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

December 18, 2015

Vice President, Operations
Entergy Operations, Inc.
Grand Gulf Nuclear Station
P.O. Box 756
Port Gibson, MS 39150

SUBJECT: GRAND GULF NUCLEAR STATION, UNIT 1 - STAFF ASSESSMENT OF INFORMATION PROVIDED PURSUANT TO TITLE 10 OF THE *CODE OF FEDERAL REGULATIONS* PART 50, SECTION 50.54(f), SEISMIC HAZARD REEVALUATIONS FOR RECOMMENDATION 2.1 OF THE NEAR-TERM TASK FORCE (NTTF) REVIEW OF INSIGHTS FROM THE FUKUSHIMA DAI-ICHI ACCIDENT AND STAFF CLOSURE OF ACTIVITES ASSOCIATED WITH NTTF RECOMMENDATION 2.1, "SEISMIC" (TAC NO. MF3750)

Dear Sir or Madam:

On 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.

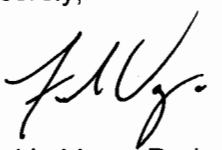
By letter dated March 31, 2014, Entergy Operations, Inc (Entergy, the licensee), responded to this request for Grand Gulf Nuclear Station, Unit 1, (GGNS).

The NRC staff has reviewed the information provided related to the reevaluated seismic hazard for GGNS and, as documented in the enclosed staff assessment, determined that you provided sufficient information in response to Enclosure 1, Items (1) - (9) of the 50.54(f) letter.

The NRC staff concludes that the licensee responded appropriately and has completed its response to Enclosure 1, of the 50.54(f) letter. Furthermore, the NRC staff review concluded that the reevaluated seismic hazard is bounded by the plants existing design-basis safe shutdown earthquake. As such, the NRC staff concludes that no further responses or regulatory actions associated with Phase 2 of Near-Term Task Force (NTTF) Recommendation 2.1 "Seismic" are requiered for GGNS. This closes out the NRC's efforts associated with Phase 1 and 2 of NTTF Recommendation 2.1 "Seismic" (TAC No. MF3750).

If you have any questions, please contact me at (301) 415-1617 or at Frankie.Vega@nrc.gov.

Sincerely,



Frankie Vega, Project Manager
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Docket No. 50-416

Enclosure:
Staff Assessment of Seismic
Hazard Evaluation and Screening Report

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STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO SEISMIC HAZARD AND SCREENING REPORT

GRAND GULF NUCLEAR STATION, UNIT 1

DOCKET NO. 50-416

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 (SRM) 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. A high-frequency evaluation (if necessary),

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

(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 (NRC, 2007), 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 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 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 provided 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 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 GMM for use by CEUS plants in developing a plant-specific GMRS.

By letter dated April 9, 2013 (Pietrangelo, 2013), industry agreed to follow the SPID to develop the SHSR for existing nuclear power plants. By letter dated September 12, 2013 (Mulligan, 2013), Entergy Operations, Inc. (Entergy, the licensee) submitted at least partial site response information for Grand Gulf Nuclear Station, Unit 1 (GGNS, Grand Gulf). By letter dated March 31, 2014 (Mulligan, 2014), the licensee submitted its SHSR.

2.0 REGULATORY BACKGROUND

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." The 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.

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 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 described 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 provided further guidance regarding the appropriate use of GMMs for the CEUS. Specifically, Section 2.3 of the SPID recommended 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

By letter dated March 31, 2014 (Mulligan, 2014), the licensee provided the SHSR for GGNS. The licensee's SHSR indicated that the plant SSE bounds the GMRS. As such, the licensee stated that neither a seismic risk evaluation nor SFP evaluation will be performed. Additionally, because the SSE bounds the GMRS above 10 Hertz (Hz), the licensee indicated that a HF confirmation will not be performed.

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 SSE bounds the GMRS between the frequency range of 1 to 100 Hz. As such, a plant seismic risk evaluation, SFP evaluation and HF confirmation are not merited.

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 requests the licensee 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 ground motion and is characterized by (1) a peak ground acceleration (PGA) value which anchors the response spectra at high frequencies (typically at 20 to 30 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 its SHSR, the licensee described its seismic design-basis for GGNS. The licensee stated that the design-basis of GGNS was determined from the seismicity of the Gulf Coast Basin tectonic province and New Madrid seismic zone. Although the PGA at the site is not expected to exceed 0.1g, the licensee selected a PGA of 0.15g for additional conservatism. The licensee defined the SSE by anchoring the modified Newmark's spectrum shape at the PGA. The licensee specified that the control point is located at the foundation grade at the top of the Catahoula formation which corresponds to elevation 87 ft. (26.5 m). The licensee noted that the bottom of the foundation of the highest safety-related structure is at elevation 83.5 ft. (25.5 m).

The NRC staff reviewed the licensee's description of its SSE in the SHSR and the Updated Final Safety Analysis Report (UFSAR) (Entergy, 2013). Based on its review, the NRC staff confirmed that the licensee's SSE is defined in terms of a PGA and a design response spectrum

anchored at 0.15 g, as described by the licensee. Finally, based on its review of the SHSR and the UFSAR (Entergy, 2013), the NRC staff confirmed that the licensee's control point elevation for the GGNS site SSE is defined at elevation 87 ft. (26.5 m) at the foundation grade, consistent with guidance in the SPID.

3.2 Probabilistic Seismic Hazard Analysis

In Section 2.2 of its SHSR, the licensee stated 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). The licensee used a minimum magnitude cutoff of **M**5.0, as specified in the 50.54(f) letter. The licensee further stated, that it included the CEUS-SSC background sources out to a distance of 400 mi (640 km) around the site and included the Charleston, Commerce, Eastern Rift Margin-North, Eastern Rift Margin-South, Marianna, Meers, New Madrid Fault System, and Wabash Valley Repeated Large Magnitude Earthquake (RLME) sources, which lie within 620 mi (1,000 km) of GGNS. The RLME sources are those source areas or faults for which more than one large magnitude (**M** ≥ 6.5) earthquake has occurred in the historical or paleo-earthquake (geologic evidence for prehistoric seismicity) record. For all but the Charleston RLME source, the licensee used a combination of 50 percent of the Gulf and 50 percent of the mid-continent versions of the updated EPRI GMM. For the Charleston source, the licensee used a combination of 17 percent of the Gulf and 83 percent of the mid-continent GMMs to reflect the relative travel path from the center of the Charleston Local zone to the GGNS site. Consistent with the SPID, the licensee did not provide its base rock seismic hazard curves since a site response analysis is necessary to determine the control point seismic hazard curves. The licensee provided its control point seismic hazard curves in Section 2.3.7 of the SHSR. The 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 base rock site conditions at the GGNS site. As input, the NRC staff used the CEUS-SSC model as documented in NUREG-2115 (NRC, 2012b) along with the updated EPRI GMM (EPRI, 2013). Consistent with the guidance provided in the SPID, the NRC staff included all CEUS-SSC background seismic sources within a 310 mi (500 km) radius of the GGNS site. In addition, the NRC staff included the Charleston, Eastern Rift Margin-North, Eastern Rift Margin-South, Marianna, Meers, New Madrid Fault System, and Wabash Valley RLME sources, which lie within 620 km (1,000 mi) of the GGNS site. The NRC staff used the midcontinent version of the EPRI (2013) GMM for all of the background seismic source zones except for the MESE-N, MESE-W, GHEX, and ECC-GC, source zones because the paths for these source zones lie within the region of the CEUS defined as Gulf Coast by the GMM. For the RLME sources, the NRC staff used the Gulf version of the EPRI (2013) GMM for all sources except for the Charleston RLME source.

Based on its 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.

3.3 Site Response Evaluation

After completing PSHA calculations for reference rock conditions, Attachment 1 to Enclosure 1 of the 50.54(f) letter requests that the licensee 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 reference or baserock conditions as defined in the GMMs 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 would 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 these layers, and the degree to which the shear modulus and damping change with increasing input bedrock amplitude. To develop site-specific hazard curves at the control point, the licensee performed a site response analysis.

3.3.1 Site Base Case Profiles

The licensee provided site profile descriptions in Sections 2.3.1 and 2.3.2 of its SHSR based on information in the UFSAR (Entergy, 2013) and the guidance in Appendix B of the SPID. The GGNS site is located in the Mississippi Alluvial Valley within the Gulf Coastal Plain physiographic province. According to the licensee, approximately 13,000 ft. (4,000 m) of Cenozoic and Cretaceous sediments and sedimentary rocks underlie the GGNS site. Precambrian basement rocks are estimated to occur at a depth of approximately 27,000 ft. (8,200 m).

Concerning the subsurface layers at the GGNS site, the licensee stated that surficial deposits consist of 145 ft. (44 m) of alluvial sands, gravels, silts and clays of Holocene age overlying 82 ft. (25 m) of Pleistocene age loess and 151 ft. (46 m) of Terrace Deposits. Underlying these surficial deposits is the Miocene Catahoula Formation, which is the foundation layer for the site. According to the licensee, the Catahoula formation is a hard to very hard clay with a maximum thickness estimated to be 320 ft. (98 m) with shear wave velocities ranging from 1,700 to 1,800 feet per second (fps) (518-549 m/s). The Catahoula clay overlies the Vicksburg Group, a series of clays and marls of varying composition.

Using shear-wave velocities determined from in-situ shear and compressional wave velocity measurements of the Catahoula clay, the licensee developed a shear-wave velocity profile for the upper 190 ft. (58 m). Below this depth, the licensee used a velocity template provided in the SPID for soil sites to extend the velocity profile to a depth of 4,000 ft. (1,219 m). The licensee

terminated its profile at 4,000 ft. (1,219 m) because shear wave velocity variations at depths greater than 4,000 ft. (1,219 m) are expected to have little impact on the site response at frequencies above the 0.5 Hz minimum defined by the GMM. To capture the uncertainty in the subsurface shear wave velocities, the licensee developed lower and upper base case velocity profiles using a scale factor of 1.25 over the upper 190 ft. (58 m) and a scale factor of 1.57 over the remainder of the profile. These values are consistent with a natural log standard deviation of 0.2 and 0.35 for the upper and lower portions of the profiles, respectively. Figure 3.3-1 of this assessment shows the licensee's three base case shear-wave velocity profiles.

In Section 2.3.2.1 of its SHSR, the licensee stated that no site-specific dynamic material properties were available for the GGNS site. Therefore, the licensee followed the SPID guidance and assumed the response of the soils to dynamic loading could be modeled with varying degrees of non-linearity. In one characterization, the licensee assumed that the materials over the upper 500 ft. (150 m) could be modeled with EPRI cohesionless soil shear modulus reduction and damping curves, representing a more non-linear alternative. In the other characterization, the licensee assumed that the materials over the upper 500 ft. (150 m) could be modeled with the Peninsular Range shear modulus reduction and damping curves, representing a more linear alternative.

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 the GGNS site, with greater than 3,000 ft. (914 m) of underlying soil, the licensee assumed a maximum kappa value of 0.04 s for the base, lower and upper profiles. The licensee stated that uncertainty in kappa is accounted for by the use of two different models for the dynamic material properties.

To account for randomness in material properties across the plant site, the licensee stated that it randomized its base case profiles following the guidance in Appendix B of the SPID. In addition, the licensee stated that it randomized the depth to base rock by ±1200 ft. (366 m), which corresponds to 30 percent of the total profile thickness. The licensee stated that this randomization did not represent the actual uncertainty in the depth to base rock, but was used to broaden the spectral peaks in the amplification functions.

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, and 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 2 of the 11 input loading levels for the each base case profile.

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 Appendix 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 reference rock hazard curves, determined from the initial PSHA (Section 3.2 of this assessment), and the amplification function 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 its own confirmatory calculations to independently test the licensee's calculations following the guidance in Appendix B of the SPID. The NRC staff developed a shear wave velocity profile, damping values and modeled nonlinear behavior of the subsurface materials using geological information and measurements provided in the GGNS UFSAR, the Early Site Permit (ESP) Site Safety Analysis Report (SSAR) (Entergy, 2005) for the Grand Gulf site, 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.

The GGNS site condition is relatively well characterized due to the extensive geotechnical work implemented during subsurface investigations conducted as part of the ESP application. Geotechnical investigations included the drilling of boreholes, P-S logging, resonant column and torsional shear (RCTS) analyses, and other geotechnical studies of the shallow subsurface. Additionally, the ESP applicant correlated this new data with data collected during initial licensing of the operating plant, demonstrating consistency in the subsurface between the two sites. As a result, the NRC staff relied on UFSAR data, obtained during original licensing, to develop the shear wave velocities for the upper portion of the profile and used ESP data to extend the site profile to about 3,000 ft. (914 m) depth. The NRC staff extended the profile to a total depth of 7,000 ft. (2,134 m) using the shear wave velocity gradient recommended in the SPID. Specifically, the upper 200 ft. (61 m) of the shear wave velocity profile is based on UFSAR Table 2.1-6.6 and the remainder of the profile is based on Figure 2.5-61 of SSAR of the ESP application. To account for the variability in shear wave velocities beneath the site, the NRC staff developed lower and upper profiles using a natural log standard deviation of 0.2. Figure 3.3-1 of this assessment shows a comparison of the three base case profiles developed by the licensee with those developed by the NRC staff. The profiles developed by the NRC staff are generally similar to those developed by the licensee over the total depth of the profile. Differences between the two sets of profiles result from the staff's use of a slightly higher velocity gradient and the total thicknesses of the profiles as the profiles developed by the NRC staff extend to a greater depth than those developed by the licensee.

Consistent with guidance in the SPID and the licensee's approach, the NRC staff used two sets of shear modulus and damping curves to model the behavior of the soil and rock layers to dynamic loading. Similar to the licensee, the NRC staff used the EPRI (1993) curves to model the upper limit of non-linearity at the site and the Peninsular Range curves to model the lower limit.

In addition, the NRC staff considered the impact of kappa on site response. Consistent with the licensee's approach, the NRC staff followed guidance in the SPID for sites with greater than 3,000 ft. (914 m) of soil overlying base rock and determined a base case kappa value of 0.04 sec. To model the uncertainty in kappa, the NRC staff used a natural log standard deviation of 0.51 to calculate lower and upper kappa values for each of the three profiles. The staff's

approach results in nine kappa values for its site response analysis, which range from 0.020 to 0.056 sec.

Figure 3.3-2 of this assessment shows a comparison of the staff's and the licensee's median site amplification functions and uncertainties (±1 standard deviation) for two of the eleven input loading levels. Amplification functions developed by the NRC staff and by the licensee peak at a value of 2-2.5 between 0.1 to 1 Hz. Differences in the site amplification curves developed by the NRC staff and the licensee are very minor and are due to the minor differences in the site velocity profiles. As shown in Figure 3.3-3 of this assessment, these differences, and differences in PSHA inputs have a modest impact on control point seismic hazard curves and the resulting GMRS, discussed below. 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, various approaches in performing site response analyses, including the modeling of uncertainty, are acceptable for the 50.54(f) response.

In summary, the NRC staff concludes that the licensee's site response was conducted using present-day guidance and methodology, including the NRC-endorsed SPID. The NRC staff performed independent calculations to confirm 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 GGNS site.

3.4 Ground Motion Response Spectra

In Section 2.4 of its 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) an then computed the GMRS using the criteria in RG 1.208. The NRC staff independently calculated the 10^{-4} and 10^{-5} UHRS using the results of its confirmatory PSHA and site response analysis, as described in Sections 3.2 and 3.3 of this staff assessment, respectively.

As shown in Figure 3.4-1 of this assessment, the licensee's GMRS shape is very similar to that calculated by the NRC staff. At frequencies where the amplitude of the GMRS determined by the licensee is different from that determined by the NRC staff, the licensee's generally exceeds that of the NRC staff. These differences in GMRS are the result of differences in the site response analyses and in the PSHA performed by the licensee and NRC staff, as discussed above.

The NRC 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 NRC staff performed both a PSHA and site response confirmatory analysis and achieved results consistent with the licensee's horizontal GMRS. As such, the NRC staff concludes that the GMRS determined by the licensee adequately characterizes the reevaluated hazard for the GGNS site. Therefore, this GMRS is suitable for use in subsequent evaluations and confirmations, as needed, for the licensee's response to the 50.54(f) letter.

4.0 CONCLUSION

The NRC NRC staff reviewed the information provided by the licensee for the reevaluated seismic hazard for the GGNS site. Based on its review, the staff concludes that the licensee conducted the seismic hazard reevaluation using present-day methodologies and regulatory guidance, 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) – (7), identified in Enclosure 1 of the 50.54(f) letter.

In reaching this determination, NRC staff confirms the licensee's conclusion that the licensee's GMRS for the GGNS site is bounded by the SSE in the 1 to 100 Hz range. As such, a seismic risk evaluation (Item 8), SFP evaluation (Item 9), and HF confirmation (Item 4) are not merited. Based upon the preceding analyses, the NRC staff concludes that the licensee responded appropriately to Enclosure 1, of the 50.54(f) letter.

REFERENCES

Note: ADAMS Accession Nos. refers to documents available through NRC's Agencywide Documents 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), 2007, A Performance-based Approach to Define the Site-Specific Earthquake Ground Motion, Regulatory Guide (RG) 1.208.

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.

NRC (U.S. Nuclear Regulatory Commission), 2011b, "Recommendations for Enhancing Reactor Safety in the 21st Century: The Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident," Enclosure to SECY-11-0093, July 12, 2011, ADAMS Accession No. ML11186A950.

NRC (U.S. Nuclear Regulatory Commission), 2011c, "Recommended Actions to be Taken Without Delay from the Near-Term Task Force Report," Commission Paper SECY-11-0124, September 9, 2011, ADAMS Accession No. ML11245A158.

NRC (U.S. Nuclear Regulatory Commission), 2011d, "Prioritization of Recommended Actions to be Taken in Response to Fukushima Lessons Learned," Commission Paper SECY-11-0137, October 3, 2011, ADAMS Accession No. ML11272A111.

NRC (U.S. Nuclear Regulatory Commission), 2012a, letter from Eric J. Leeds, Director, Office of Nuclear Reactor Regulation and Michael R. Johnson, Director, Office of New Reactors, to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status, March 12, 2012, ADAMS Accession No. ML12053A340.

NRC (U.S. Nuclear Regulatory Commission), 2012b, "Central and Eastern United States Seismic Source Characterization for Nuclear Facilities", NUREG-2115, ADAMS stores the NUREG as multiple ADAMS documents, which are most easily accessed through the web page http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2115/.

NRC (U.S. Nuclear Regulatory Commission), 2013a. Letter From Eric J. Leeds, to Joseph Pollock, Executive Director NEI, Acceptance Letter for NEI Submittal of Augmented Approach, Ground Motion Model Update Project, and 10 CFR 50.54(f) Schedule Modifications Related to the NTTF Recommendation 2.1, Seismic Reevaluations, May 7, 2013, ADAMS Accession No. ML13106A331.

NRC (U.S. Nuclear Regulatory Commission), 2013b, letter from David L. Skeen, Director, Japan Lessons-Learned Directorate, to Joseph E. Pollock, Executive Director, Nuclear Energy Institute, Endorsement of Electric Power Research Institute Draft Report 1025287,

"Seismic Evaluation Guidance," February 15, 2013, ADAMS Accession No. ML12319A074.

NRC (U.S. Nuclear Regulatory Commission), 2013c. Letter from D. L. Skeen (NRC) to K. A.Keithline (NEI), Approval of Electric Power Research Institute Ground Motion Model Review Project Final Report for Use by Central and Eastern United States Nuclear Power Plants, August 28, 2013 ADAMS Accession No. ML13233A102.

NRC (U.S. Nuclear Regulatory Commission) 2014a. Letter from Eric J. Leeds, Director, Office of Nuclear Reactor Regulation to All Power Reactor Licensees and holders of Construction Permits in Active or Deferred Status, Seismic Screening and Prioritization Results Regarding Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Seismic Hazard Reevaluations for Recommendations 2.1 of the Near-Term Task Force Review of Insights, May 9, 2014, ADAMS Accession No. ML14111A147.

Other References

Electric Power Research Institute (EPRI), 2004. EPRI Report 1009684, "CEUS Ground Motion Project Final Report." Palo Alto, CA, 2004.

Electric Power Research Institute (EPRI), 2006. EPRI Report 1014381, "Truncation of the Lognormal Distribution and Value of the Standard Deviation for Ground Motion Models in the Central and Eastern United States." Palo Alto, CA, 2006.

Electric Power Research Institute (EPRI), 2012. 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" November 27, 2012, ADAMS Accession No. ML12333A170.

Electric Power Research Institute (EPRI), 2013. EPRI Report 3002000717 "EPRI (2004, 2006) Ground-Motion Model Review Project Final Report," Palo Alto, CA, 2013.

Entergy, 2005, Grand Gulf Early Site Permit Application, Docket No. 52-009, Revision 2, October 3, 2005, ADAMS Accession No. ML052780449.

Entergy, 2013. Grand Gulf Nuclear Station Updated Final Safety Analysis Report, Docket No. 50-416, Revision Nov. 2011.

Keithline, 2012, Letter from Kimberly Keithline, Senior Project Manager, NEI, to David L. Skeen, Director, Japan Lessons Learned Project Directorate, NRC, Final Draft of Industry Seismic Evaluation Guidance (EPRI 1025287), November 27, 2012, ADAMS Accession No. ML12333A168.

Keithline, 2013, Submittal of EPRI (2004, 2006) Ground Motion Model Review Final Report, June 3, 2013, ADAMS Accession No. ML13170A378.

Mulligan, K. 2013, Letter from K. Mulligan (Entergy Operations, Inc.) to 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, September 12, 2013, ADAMS Accession No. ML13254A311.

Mulligan. K. 2014, Letter from K. Mulligan (Entergy Operations, Inc.) to NRC, 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, March 31, 2014, ADAMS Accession Nos. ML14090A098 and ML14090A141, respectively.

Pietrangelo, 2013, Letter from A. R. Pietrangelo (NEI) to D. L. Skeen (NRC), Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations, April 9, 2013, ADAMS Accession No. ML13101A379.

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

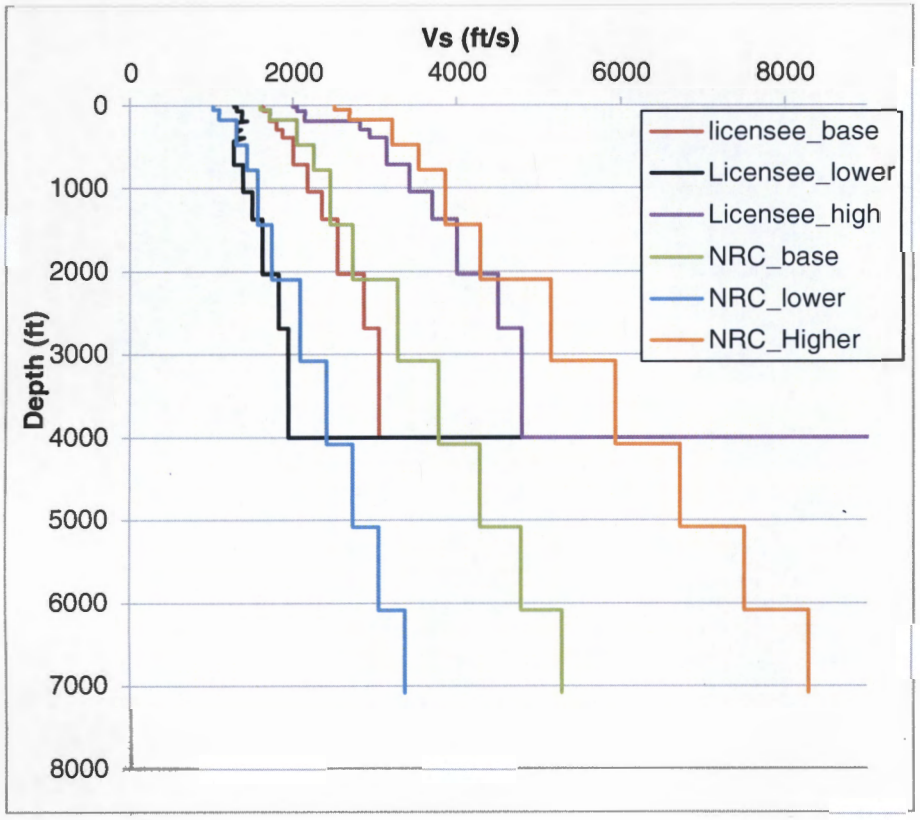


Figure 3.3- 2 Plot Comparing the Staff's and the Licensee's Median Amplification Functions and Uncertainties for the GGNS site.

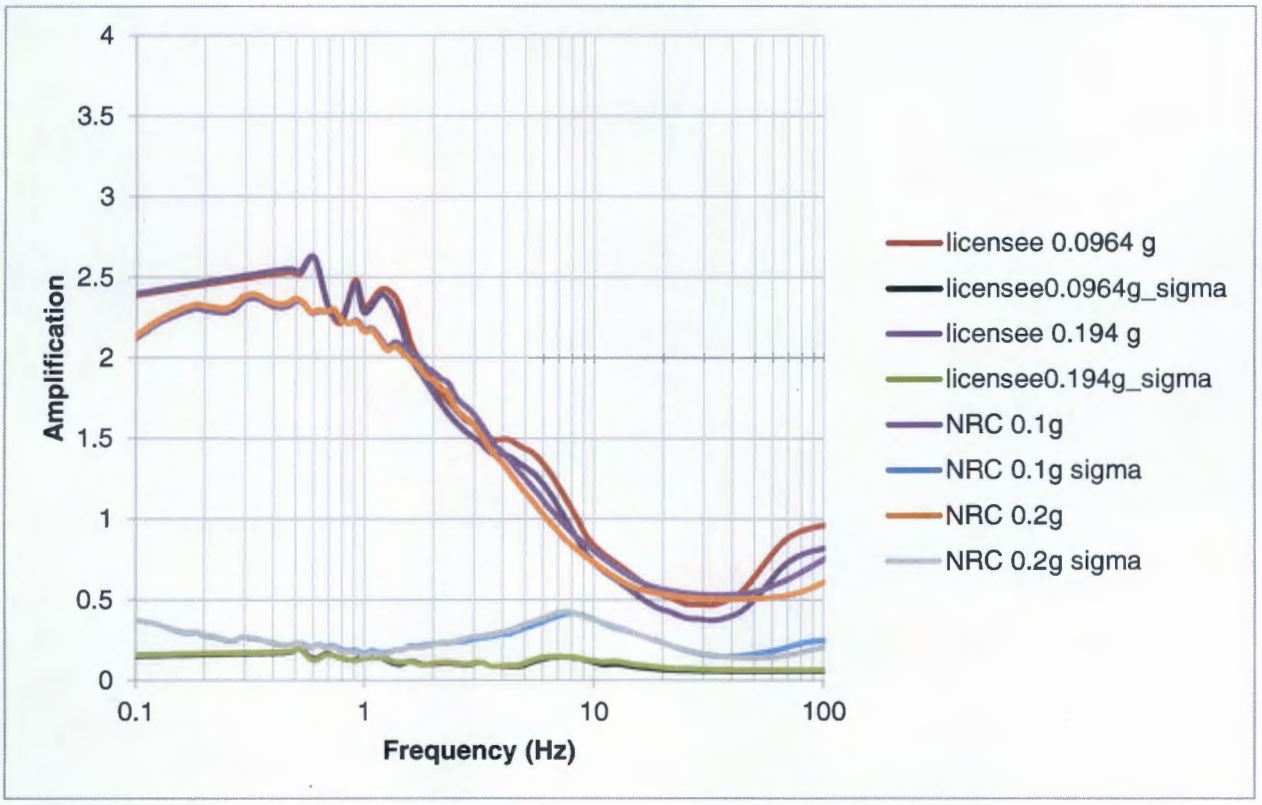


Figure 3.3-3 Plot Comparing the Staff's and the Licensee's Mean Control Point Hazard Curves at a Variety of Frequencies for the GGNS site

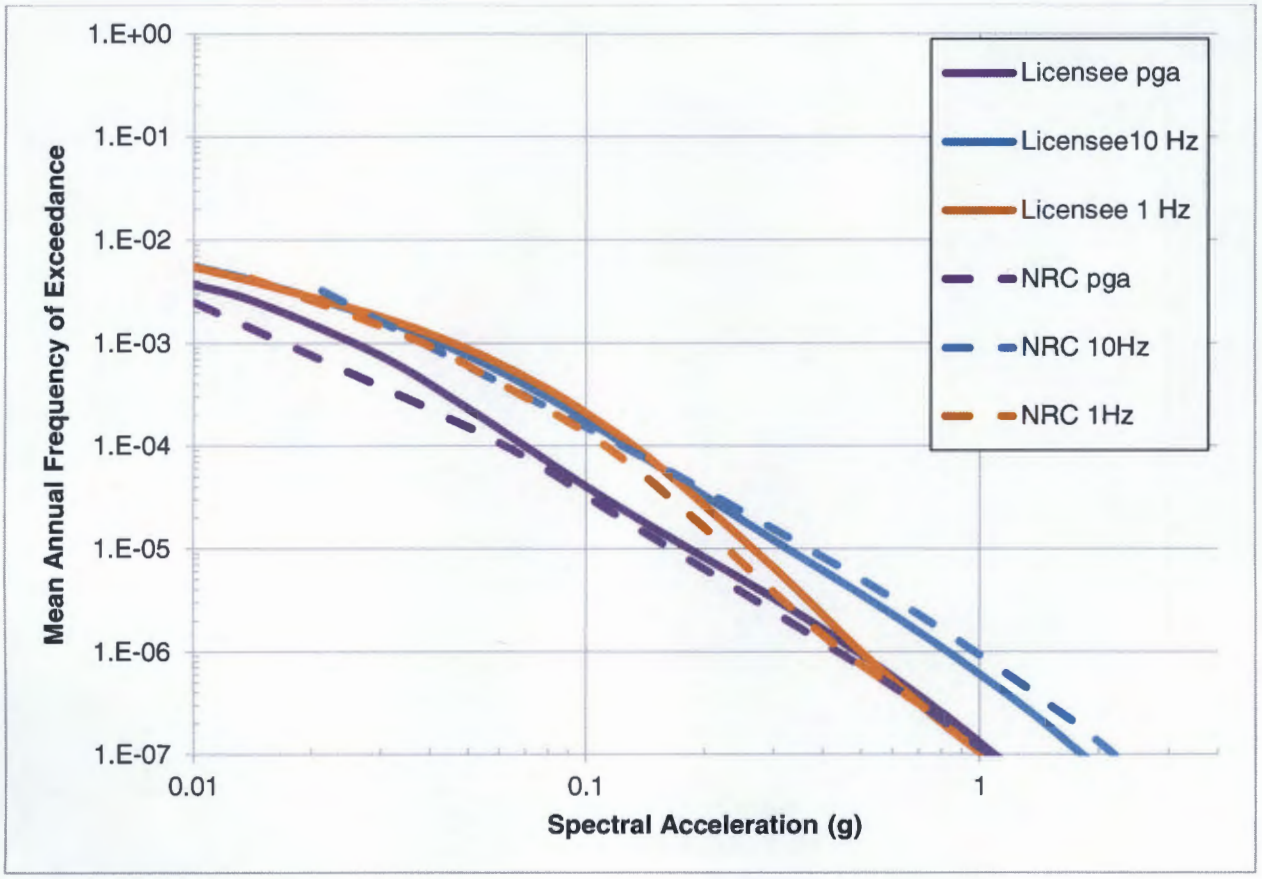
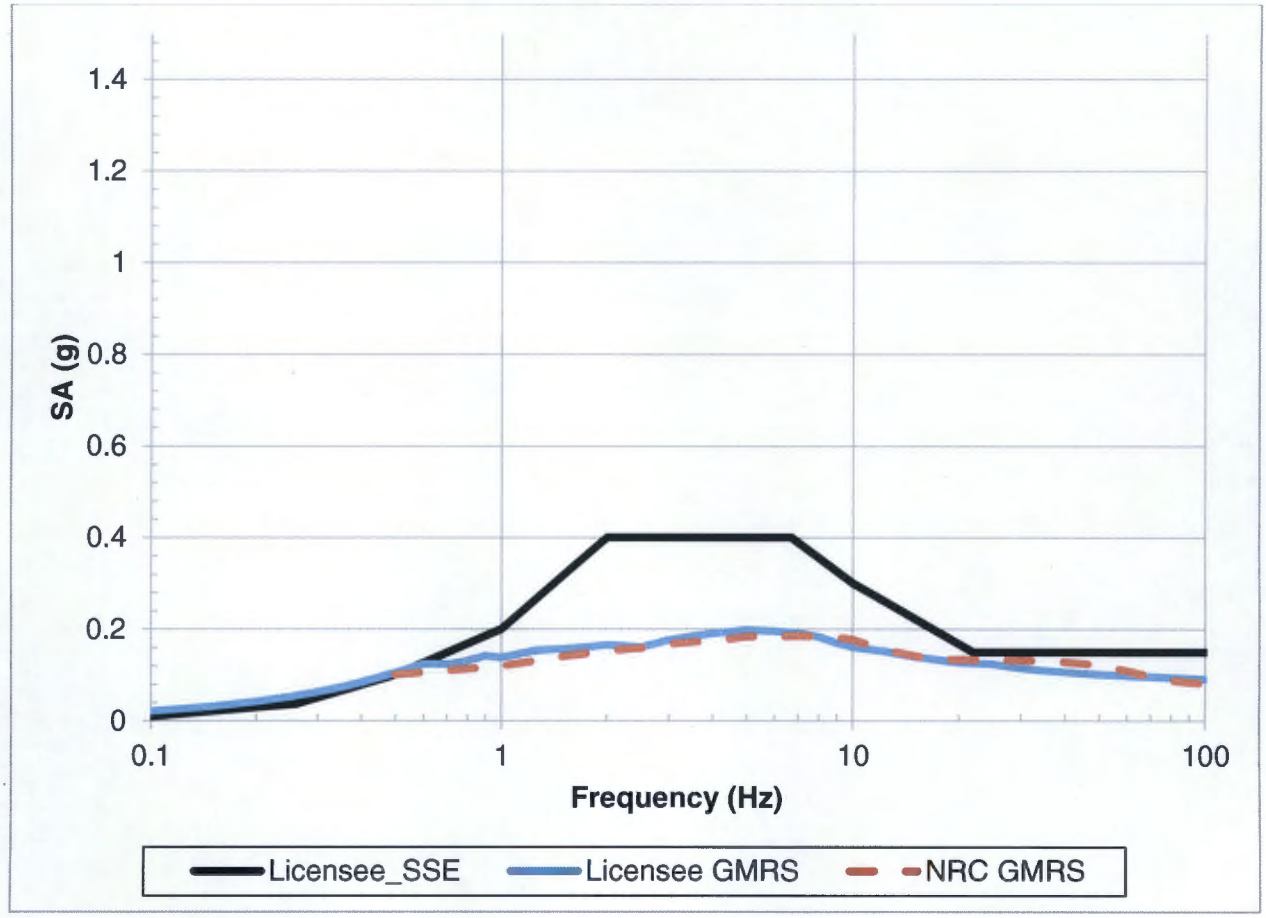


Figure 3.4-1 Comparison of the Staff's GMRS with Licensee's GMRS and the SSE for the GGNS site



If you have any questions, please contact me at (301) 415-1617 or at Frankie.Vega@nrc.gov.

Sincerely,

/RA/

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

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