UNITED STATES
NUCLEAR REGULATORY COMMISSION
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Mr. Louis Cortopassi
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Fort Calhoun Station
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SUBJECT: FORT CALHOUN 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 REVIEW OF INSIGHTS FROM THE FUKUSHIMA DAI-ICHI ACCIDENT (TAC NOS. MF3735)

Dear Mr. Cortopassi:

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, Omaha Public Power District (OPPD, the licensee), responded to this request for Fort Calhoun Station, Unit 1 (FCS).

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

Contingent upon the NRC staff's review and acceptance of OPPD's spent fuel pool evaluation (i.e., Item (9)) and the full - scope Individual Plant Examination of External Events (IPEEE) relay chatter review (requested to meet the criteria for using an IPEEE program to demonstrate that a seismic risk evaluation (Item 8) is not merited) for FCS, the Seismic Hazard Evaluation identified in Enclosure 1 of the 50.54(f) letter will be completed.

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

Sincerely,

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

Docket No. 50-285

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

FORT CALHOUN STATION

DOCKET NO. 50-285

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] 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,

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

(4) Comparison of the GMRS and SSE. A high-frequency (HF) evaluation (if necessary),

(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 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 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 committed to following the SPID to develop the SHSR for existing nuclear power plants. By letter dated September 12, 2013 (Cortopassi, 2013), Omaha Public Power District (OPPD, the licensee) submitted at least partial site response information for the Fort Calhoun Station, Unit 1 (Fort Calhoun, FCS). By letter dated March 31, 2014 (Cortopassi, 2014a), OPPD submitted its SHSR for Fort Calhoun.

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 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

By letter dated March 31, 2014 (Cortopassi, 2014a), the licensee provided the SHSR for Fort Calhoun. The licensee's SHSR indicates that the site GMRS exceeds the site SSE for a portion of the frequency range of 1 to 10 Hertz (Hz). However, the licensee indicated that over the frequency range of 1 to 10 Hz, the GMRS is bounded by the site Individual Plant Examination for External Events (IPEEE) plant-level high confidence of low probability of failure (HCLPF) spectrum (IHS). In Appendix B of its SHSR, the licensee described its IPEEE program in order to use the IHS demonstrated for FCS as the plant capacity for its screening comparison with the GMRS. Because the IHS bounds the GMRS over the 1 to 10 Hz range, the licensee indicated that FCS screens out of performing a plant seismic risk evaluation. The licensee stated that the full scope IPEEE detailed review of relay chatter required in SPID Section 3.3.1 had not been completed at the time of submittal. Therefore, the licensee stated that it will complete the relay chatter review consistent with NEI letter to NRC dated October 3, 2013 (Keithline, 2013), on the same schedule as the high frequency confirmation as proposed in the NEI letter dated April 9, 2013 (Pietrangelo, 2013), and accepted in NRC's letter dated May 7, 2013 (NRC, 2013a). With respect to the SFP evaluation, the licensee indicated that since the GMRS exceeds the SSE for FCS, an evaluation will be performed.

On May 9, 2014 (NRC, 2014a), the NRC staff issued a letter providing the outcome of its 30- day, preliminary screening and prioritization evaluation. In the letter, the NRC staff characterized the FCS site as conditionally screened-in, because additional information was needed to support a screening decision using the IPEEE screening criteria in the SPID, and a prioritization decision. On September 22, 2014 (NRC, 2014b), the NRC staff issued a letter providing the outcome of its final seismic screening and prioritization results. After review of Appendix B of the licensee's SHSR, the NRC staff concluded that the licensee's IPEEE program met the criteria in the SPID for IPEEE adequacy. As such, even though the licensee's GMRS, as well as the staff's confirmatory GMRS, exceeds the SSE for FCS over a portion of the frequency range of 1 to 10 Hz, the licensee's IHS bounds the GMRS over this frequency range. Therefore, FCS was screened out for conducting a seismic risk evaluation. However, this screening decision is based on the licensee's commitment to successfully complete the IPEEE relay chatter review, in accordance with the IPEEE program screening criteria in the SPID. If the IPEEE relay chatter review is not successfully completed, the GMRS comparison would be with the SSE for the screening decision. Because the GMRS exceeds the SSE in the frequency range of 1 to 10 Hz, FCS would screen in for a plant seismic risk evaluation. The SFP evaluation is merited because the IPEEE program did not include the SFP and the GMRS exceeds the SSE. Additionally, in the frequency range above 10 Hz, the IHS bounds the GMRS. As such, a high frequency confirmation is 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 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 its SHSR, the licensee described its seismic design bases for FCS. The licensee stated that the SSE for FCS was developed by evaluating the maximum earthquake potential for the site region and was defined in terms of a peak ground acceleration (PGA) and a design response spectrum. The spectral shape for FCS is a Housner-type normalized to 0.17g. The licensee specified that the SSE control point is located at the ground surface at elevation 1,004.5 ft [306.2 m].

The NRC staff reviewed the licensee's description of its SSE in the SHSR for FCS. With regard to the SSE, based on its review of the SHSR and the Updated Safety Analysis Report (USAR) (OPPD, 2011), the NRC staff confirmed that the licensee's SSE is defined in terms of PGA and a design response spectrum anchored at 0.17 g. Finally, based on review of the SHSR and the USAR (OPPD, 2011), the NRC staff confirmed that the licensee's control point elevation for FCS's SSE is defined at the ground surface elevation, 1004.5 ft [306.2 m], consistent with the guidance provided 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). 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 Cheraw, Commerce, Meers, Marianna, New Madrid Fault System and Wabash Valley repeated large magnitude earthquake (RLME) sources which lie 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 in SHSR Section 2.2.2 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 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 FCS 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 FCS site. In addition, the NRC staff included all RLME sources falling within a 620 mi [1000 km] radius of the site, which include the Cheraw, Commerce, Eastern Rift Margin – North, Eastern Rift Margin – South, Marianna, Meers, Wabash Valley, and New Madrid Fault System RLME sources. 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 NRC 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 its review of the SHSR, the NRC staff concludes that the licensee 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 site 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 base rock 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 the licensee 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 FCS USAR (OPPD, 2011). The licensee stated that the site is underlain by approximately 75 ft [23 m] of fill and alluvial terraces overlying limestones and shales to a depth of 2,200 ft [671 m] with hard bedrock below.

Geophysical investigations for the FCS site consisted of refraction surveys, laboratory test, and ReMi (shear wave) methods. 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 1,000 feet per second (fps) [305 meters per second (m/s)] for the fill, 1,500 fps [457 m/s] for the alluvial terraces, 5,000 to 9,000 fps [1,524 to 2,740 m/s] for the limestone and shale, and upwards of 10,000 fps [3,048 m/s] for the competent Precambrian granite bedrock.

To characterize the subsurface geology, the licensee developed three site base case profiles. The licensee's middle, or best estimate, profile was developed using measured shear-wave velocities to a depth of 700 ft (213 m). Below this depth, the licensee used data from nearby water, oil and gas wells to develop the shear wave velocities. Consistent with the SPID, the licensee developed the upper and lower base case profiles using a scale factor of 1.25 in the upper 700 ft (213 m) and 1.57 below that depth. Figure 3.3-1 of this assessment shows the licensee's three shear-wave velocity base case profiles.

In Section 2.3.2.1 of its SHSR, the licensee assumed that materials at the site could be modeled as either linear or nonlinear and used two, equally weighted, sets of modulus reduction and damping curves to accommodate these alternatives. Consistent with the SPID, the licensee used the EPRI soil and rock curves to model the upper limit of nonlinearity expected at the site over the upper 500 ft (152 m) of the subsurface. To model the lower limit of nonlinearity expected at the site, the licensee used the Peninsular Range curves for soils and a constant low strain damping, consistent with the low strain damping values from the EPRI rock curves, for the underlying rock over the upper 500 ft (152 m) of the subsurface.

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 FCS, the licensee estimated kappa based on the low-strain damping over the top 500 ft (152 m) and a constant damping of 1.25 percent for the rock layers below 500 ft (152 m) in order to calculate kappa values for each of the three base case profiles. The licensee also added an additional kappa value of 0.006 sec to account for damping in the underlying base rock material, resulting in total profile kappa values for the best estimate, upper, and lower base case velocity profiles of 0.020, 0.013, and 0.025 sec, respectively.

To account for randomness in material properties across the plant site, the licensee stated that it randomized its base case shear-wave velocity profiles in accordance with Appendix B of the SPID. In addition, the licensee randomized the depth to bedrock by ±660 ft (201 m) for the best estimate and lower base cases, which corresponds to 30-percent of the total profile thickness.

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 the cases analyzed. Amplification functions are shown for eleven input loading levels for the base case profile with EPRI soil and firm 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 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 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 FCS site. The NRC staff independently developed a shear-wave velocity profile, damping values, and modeled the nonlinear behavior of the subsurface using measurements and geologic information provided in the FCS USAR (OPPD, 2011) 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.

Following guidance provided in the SPID for sites with little at-site information, the NRC staff independently determined best-estimate, upper and lower base case profiles for the FCS site. To develop upper and lower base case profiles, the NRC staff used a scale factor of 1.57. The staff's base case shear-wave velocity profiles are shown along with the licensee's base case profiles in Figure 3.3-1 of this assessment. The staff's shear wave velocity profiles are similar to those submitted by the licensee with only a minor difference in the estimated depth to individual sedimentary rock formations and the staff's interpretation of a shear wave velocity estimate of 7200 fps (2195 m/s) for a 130 ft (40 m) thick layer at a depth of 170 ft (52 m). The staff's estimate of 7200 fps (2195 m/s) is based on shear wave velocity estimates of similar rock formations.

Similar to the approach used by the licensee, the NRC staff used the SPID guidance to characterize the dynamic material behavior of the base case profiles. The NRC staff assumed that the material in the upper 500 ft. could behave both linearly and non-linearly in response to the range of input loading motions. For soil type material, the NRC staff used the EPRI soil curves to model the more non-linear response and the Peninsular curves to represent the more linear alternative. For the underlying rock, the NRC staff used the EPRI rock curves to represent non-linear response, and a constant damping value of about three percent to model the linear alternative. The NRC staff weighted each of these alternatives equally in the site response analysis.

To determine kappa for its three profiles, the NRC staff used the low strain damping values, shear-wave velocities, and layer thicknesses for each geologic layer to arrive at values of 0.015, 0.019, and 0.014 sec, for the best-estimate, lower, and upper base cases, respectively. These values include the 0.006 sec contribution from the reference rock. To model the uncertainty in kappa, the NRC staff used a natural log standard deviation of 0.35 to calculate lower and upper values of kappa for each profile. This approach results in nine kappa values for the staff's site response analysis, which range from 0.009 to 0.030 sec.

Figure 3.3-2 of this assessment shows a comparison of the staff's and the licensee's median site amplification functions and associated uncertainties (±1 standard deviation) for two of the eleven input loading levels. Both the staff's and licensee's site amplifications are similar in shape; however, the licensee has a higher peak amplification at 5 Hz compared with the staff's result. The licensee's larger peak amplification is due to differences in the staff's and licensee's velocity profiles as well as differences in the range of kappa values used by the NRC staff and licensee for the site response analyses.

As shown in Figure 3.3-3 of this assessment, differences in site response analyses have only a minor impact on the control point seismic hazard curves and the resulting GMRS, discussed below. Overall, the control point seismic hazard curves develop by the NRC staff are similar to those developed by the licensee. 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 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 FCS 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 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 NRC staff assessment, respectively. Figure 3.4-1 of this assessment shows a comparison of the GMRS determined by the licensee to that determined by the NRC staff.

As shown in Figure 3.4-1 below, the licensee's and staff's GMRS are very similar. As described above in Section 3.3, the NRC staff concludes that these minor differences are primarily due to the differences in the site response analyses performed by the licensee and NRC staff. 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 staff concludes that the GMRS determined by the licensee adequately characterizes the reevaluated hazard for the FCS 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 FCS site. Based on its review, the NRC staff concluded 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. The NRC staff concluded that the licensee demonstrated meeting the IPEEE screening criteria in the SPID, and therefore, the IHS could be used for comparison with the GMRS for the screening decision provided that the relay chatter review is completed. Based upon the preceding analysis and with the completion of the relay review, the NRC staff concludes that the licensee provided an acceptable response to Requested Information Items (1)-(3) and (5)-(7), and the comparison portion of 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 will perform the full - scope IPEEE relay chatter review to complete the criteria for using the IPEEE program to demonstrate that a seismic risk evaluation (Item (8)) is not merited, as described in the SPID. Further, the HF confirmation portion of Item (4) is not merited if the IPEEE relay chatter review is completed because the IHS bounds the GMRS in the frequency range above 10 Hz. A SFP evaluation (Item 9) is merited because the SFP was not included in the IPEEE program.

If the relay chatter review is not successful in demonstrating relay adequacy, then a case-by-case justification to a limited number of exceptions would be expected. Failure to meet the IPEEE program screening criteria in the SPID would merit screening by the GMRS to the SSE and then a seismic risk evaluation, SFP evaluation, and HF confirmation would be merited because the GMRS exceeds the SSE.

The NRC review and acceptance of the OPPD's SFP evaluation and IPEEE relay chatter review will complete the Seismic Hazard Evaluation for FCS identified in 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, March 2007.

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

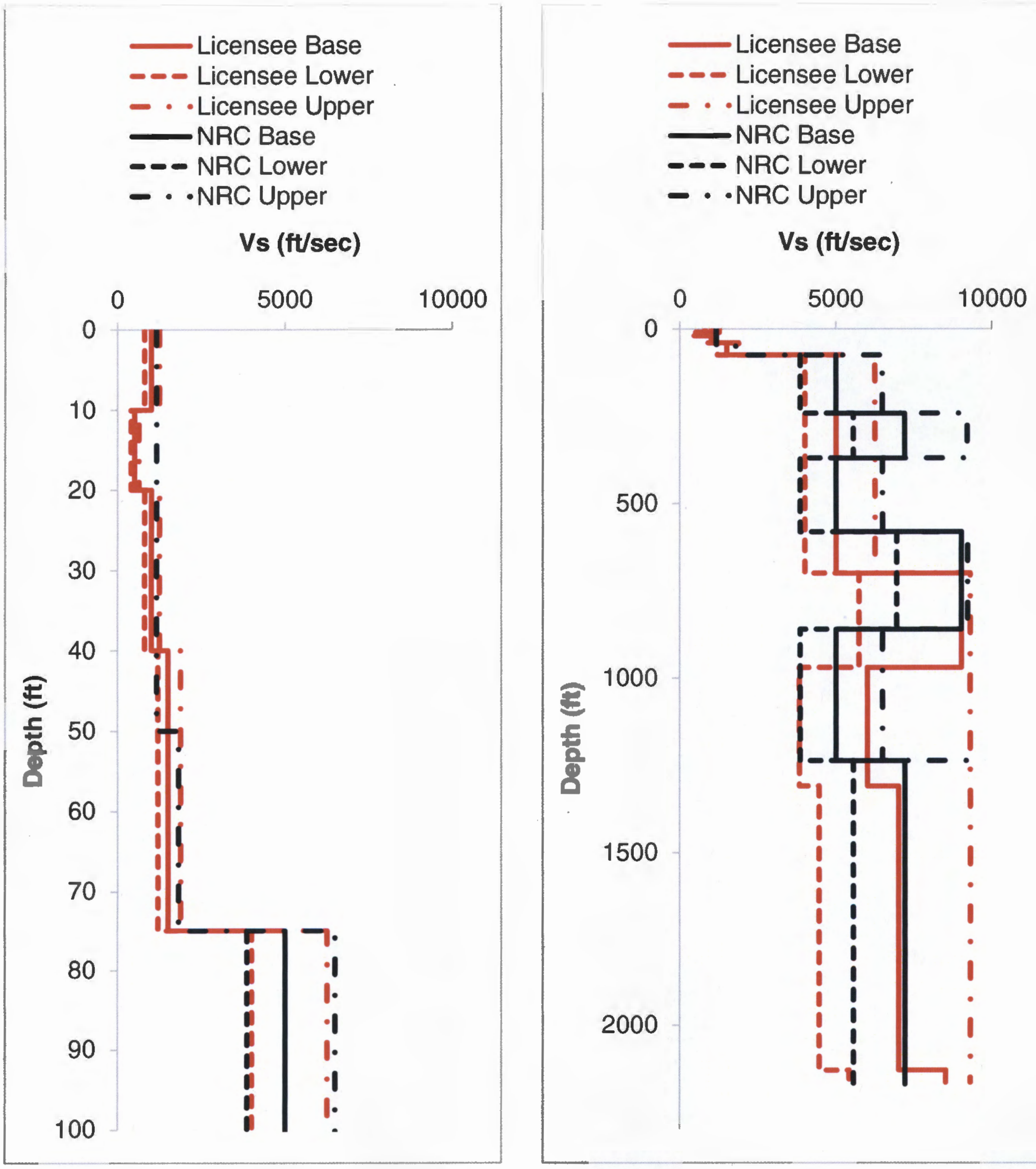


Figure 3.3- 2 Plot Comparing the Staff's and the License's Median Amplification Functions and Uncertainties for two input loading levels for the FCS site

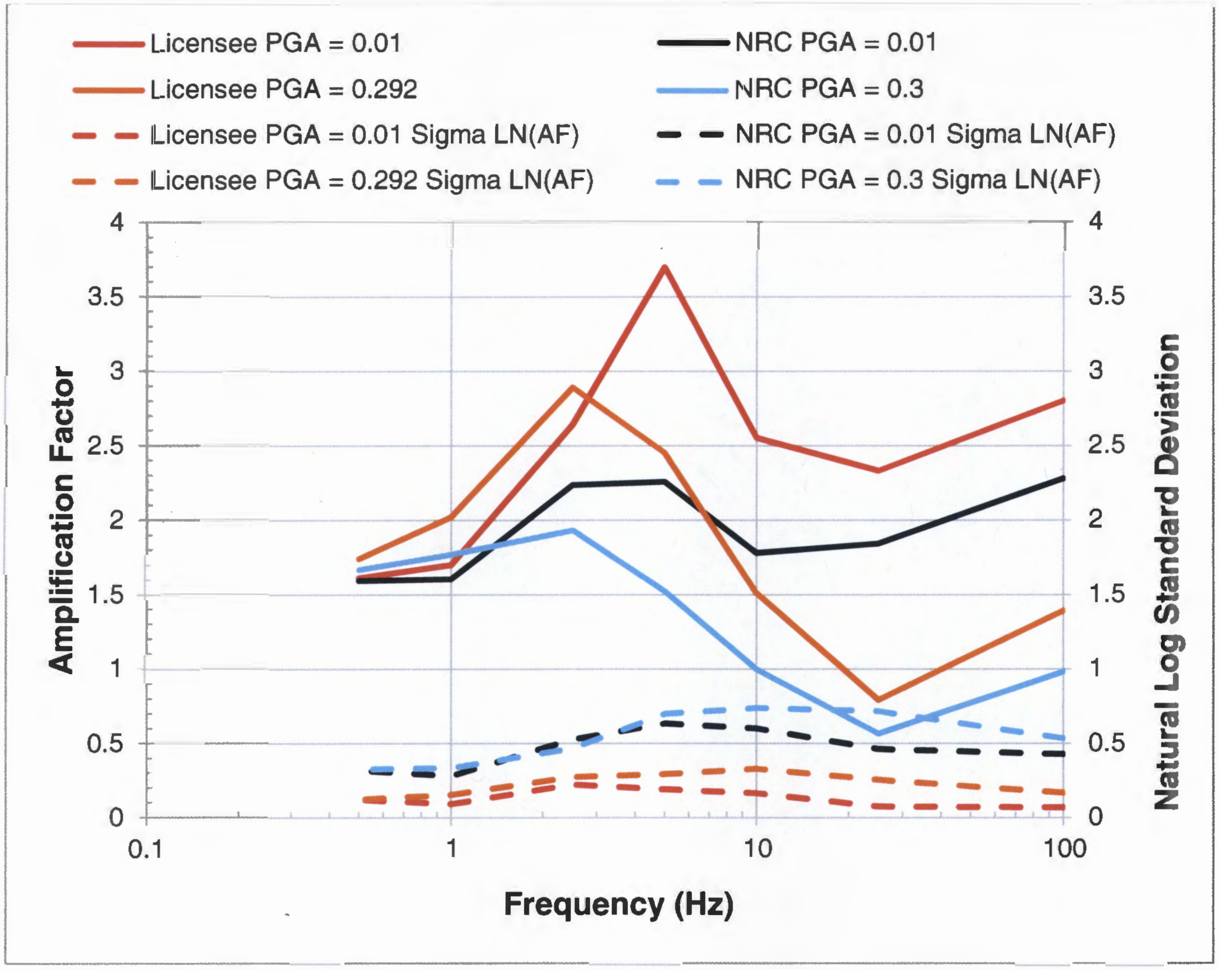


Figure 3.3-3 Plot Comparing the Staff's and the Licensee's Mean Control Point Hazard Curves at a Variety of Frequencies for the FCS site

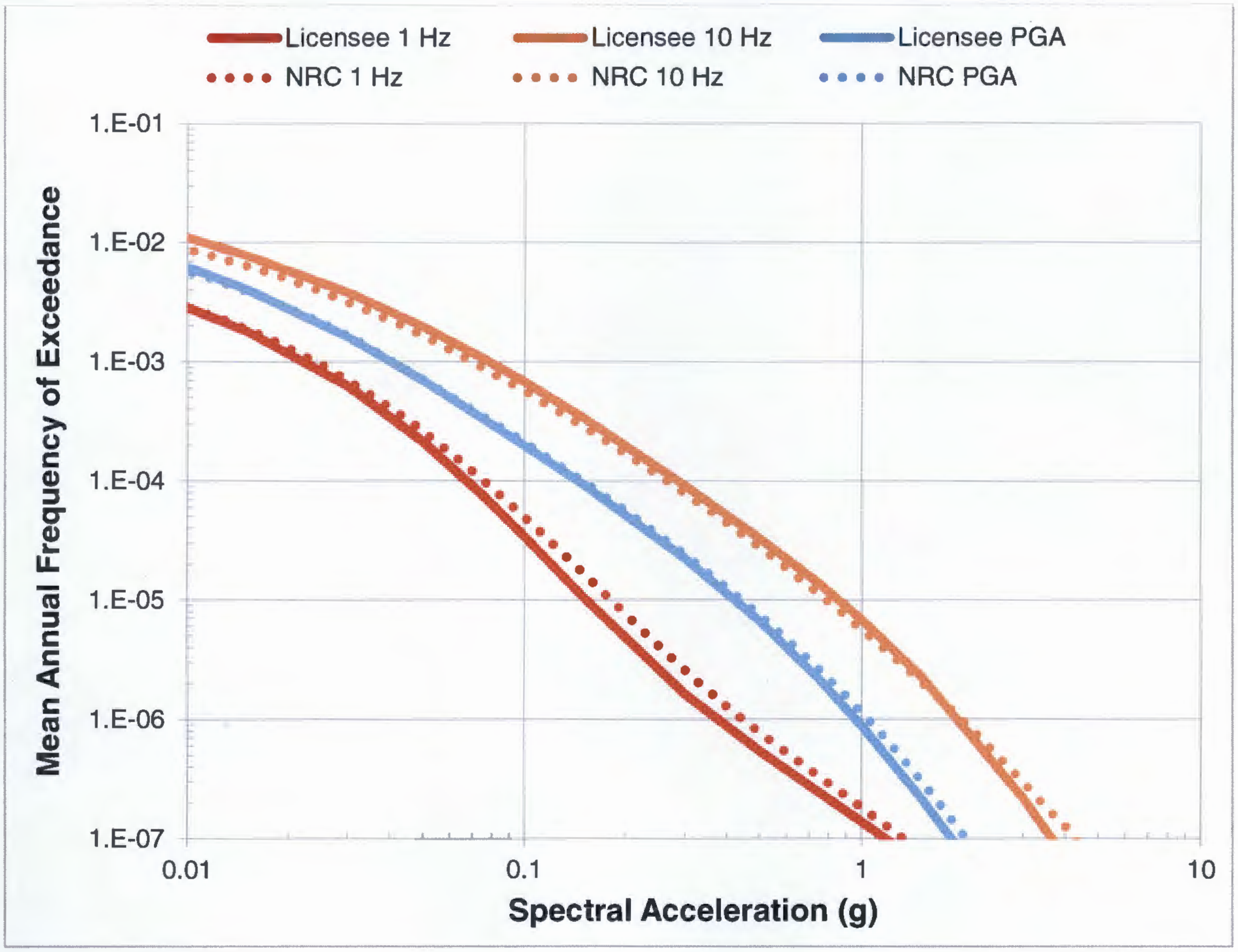
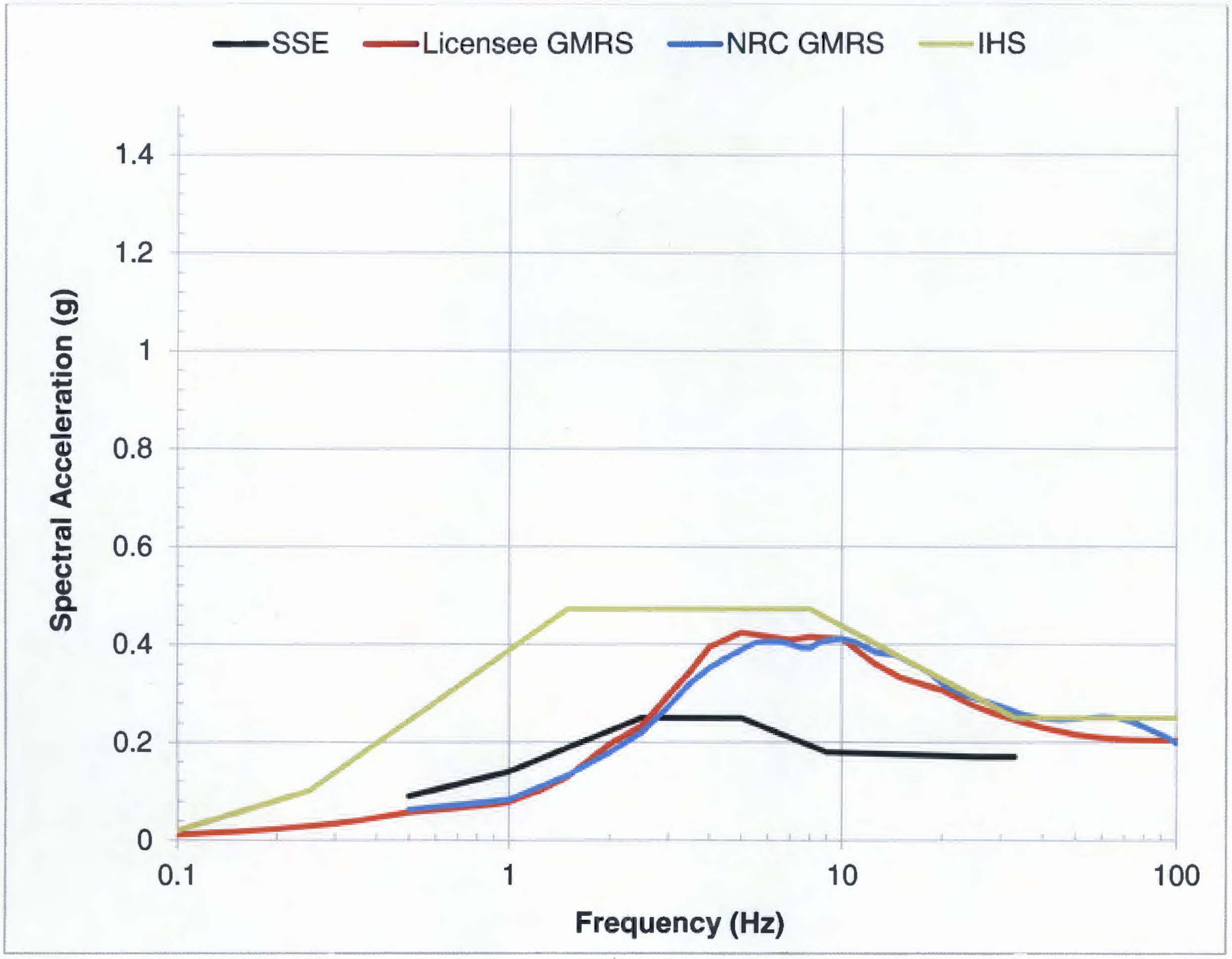


Figure 3.4-1 Comparison of the Staff's GMRS with Licensee's GMRS and the SSE for the FCS site



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

Sincerely,

/RA/

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

Docket No. 50-285

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