrim, PNPS). By letter dated March 31, 2014 (Dent, 2014), Entergy submitted its SHSR for Pilgrim.

2.0 REGULATORY EVALUATION

The structures, systems, and components (SSCs) important to safety in operating nuclear power plants are designed either in accordance with, or meet the intent of Appendix A to 10 CFR Part 50, General Design Criteria (GDC) 2: "Design Bases for Protection Against Natural Phenomena;" and Appendix A to 10 CFR Part 100, "Reactor Site Criteria." GDC 2 states that SSCs important to safety at nuclear power plants shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. Plants with construction permits issued prior to May 21, 1971, were approved for construction based on the proposed general design criteria published by the Atomic Energy Commission (AEC). Specifically, Pilgrim has a license that conforms to AEC Preliminary Criterion 2, as documented in "Design Basis Document for Seismic Design."

For initial licensing, each licensee was required to develop and maintain design bases that, as defined by 10 CFR 50.2, identify the specific functions that an SSC of a facility must perform, and the specific values or ranges of values chosen for controlling parameters as reference bounds for the design. The design bases for the SSCs reflect appropriate consideration of the most severe natural phenomena that had been historically reported for the site and surrounding area. The design bases also considered limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The seismic design bases for currently operating nuclear power plants were either developed in accordance with, or meet the intent of GDC 2 and 10 CFR Part 100, Appendix A. Although the regulatory requirements in Appendix A to 10 CFR Part 100 are fundamentally deterministic, the NRC process for determining the seismic design-basis ground motions for new reactor applications after January 10, 1997, as described in 10 CFR 100.23, requires that uncertainties be addressed through an appropriate analysis such as a probabilistic seismic hazard analysis (PSHA).

Section 50.54(f) of 10 CFR states that a licensee shall at any time before expiration of its license, upon request of the Commission, submit written statements, signed under oath or affirmation, to enable the Commission to determine whether or not the license should be modified, suspended, or revoked. On March 12, 2012, the NRC staff issued requests for licensees to reevaluate the seismic hazards at their sites using present-day NRC requirements and guidance, and identify actions planned to address plant-specific vulnerabilities associated with the updated seismic hazards.

Attachment 1 to Enclosure 1 of the 50.54(f) letter describes an acceptable approach for performing the seismic hazard reevaluation for plants located in the CEUS. Licensees are expected to use the CEUS Seismic Source Characterization (CEUS-SSC) model in NUREG-2115 (NRC, 2012b) along with the appropriate EPRI (2004, 2006) GMMs. The SPID provides further guidance regarding the appropriate use of GMMs for the CEUS. Specifically, Section 2.3 of the SPID recommends the use of the updated GMM (EPRI, 2013) and, as such, licensees used the NRC-endorsed updated EPRI GMM instead of the older EPRI (2004, 2006) GMM to develop PSHA base rock hazard curves. Finally, Attachment 1 requested that licensees conduct an evaluation of the local site response in order to develop site-specific hazard curves and GMRS for comparison with the plant SSE.

2.1 Screening Evaluation Results

The licensee's SHSR indicated that the site GMRS exceeds the SSE for the PNPS over the frequency range of 1 to 10 Hertz (Hz). As such, PNPS screens-in to perform a seismic risk evaluation. The GMRS also exceeded the SSE at frequencies above 10 Hz. The licensee indicated that the risk evaluation would address the high frequency exceedance.

On May 9, 2014 (NRC, 2014), the NRC staff issued a letter providing the outcome of its 30-day screening and prioritization evaluation. As indicated in the letter, the NRC staff confirmed the licensee's screening results. The licensee's GMRS as well as the confirmatory GMRS, developed by the NRC staff, exceed the SSE for PNPS over the frequency range of 3 to 100 Hz. Therefore, PNPS screens-in for conducting a seismic risk evaluation and a high frequency confirmation. Additionally, a SFP evaluation is merited for PNPS.

3.0 TECHNICAL EVALUATION

The NRC staff evaluated the licensee's submittal to determine if the provided information responded appropriately to Enclosure 1 of the 50.54(f) letter with respect to characterizing the reevaluated seismic hazard.

3.1 Plant Seismic Design Basis

Enclosure 1 of the 50.54(f) letter requested that licensees provide the SSE ground motion values, as well as the specification of the control point elevation(s) for comparison to the GMRS. For operating reactors licensed before 1997, the SSE is the plant licensing basis earthquake and is characterized by 1) a peak ground acceleration (PGA) value which anchors the response spectra at high frequencies (typically at 33 Hz for the existing fleet of nuclear power plants; 2) a response spectrum shape which depicts the amplified response at all frequencies below the PGA; and 3) a control point where the SSE is defined.

In Section 3.1 of the SHSR, the licensee described its seismic design bases for PNPS. The licensee stated that the SSE for PNPS was developed in accordance with AEC 1967 Preliminary

Criterion 2. Based on historic seismicity of the region, the maximum postulated earthquake was determined to have an intensity of VIII on the Modified Mercalli Intensity Scale of 1931. The spectral shape for PNPS is anchored at a PGA value of 0.15 g.

The licensee specified that the SSE control point is located at the Reactor Building foundation at elevation -26 ft mean sea level based on information provided in the updated final safety analysis report (UFSAR) which states that the SSE is associated with foundation depths. The selection of the control point is consistent with guidance provided in Section 2.4.2 of the SPID to define the control point.

3.2 Probabilistic Seismic Hazard Analysis

In Section 2.2 of the SHSR, the licensee states that, in accordance with the 50.54(f) letter and the SPID, it performed a PSHA using the CEUS-SSC model and the updated EPRI GMM for the CEUS (EPRI, 2013). For its PSHA, the licensee used a minimum moment magnitude (M_w) of 5.0 as specified in the 50.54(f) letter. The licensee further stated that it included CEUS-SSC background sources out to a distance of 400 miles [640 km] and included the Charlevoix repeated large magnitude earthquake (RLME) source, the only RLME which lies within 620 miles [1,000 km] of the site. The RLME sources are those source areas or faults for which more than one large magnitude (M_w >= 6.5) earthquake has occurred in the historical or paleo-earthquake (geologic evidence for prehistoric seismicity) record. The licensee used the mid-continent version of the updated EPRI GMM (EPRI, 2013) for each of the CEUS-SSC sources. Consistent with the SPID, the licensee did not provide base rock seismic hazard curves because it performed a site response analysis to determine the control point seismic hazard curves. The licensee provided its control point seismic hazard curves in Section 2.3.7 of its SHSR. The NRC staff's review of the licensee's control point seismic hazard curves is provided in Section 3.3 of this staff assessment.

As part of its confirmatory analysis of the licensee's GMRS, the NRC staff performed PSHA calculations for the PNPS site. As input, the staff used the CEUS-SSC model, as documented in NUREG-2115 (NRC, 2012b), along with the updated EPRI GMM model (EPRI, 2013). Consistent with the guidance provided in the SPID and the licensee's approach, the staff included all CEUS-SSC background seismic sources within a 310 mi [500 km] radius of the PNPS site. In addition, the staff included all of the RLME sources within a 620 mi [1000 km] radius of the site, which includes the Charlevoix RLME source. For each of the CEUS-SSC sources used in the PSHA, the staff used the mid-continent version of the updated EPRI GMM (EPRI, 2013). The staff used the resulting base rock seismic hazard curves together with a confirmatory site response analysis, described in the next section, to develop control point seismic hazard curves and a GMRS for comparison with the licensee's results.

Based on review of the SHSR, the NRC staff concludes that the licensee appropriately followed the guidance provided in the SPID for selecting the PSHA input models and parameters for the site. This includes the licensee's use and implementation of the CEUS-SSC model and the updated EPRI GMM. The licensee provided its control point seismic hazard curves in Section 2.3.7 of its SHSR. The NRC staff's review of the licensee's control point seismic hazard curves is provided in Section 3.3 of this staff assessment.

3.3 Site Response Evaluation

After completing PSHA calculations for reference rock site conditions, Attachment 1 to Enclosure 1 of the 50.54(f) letter requests that licensees provide a GMRS developed from the site-specific seismic hazard curves at the control point elevation. In addition, the 50.54(f) letter specifies that the subsurface site response model, for both soil and rock sites, should extend to sufficient depth to reach the generic or base rock conditions as defined in the ground motion models used in the PSHA. To develop site-specific hazard curves at the control point elevation, Attachment 1 requests that licensees perform a site response analysis.

Detailed site response analyses were not typically performed for many of the older operating plants; therefore, Appendix B of the SPID provides detailed guidance on the development of site-specific amplification factors (including the treatment of uncertainty) for sites that do not have detailed, measured soil and rock parameters to extensive depths.

The purpose of the site response analysis is to determine the site amplification that will occur as a result of bedrock ground motions propagating upwards through the soil/rock column to the surface. The critical parameters that determine what frequencies of ground motion are affected by the upward propagation of bedrock motions are the layering of soil and/or soft rock, the thicknesses of these layers, the shear-wave velocities and low-strain damping of the layers, and the degree to which the shear modulus and damping change with increasing input bedrock amplitude.

3.3.1 Site Base Case Profiles

The licensee provided detailed site profile descriptions in Sections 2.3.1 and 2.3.2 of its SHSR based on information provided in the PNPS UFSAR (Entergy, 2013) and supported by more recent measurements at a nearby Independent Spent Fuel Storage Installation (ISFSI). The licensee stated that the site is underlain by approximately 42 ft [13 m] of glacial outwash, and the glacial outwash is underlain by about 6 ft [2 m] of weathered bedrock with hard bedrock below.

Geophysical investigations for PNPS consisted of refraction surveys. Cross-hole shear wave velocities were measured at the nearby ISFSI. These measurements were the basis for shear wave velocities used by the licensee for site response analyses. The licensee provided a brief description of the subsurface materials in terms of geologic units and thickness in its SHSR. Seismic velocities associated with subsurface materials by the licensee are 1800 feet per second (fps) [550 meters per second] for the glacial outwash, 6000 fps [1830 meters per second] for the weathered bedrock and 10,500 fps [3200 meters per second] for the competent Dedham granodiorite bedrock.

To characterize the subsurface geology, the licensee developed three site base case profiles. The middle, or best estimate profile was developed using measured shear-wave velocity from the site refraction surveys and nearby cross-hole geophysical investigations. Upper and lower base case profiles were developed using a natural log standard deviation of 0.174 and an additional scale factor of 1.28. Figure 3.3-1 shows the licensee's three shear-wave velocity base case profiles.

In Section 2.3.2.1, the licensee assumed the soil material over the upper 42 ft [12.8 m] could be modeled with either EPRI cohesionless soil or Peninsular Range shear modulus degradation and hysteretic damping curves. The shear modulus degradation and hysteretic damping for the weathered rock was modeled as either EPRI rock or linear. The more nonlinear site response was modeled by using the EPRI cohesionless and EPRI rock curves concurrently for the respective soil and rock materials, and the less nonlinear response was modeled by using the Peninsular Range and linear curves concurrently. The licensee weighted these alternative material behaviors equally, assigning 50 percent to each case.

The licensee also considered the impact of kappa, or small strain damping, on site response. Kappa is measured in units of seconds (sec), and is the damping contributed by both intrinsic hysteretic damping as well as scattering due to wave propagation in heterogeneous material. For PNPS, the sediment column thickness is less than 3000 ft [1000 m] to hard rock. Therefore, the licensee implemented SPID guidance and used an empirical relationship where kappa is dependent on sediment column thickness. Because kappa is dependent on sediment column thickness, the kappa for each base case profile was the same, 0.007 sec. The licensee did not apply a scale factor in an attempt to account for epistemic uncertainty associated with kappa.

To account for randomness in material properties across the plant site, the licensee stated that, consistent with Appendix B of the SPID, it randomized its base case shear-wave velocity profiles. In addition, the licensee randomized the depth to bedrock by ±10 ft (±3 m), which corresponds to 20 percent of the total profile thickness. The licensee stated that this randomization was used to broaden the spectral peaks and to reflect actual random variations in the depth to basement shear-wave velocities across the footprint.

3.3.2 Site Response Method and Results

In Section 2.3.4 of its SHSR, the licensee stated that it followed the guidance in Appendix B of the SPID to develop input ground motions for the site response analysis. In Section 2.3.5, the licensee described its implementation of the random vibration theory (RVT) approach to perform its site response calculations. Finally, Section 2.3.6 of the SHSR shows the resulting amplification functions and associated uncertainties for two of the many cases analyzed. Amplification functions are shown for eleven input loading levels for the base case profile with EPRI cohesionless/EPRI rock shear modulus and damping curves and the base case profile with Peninsular Range/Linear shear modulus and damping curves.

In order to develop probabilistic site-specific control point hazard curves, as requested in Requested Information Item 1 of the 50.54(f) letter, the licensee used Method 3, described in Section B-6.0 of the SPID. The licensee's use of Method 3 involved computing the site-specific control point elevation hazard curves for a broad range of spectral accelerations by combining the site-specific bedrock hazard curves, determined from the initial PSHA (Section 2.3.7), and the amplification functions and their associated uncertainties, determined from the site response analysis.

3.3.3 Staff Confirmatory Analysis

To confirm the licensee's site response analysis, the NRC staff performed site response calculations for the PNPS site. The staff independently developed a shear-wave velocity profile, damping values, and modeled the potential nonlinear behavior of the soil and rock using geologic information provided in the PNPS UFSAR (Entergy, 2009), the General Atomic Company Site Parameter Study (Leeds, 1974), Seismic Investigations on Cape Cod, Massachusetts by Oldale and Tuttle (1963), and Appendix B of the SPID. For its site response calculations, the NRC staff employed the RVT approach and developed input ground motions in accordance with Appendix B of the SPID.

Based on the limited knowledge of measurement methods used to obtain the shear wave velocities reported in the General Atomic Site Parameter Study, a scale factor of 1.57 was used to obtain estimates of the lower base case velocity of the glacial soil. This scale factor corresponds to a natural log standard deviation of 0.35. The upper base case velocity of the glacial soil was limited to 3000 ft/s [910 m/s], which is less than 1.57 times the base case velocity. Measured compression wave velocities from Oldale and Tuttle (1963) were used to develop the base case velocities at the interface between the glacial soils and bedrock with an assumed gradient from this soil rock interface until reference rock velocities are reached. To capture the uncertainty in the depth to base rock, the staff used a value of ±7 ft [±2 m]. Figure 3.3.-1 shows the staff velocity profile compared to the base case profiles developed by the licensee.

Similar to the approach used by the licensee, the NRC staff assumed both EPRI cohesionless and Peninsular Range shear modulus degradation and hysteretic damping curves for the glacial soils. The staff assumed both EPRI Rock and linear behavior for the Dedham granodiorite where shear wave velocities were less than the reference rock velocity. The damping for the linear behavior was set equal to the small strain damping from the EPRI Rock curves.

To determine kappa, the staff used the empirical relationship from the SPID for shallow soil sites. Using a sediment depth of 35 ft [10.7 m], a site kappa value of 0.0066 sec was estimated. To model the uncertainty in the kappa value, the staff used a natural log standard deviation value of 0.40 to calculate the upper value for kappa of 0.011 sec. The lower value of kappa was limited at 0.006 sec.

Figure 3.3-2 shows a comparison of the staff's and licensee's median site amplification functions and uncertainties for two of the eleven input loading levels. Due to differences in the near surface shear wave velocity and estimated thickness of the glacial deposits, the amplification function peaks are at different frequencies. The peaks occur near the estimated fundamental frequency of the glacial soil layer. The amplitudes of the peak amplification functions are similar.

The key differences between the staff's and licensee's approaches for site response calculations are the velocity profile and treatment of kappa uncertainty. Based on staff's review of the UFSAR, glacial soils were approximately 35 ft [10 m] thick; whereas, the licensee estimated the glacial soil to be 42 ft [12.8 m] thick. The staff relied on information in the PNPS UFSAR (Section 12.2.4.4.3) for estimating the thickness of the glacial outwash deposits. The licensee utilized 18 boring logs located near PNPS to estimate a deeper depth to bedrock. The licensee also assessed the glacial soils to have a slightly lower shear wave velocity than the staff and implemented less epistemic uncertainty as a result of the data available to the licensee. The licensee utilized cross-hole shear wave velocity data from a nearby ISFSI site investigation as the basis for the glacial outwash shear wave velocity. NRC staff relied on shear wave velocity data available in the site parameter study reported in the Leeds letter report. In addition to the shear wave velocity profiles, the licensee used a single kappa value in their analyses. Staff explicitly accounted for epistemic uncertainty in kappa.

Overall, the licensee's approach to modeling the subsurface material properties and their uncertainty results in the peak of the site amplification factors occurring at a lower frequency. However, as shown in Figure 3.3-3, these differences in the site response analysis do not have a large impact on the control point seismic hazard curves or the resulting GMRS at 1 Hz or at PGA, as discussed below. The licensee's approach results in a slightly higher hazard estimate at frequencies between 3 and 10 Hz. Appendix B of the SPID provides guidance for performing site response analyses, including capturing the uncertainty for sites with less subsurface data; however, the guidance is neither entirely prescriptive nor comprehensive. As such, alternative approaches in performing site response analyses, including the modeling of uncertainty, are acceptable for this application.

In summary, the staff concludes that the licensee's site response was conducted using present-day guidance and methodology, including the NRC-endorsed SPID. The staff performed independent calculations which confirmed that the licensee's amplification factors and control point hazard curves adequately characterize the site response, including the uncertainty associated with the subsurface material properties, for the PNPS site.

3.4 Ground Motion Response Spectra

In Section 2.4 of the SHSR, the licensee stated that it used the control point hazard curves, described in SHSR Section 2.3.7, to develop the 10^{-4} and 10^{-5} (mean annual frequency of exceedance) uniform hazard response spectra (UHRS) and then computed the GMRS using the criteria in RG 1.208.

The staff independently calculated the 10^{-4} and 10^{-5} UHRS using the results of its confirmatory PSHA and site response analyses, as described in Sections 3.2 and 3.3 of this staff assessment, respectively. Figure 3.4-1 shows a comparison of the GMRS determined by the licensee to that determined by the staff.

As shown in Figure 3.4-1 below, the licensee's and staff's GMRS shape are generally similar with the peak occurring at different frequencies. The licensee's GMRS is somewhat higher than the staff's confirmatory analysis at frequencies between 3 and 10 Hz. As described above in Section 3.3, the staff concludes that these differences over this frequency range are primarily due to the differences in the site response analyses performed by the licensee and staff. The staff concludes that these differences are acceptable for this application because the licensee followed the guidance provided in the SPID with respect to both the PSHA and site response analysis for the PNPS site.

The staff confirms that the licensee used the present-day guidance and methodology outlined in RG 1.208 and the SPID to calculate the horizontal GMRS, as requested in the 50.54(f) letter. The staff performed both a PSHA and site response confirmatory analysis and achieved results consistent with the licensee's horizontal GMRS. As such, the staff concludes that the GMRS determined by the licensee adequately characterizes the reevaluated hazard for the PNPS site. Therefore, this GMRS is suitable for use in subsequent evaluations and confirmations, as needed, for the response to the 50.54(f) letter.

4.0 CONCLUSION

The NRC staff reviewed the information provided by the licensee for the reevaluated seismic hazard for the PNPS site. Based on its review, the staff concludes that the licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance, it appropriately characterized the site given the information available, and met the intent of the guidance for determining the reevaluated seismic hazard. Based upon the preceding analysis, the NRC staff concludes that the licensee provided an acceptable response to Requested Information Items (1) – (3), (5), (7), and a partial response to Item (4), identified in Enclosure 1 of the 50.54(f) letter. Further, the licensee's reevaluated seismic hazard is acceptable to address other actions associated with NTTF Recommendation 2.1, "Seismic."

In reaching this determination, the NRC staff confirms the licensee's conclusion that the licensee's GMRS for the PNPS site exceeds the SSE in the 1 to 10 Hz range. As such, PNPS screens in to perform a seismic risk evaluation. A SFP evaluation is also merited. The staff also confirms the licensee's conclusion that because the GMRS exceeds the SSEs above 10 Hz, PNPS will perform a high-frequency confirmation (i.e., Item (4) of the Seismic Hazard Evaluation), which the licensee indicated would be performed as part of its seismic risk evaluation. The NRC review and acceptance of Entergy's ESEP and seismic risk evaluation with the high frequency and SFP evaluations (i.e., Items (4), (6), (8), and (9)) for PNPS will complete the Seismic Hazard Evaluation identified in Enclosure 1 of the 50.54(f) letter.

REFERENCES

Note: ADAMS Accession Nos. refers to documents available through NRC's Agencywide Document Access and Management System (ADAMS). Publicly-available ADAMS documents may be accessed through http://www.nrc.gov/reading-rm/adams.html.

U.S. Nuclear Regulatory Commission Documents and Publications

NRC (U.S. Nuclear Regulatory Commission), 1978, "Development of Criteria for Seismic Review of Selected Nuclear Power Plants." NUREG/CR-0098, May 1978.

NRC (U.S. Nuclear Regulatory Commission), 2007, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion." RG 1.208, March, 2007.

NRC (U.S. Nuclear Regulatory Commission), 2011a, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," Commission Paper SECY-11-0093, July 12, 2011, ADAMS Accession No. ML11186A950.

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Figure 3.3- 1Plot of Staff's and Licensee's Base Case Shear-Wave Velocity Profiles for the Pilgrim site

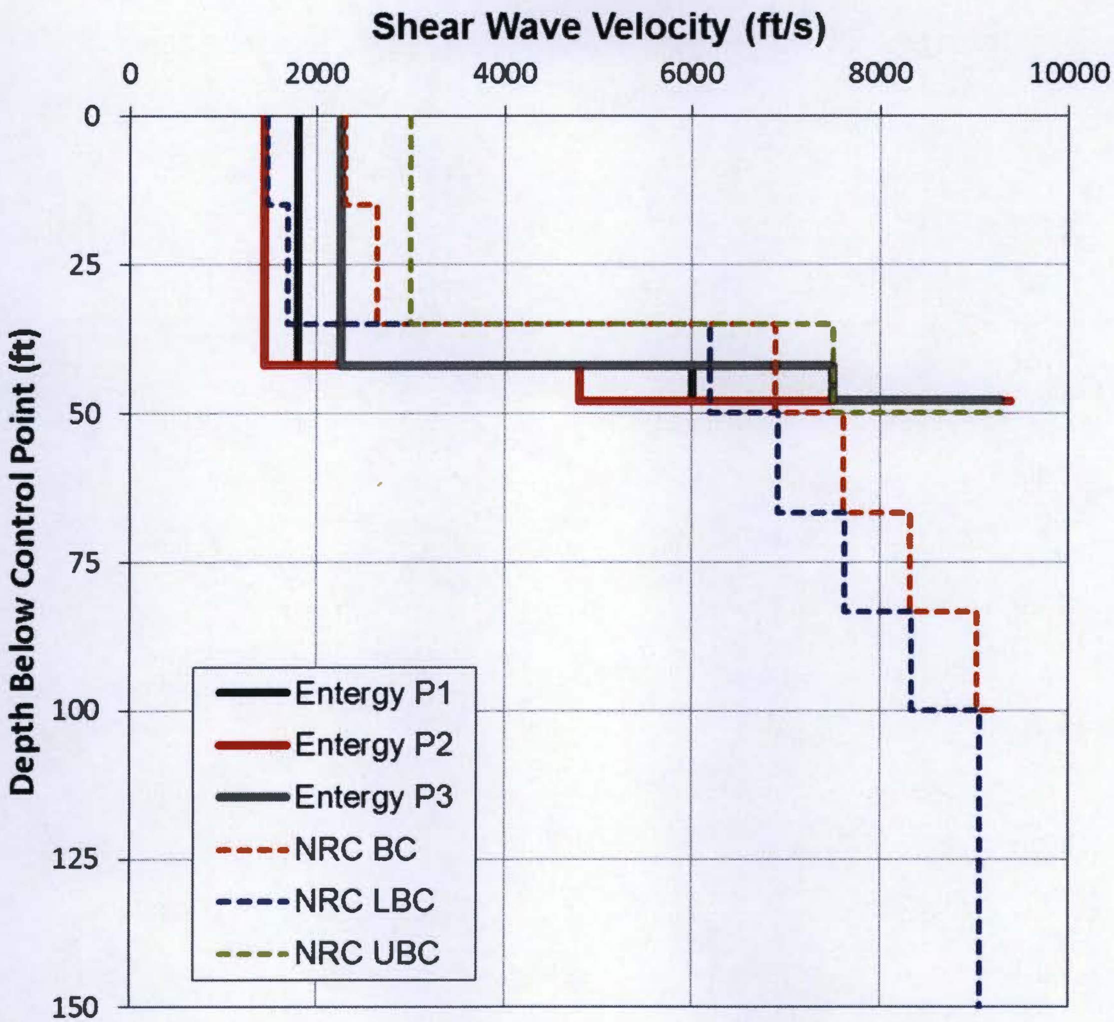


Figure 3.3- 2 Plot Comparing the Staff's and the License's Median Amplification Functions and Uncertainties for two input loading levels for the Pilgrim site

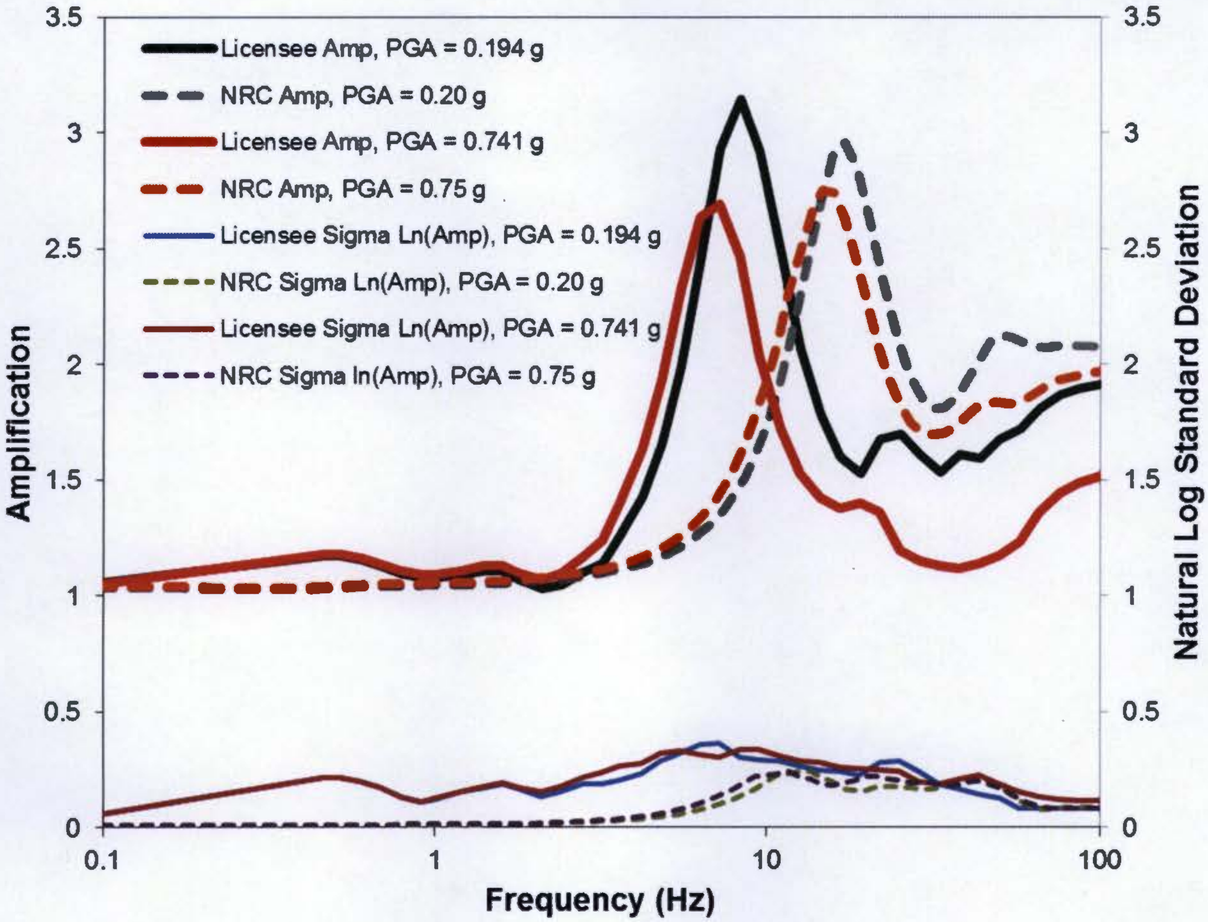


Figure 3.3-3 Plot Comparing the Staff's and the Licensee's Mean Control Point Hazard Curves at a Variety of Frequencies for the Pilgrim site

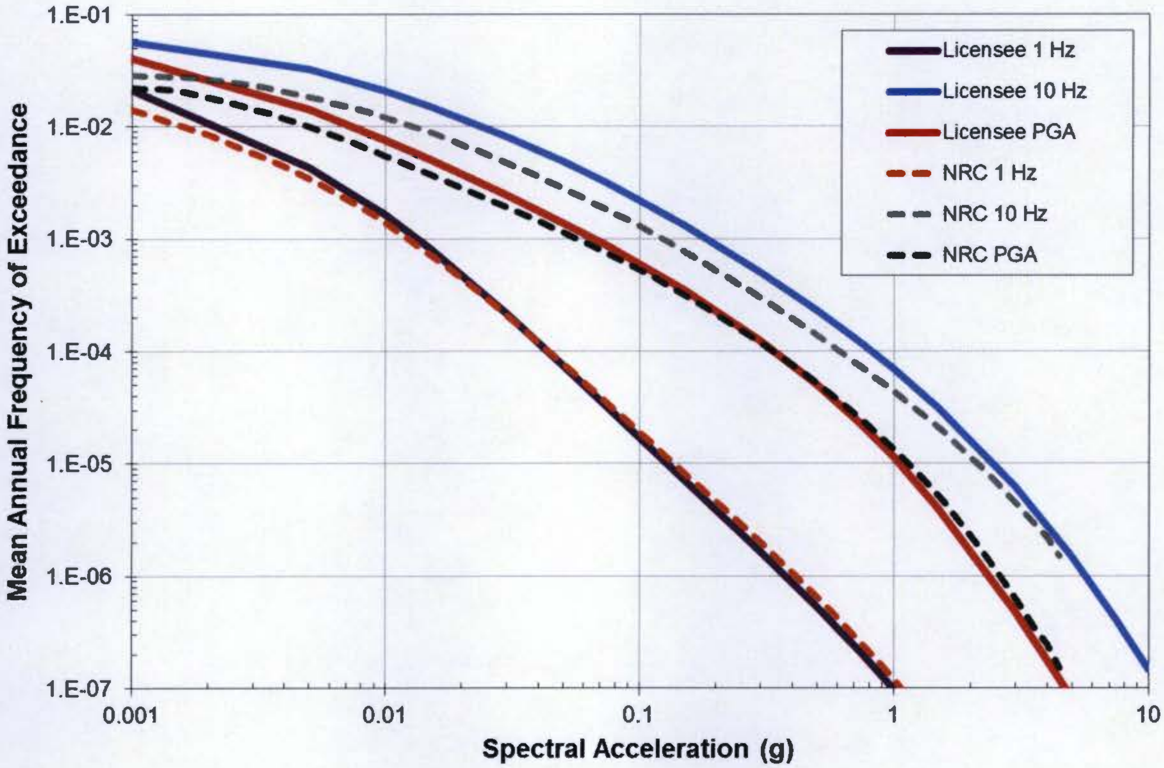
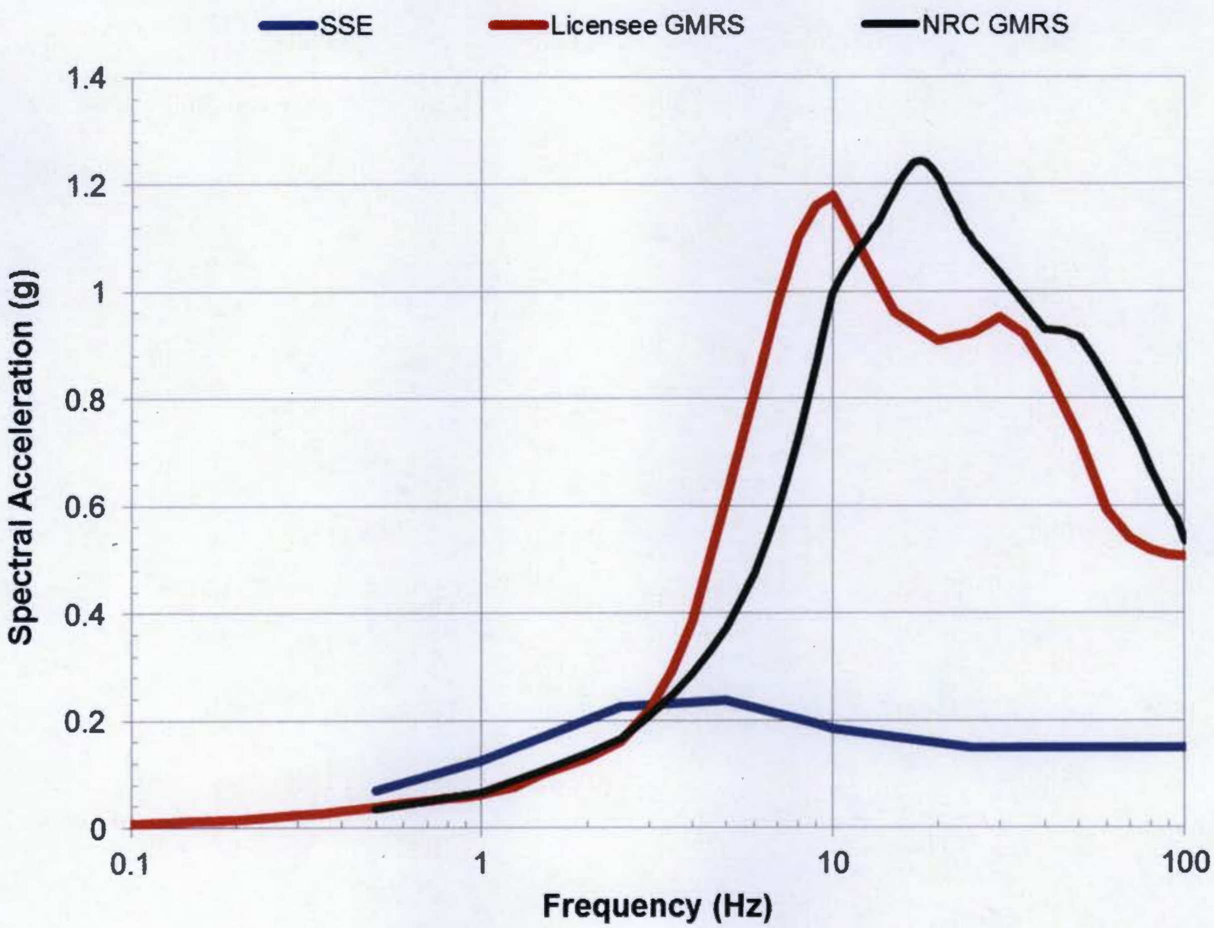


Figure 3.4-1 Comparison of the Staff's GMRS with Licensee's GMRS and the SSE for the Pilgrim site



If you have any questions, please contact me at (301) 415-6197 or via e-mail at Tekia.Govan@nrc.gov.

Sincerely,

/RA/

Tekia Govan, Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket No. 50-293

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