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

April 21, 2015

Mr. Joseph W. Shea
Vice President, Nuclear Licensing
Tennessee Valley Authority
1101 Market Street, LP 3D-C
Chattanooga, TN 37402-2801

SUBJECT: BROWNS FERRY NUCLEAR PLANT, UNITS 1,2 AND 3 - 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. MF3764, MF3765 AND MF3766)

Dear Mr. Shea:

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, Tennessee Valley Authority (TVA), responded to this request for Browns Ferry Nuclear Plant, Units 1, 2 and 3 (BFNP).

The NRC staff has reviewed the information provided related to the reevaluated seismic hazard for the BFNP site and, as documented in the enclosed staff assessment, determined that you provided sufficient information in response to Enclosure 1, Items (1) – (3), (5), (7) and screening review portion of Item (4) of the 50.54(f) letter. Further, the 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's review and acceptance of TVA's expedited seismic evaluation process, and seismic risk evaluation including the high frequency confirmation and spent fuel pool evaluations (i.e., Items (4), (6), (8), and (9)) for BFNP, Units 1,2 and 3, the Seismic 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) 415-1617 or at Frankie.Vega@nrc.gov.

Sincerely,

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

Docket Nos. 50-259, 50-260 and 50-296

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

BROWNS FERRY NUCLEAR PLANT, UNITS. 1, 2, AND 3

DOCKET NOS. 50-259, 50-260, AND 50-296

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 requested 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 licensees to submit Requested Information Items (1) through (7) within 1.5 years of the date of the 50.54(f) letter for sites within the Central and Eastern United States (CEUS). Specifically, the NRC requested 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 for screening purposes. 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) Selected risk evaluation approach (if 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 referred to as 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 staff endorsed the SPID.

The required response section of Enclosure 1 to the 50.54(f) letter specifies that 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 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 March 31, 2014 (Shea, 2014), Tennessee Valley Authority (TVA or the licensee) submitted partial site response information for Browns Ferry Nuclear Plant (BFNP or Browns Ferry), Units 1, 2, and 3. By letter dated March 31, 2014 (Shea, 2014), TVA submitted its Seismic Hazard and Screening Report (SHSR) for BFNP Units 1, 2 and 3.

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." 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. Generally plants with construction permits issued prior to May 21, 1971, were approved for construction based on proposed GDC published by the Atomic Energy Commission (AEC).

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. According to updated Final Safety Analysis (UFSAR) Appendix A, Browns Ferry, Units 1, 2 and 3 followed the proposed AEC GDC Criterion 2 when developing its seismic design-basis which meets the intent of GDC 2 in Appendix A to 10 CFR Part 50. 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 (Shea, 2014), TVA provided the SHSR for the BFNP, Units 1, 2, and 3. The licensee stated that the GMRS exceeds the SSE over the frequency range of 1 to 10 Hertz (Hz) range. However, the licensee indicated that in that range the GMRS is bounded by the site Individual Plant Examination of External Events (IPEEE) plant-level high confidence of low probability of failure spectrum. The licensee provided the evaluation of the IPEEE screening criteria referenced in the SPID to credit the plant capacity determined in the IPEEE program. Therefore, the licensee determined it would not perform a seismic risk evaluation. For the range above 10 Hz, the GMRS exceeds the SSE. Therefore, the licensee stated that it would perform a high-frequency confirmation. Further, the licensee indicated that since the GMRS also exceeds the SSE in the range of 1 to 10 Hz and a SFP evaluation was not included in the original IPEEE program, BFNP screens in for a SFP evaluation.

On May 9, 2014 (NRC, 2014), the staff issued a letter providing the outcome of its 30-day screening and prioritization evaluation. In the letter, the staff characterized the site as screened in. This was based on the staff determination that the IPEEE program did not meet the IPEEE program screening criteria described in the SPID. The licensee's GMRS as well as the confirmatory GMRS developed by the staff, exceed the SSE for BFNP, Units 1, 2, and 3 above approximately 3 Hz to 100 Hz range. Therefore, a plant seismic risk evaluation, a SFP evaluation and a high frequency confirmation are merited for BFNP, Units 1, 2 and 3.

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 to 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 BFNP, Units 1, 2 and 3. The licensee stated that the SSE for the BFNP site is based on the evaluation of the maximum earthquake potential for the region surrounding the site. Considering the historic seismicity of the site region, the licensee determined that the maximum potential earthquake would produce a ground motion intensity of VII on the Modified Mercalli Intensity (MMI) scale. The SSE is defined in terms of a PGA and a design response spectrum. Considering a site intensity of VII, the licensee estimated a PGA of 0.20 g (20 percent of the acceleration due to Earth's gravity) as the anchor point for the SSE (final safety analysis report (FSAR), Section 2.5.4 and Figure 2.5-9). In Section 3.2 of the SHSR, the licensee defined the SSE control point elevation at a depth of 52 ft [16 m] (AMEC, 2013), (EPRI, 2014), which is at the top of the dolomite and limestone bedrock beneath the plant.

The staff reviewed the licensee's description of its SSE for BFNP, Units 1, 2, and 3 in the SHSR. The staff performed its screening evaluation for Units 1, 2, and 3 based on a comparison of the GMRS with the licensee's SSE, which is a Housner shape design spectrum anchored at 0.20 g. Finally based on review of the SHSR and the UFSAR, the staff confirmed that the licensee's control point elevation for BFNP is consistent with the guidance provided in the SPID.

3.2 Probabilistic Seismic Hazard Analysis

In Section 2.2 of the 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**) of **M**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 Charleston, Commerce, Eastern Rift Margin Fault northern segment, Eastern Rift Margin Fault southern segment, Marianna, New Madrid Fault System, and Wabash Valley repeated large magnitude earthquake (RLME) sources, which lie within 620 miles [1000 km] of the site. 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. 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 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 staff performed PSHA calculations for base or reference rock site conditions at the BFNP site. As input, the 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 staff included all CEUS-SSC background seismic sources within a 310 mi [500 km] radius of the BFNP site. In addition, the staff included all of the RLME sources falling within a 620 mi [1000 km] radius of the site, which include the Charleston, Commerce, Eastern Rift Margin Fault northern segment, Eastern Rift Margin Fault southern segment, Marianna, New Madrid Fault System, and Wabash Valley 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 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 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 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 a detailed description of the site profile in Sections 2.3.1 and 2.3.2 of its SHSR based on the information documented in AMEC (2013), and EPRI (2014). The information used to create the site geologic profile at the site is shown in Tables 2.3.1-1 and 2.3.1-2 of the SHSR. According to Table 2.3.1-1, the SSE control point at a depth of 52 ft [16 m] (Elevation 513 ft [156 m] lies on limestone of Lower Mississippian age (Fort Payne Chert; Table 2.3.1-2) which is about 200 ft [61 m] thick. The best estimate shear-wave velocity for the Fort Payne Chert is 9500 ft/s [2895 m/s] at the depth of the SSE control point (Table 2.3.1-2). In Table 2.3.1-2 the shear-wave velocities at greater depths range from 7000 ft/s (2133 m/s) to 9500 ft/s (2895 m/s). There is about 3973 ft [1211 m] of firm Paleozoic sedimentary rocks overlying hard basement rock, which is assumed to occur at the top of the Rome Formation beneath the site. Based on the limited amount of site subsurface measurements, the licensee used a scale factor of 1.57 to develop upper and lower base case profiles, reflecting the overall uncertainty in the properties of the rock beneath the site.

The licensee stated that because no site-specific dynamic material properties were determined in the initial BFNP siting, it followed the SPID guidance for firm rock sites by selecting two alternative characterizations of dynamic material behavior with equal weights. In the upper 500 ft [152 m] the licensee used the EPRI rock curves for one model and for the second model the licensee assumed a linear response with a low-strain damping value of about 3 percent. For the deeper rock layers below 500 ft [152 m] to the reference or base rock rock elevation, the licensee assumed a linear response and used a lower damping value of 1.25 percent.

To characterize the low-strain damping or kappa value for the rock layers, the licensee used the guidance in Appendix B of the SPID (EPRI, 2012) for firm rock sites with at least 3,000 ft [1,000 m] in thickness. For the three profiles, the licensee estimated kappa values of 0.006 sec for the best estimate and upper profiles and 0.012 sec for the lower base case profile. These very low values for kappa are consistent with the very stiff hard rock layers beneath the site.

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 the SPID. In addition, the licensee randomized the depth to bedrock by 30 percent of the total profile thickness. The licensee stated that this randomization was included to provide a realistic broadening of the spectral peaks and to reflect random variations in depth-to-basement shear 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 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 two of the eleven input loading levels for the base case profile and EPRI rock 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 3.2 of this assessment), 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 staff performed a site response confirmatory evaluation for the BFNP site. The staff independently developed shear-wave velocity profiles, damping values, and modeled the potential nonlinear behavior of the rock using measurements and geologic information provided in the BFNP UFSAR, and the guidance in Appendix B of the SPID. For its site response calculations, the staff employed the RVT approach and developed input ground motions in accordance with Appendix B of the SPID.

The NRC staff developed three velocity profiles based on the geological information in UFSAR (TVA, Amendment 25.3). Core information from 29 holes drilled in the main plant area places the bedrock at about 50 ft [15 m] below the ground surface. The bedrock below the control point is limestone of Mississippian age Fort Payne Formation. The staff used laboratory measurements of limestone shear-wave velocity reported in Mavko et al. (2009) as well as the velocity profiles in EPRI (2008) to develop its three base case profiles. The measured shear wave velocity for limestone (Mavko et al., 2009) ranges between 5,479 ft/s [1,670 m/s] and 9,974 ft/s [3,040 m/s]. Assuming that this range represents 10 percent and 90 percent fractiles in a log-normal distribution, NRC staff estimated the median shear wave velocity of 7,392 ft/s [2,253 m/s] for the best estimate profile. To develop the upper and lower profiles, the staff assumed a standard deviation of 0.23, which is consistent with the guidance in the SPID. The NRC staff placed the reference or base rock boundary at a depth of 6,562 ft [2,000 m] below the control point (EPRI, 2008). Figure 3.3-1 of this assessment shows a comparison between the staff's and the licensee's base case profiles. The staff's best estimate base-case profile is similar to that of the licensee; however, the licensee's upper and lower profiles are wider, which reflects the licensee's use of a higher standard deviation (0.35) than that used by the staff (0.23).

To characterize the dynamic material behavior of the rock as well as the low-strain damping or kappa value, the staff used the same approach as the licensee. In addition, to account for aleatory variability in material properties across the plant site, the staff randomized its base case shear-wave velocity profiles following the guidance provided in Appendix B of the SPID. Finally, similar to the licensee's approach, the NRC staff randomized the depth to bedrock by 30 percent of the total profile thickness.

Figure 3.3-2 of this assessment shows a comparison of the staff and the licensee median site amplification functions and uncertainties for two of the eleven input loading levels. As shown in this figure, the licensee's amplification functions are slightly higher at frequencies below 2 Hz, and above 8 Hz. The standard deviations of the licensee are almost identical to those of NRC below 10 Hz, but lower at frequencies above 10 Hz. The differences in the amplification functions are mainly due to differences in the velocity profiles of the staff and the licensee; however, these small differences are within the limits of the uncertainty, and judged by staff to be reasonable.

Overall, the licensee's approach to modeling the subsurface rock properties and their uncertainty, results in similar site amplification factors. As shown in Figure 3.3-3 of this assessment, the control point hazard curves developed by the licensee and the staff are also very similar. 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 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 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 BFNP 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 of this assessment shows a comparison of the GMRS determined by the licensee to that determined by the staff.

As shown in Figure 3.4-1, the licensee's GMRS shape is generally similar to that calculated by the staff at frequencies less than 10 Hz. However, NRC staff's confirmatory GMRS is somewhat lower than the licensee's at frequencies above 10 Hz. As described in Section 3.3 of this assessment, the staff concludes that these minor differences over the higher frequency range are primarily due to the differences in velocity profiles as part of the site response analyses performed by the licensee and staff. The staff concludes that these minor 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 BFNP 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 BFNP 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 BFNP 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 screening review portion of Item (4), identified in Enclosure 1 of the 50.54(f) letter, dated March 12, 2012. Further, the licensee's reevaluated seismic hazard is acceptable to address other actions associated with NTTF Recommendation 2.1, "Seismic".

In reaching this determination, staff confirms the licensee's conclusion that the licensee's GMRS for the BFNP site exceeds the SSE above approximately 3 Hz to 100 Hz range. As such, a seismic risk evaluation, SFP evaluation, and high-frequency confirmation are merited for BFNP, Units 1, 2 and 3. NRC review and acceptance of the TVA seismic risk evaluation, and also an

ESEP interim evaluation, SFP evaluation, and high frequency confirmation (i.e., Items (4), (6), (8), and (9)) for BFNP, Units 1, 2 and 3 will complete the items requested in Enclosure 1 of the 50.54(f) letter.

REFERENCES

Note: ADAMS Accession Nos. refer 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), 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.

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

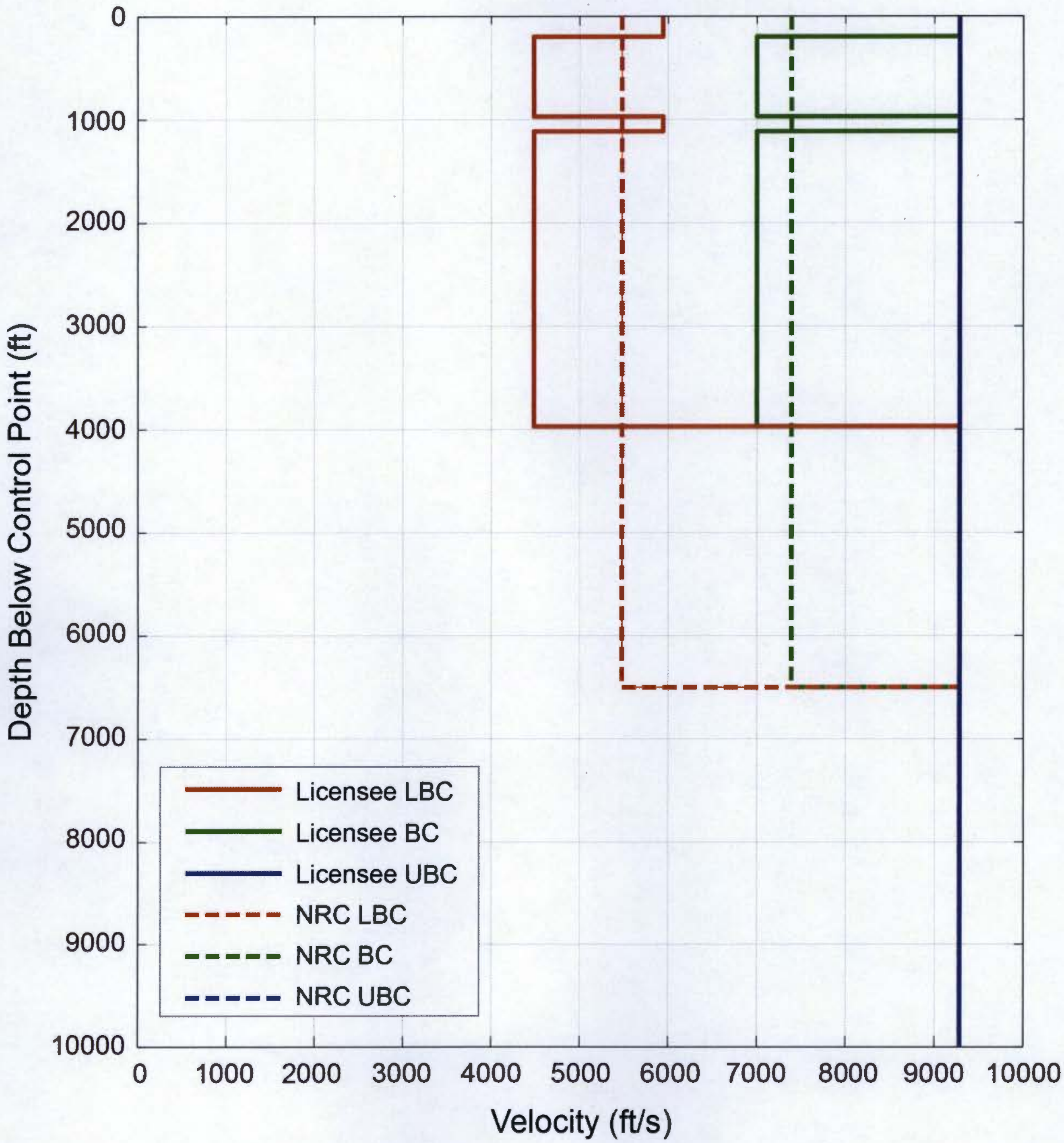


Figure 3.3- 1 Plot Comparing the Staff's and the License's Median Amplification Functions and Uncertainties for the BFNP site

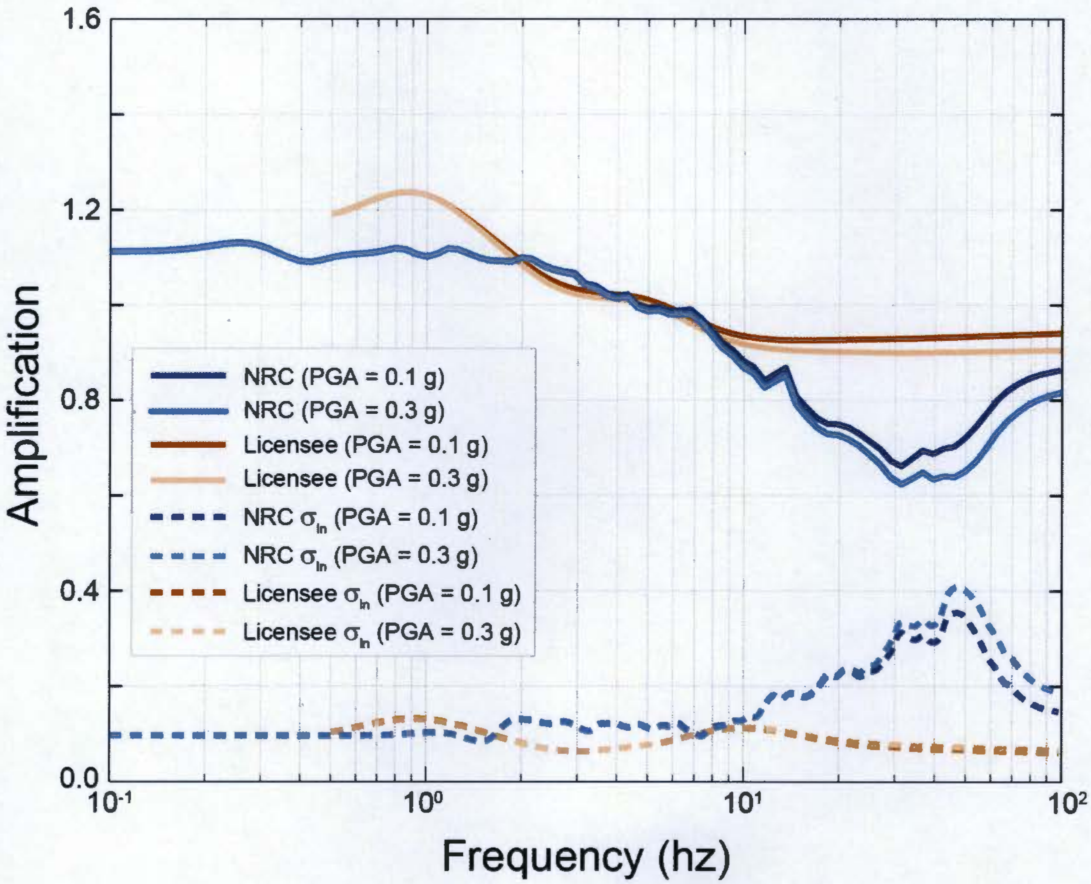


Figure 3.3-2 Plot Comparing the Staff's and the Licensee's Mean Control Point Hazard Curves at t a Variety of Frequencies for the BFNP site

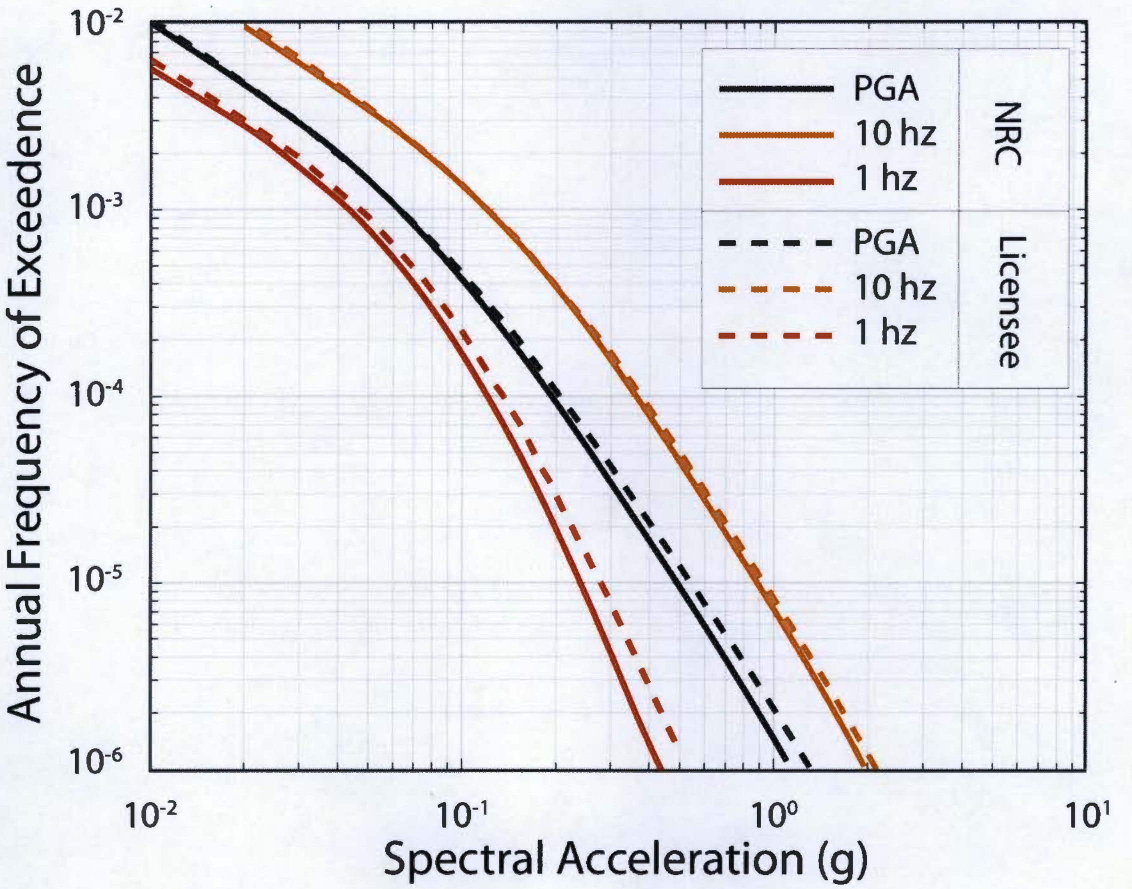
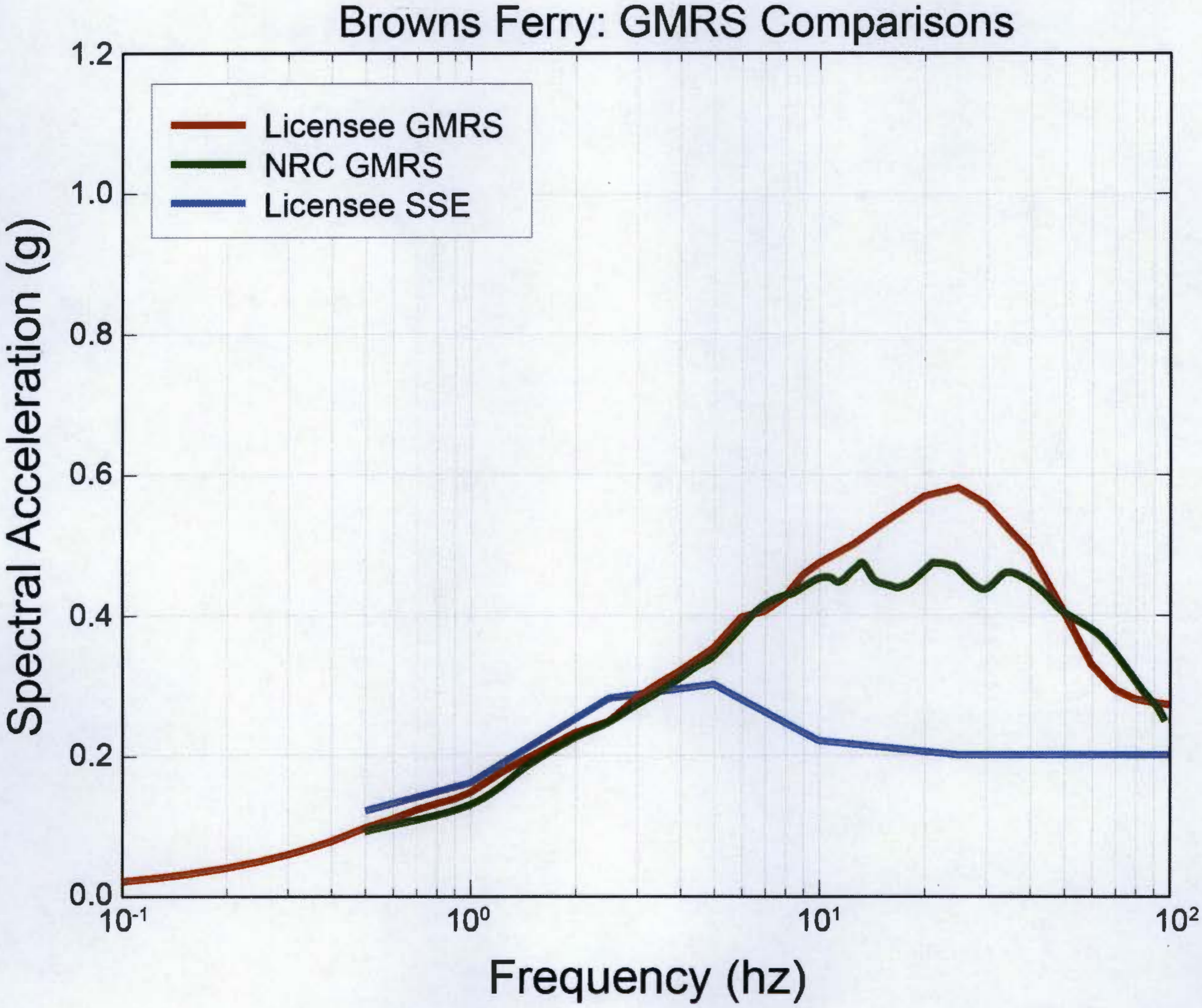


Figure 3.4-1 Comparison of the Staff's GMRS, Licensee's GMRS, and the SSE for the BFNP site



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

Docket Nos. 50-259, 50-260 and 50-296

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