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

July 20, 2015

Mr. Steven D. Capps
Vice President – McGuire Site
Duke Energy Carolinas, LLC
McGuire Nuclear Station
12700 Hagers Ferry Road
Huntersville, NC 28078-8985

SUBJECT: MCGUIRE NUCLEAR STATION, UNITS 1 AND 2 - 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. MF3689 AND MF3690)

Dear Mr. Capps:

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.

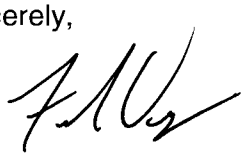
By letter dated March 20, 2014, Duke Energy Carolinas, LLC (Duke, the licensee), responded to this request for McGuire Nuclear StationMcGuire, Units 1 and 2 (McGuire).

The NRC staff has reviewed the information provided related to the reevaluated seismic hazard for McGuire 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 the comparison 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 staff's review and acceptance of the licensee's expedited seismic evaluation process and seismic risk evaluation including the high frequency confirmation and spent fuel pool evaluation (i.e., Items (4), (6), (8), and (9)) for McGuire, 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
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Office of Nuclear Reactor Regulation

Docket Nos. 50-369 and 50-370

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

WMCGUIRE NUCLEAR STATION, UNITS 1 AND 2

DOCKET NOS. 50-369 AND 50-370

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

The required response section of Enclosure 1 to the 50.54(f) letter specifies that Central and Eastern United States (CEUS) licensees provide their Seismic Hazard and Screening Report (SHSR) by 1.5 years after issuance of the 50.54(f) letter. However, in order to complete its update of the EPRI seismic ground motion models (GMM) for the CEUS (EPRI, 2013), industry proposed a six-month extension to March 31, 2014, for submitting the SHSR. Industry also proposed that licensees perform an expedited assessment, referred to as the Augmented Approach, for addressing the requested interim evaluation (Item 6 above), which would use a simplified assessment to demonstrate that certain key pieces of plant equipment for core cooling and containment functions, given a loss of all alternating current power, would be able to withstand a seismic hazard up to two times the design basis. Attachment 2 to the April 9, 2013, letter (Pietrangelo, 2013) provides a revised schedule for plants needing to perform (1) the Augmented Approach by implementing the Expedited Seismic Evaluation Process (ESEP) and (2) a seismic risk evaluation. By letter dated May 7, 2013 (NRC, 2013a), the NRC determined that the modified schedule was acceptable and by letter dated August 28, 2013 (NRC, 2013c), the NRC determined that the updated GMM (EPRI, 2013) is an acceptable 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 11, 2013 (Waldrep, 2013), Duke Energy Carolinas, LLC (Duke, the licensee) submitted partial site response information for the McGuire Nuclear Station McGuire, Units 1 and 2 (McGuire) site. By letter dated March 20, 2014 (Waldrep, 2014), the licensee submitted its SHSR for McGuire, Units 1 and 2.

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 requests 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 20, 2014 (Waldrep, 2014), the licensee provided the SHSR for the McGuire site. The licensee's SHSR indicates that the site GMRS exceeds the SSE for the McGuire site over the frequency range of 1 to 10 Hz. Therefore, the licensee will perform a seismic risk evaluation, as well as a SFP evaluation. In addition, the licensee stated that since the GMRS also exceeds the SSE above 10 Hertz (Hz), that it will perform a high frequency confirmation as part of the plant risk evaluation.

On May 9, 2014 (NRC, 2014), the staff issued a letter providing the outcome of its 30-day screening and prioritization evaluation. As indicated in the letter, the staff confirmed the licensee's screening results. The licensee's GMRS, as well as the staff's confirmatory GMRS, exceed the SSE for the McGuire site over the frequency range of approximately 6 to 100 Hz. Therefore, a seismic risk evaluation, SFP evaluation and high frequency confirmation are merited for McGuire.

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 that the licensee provide the SSE ground motion values, as well as the specification of the control point elevation 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 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 bases for the McGuire site and states that the SSE is defined in terms of a peak ground acceleration (PGA) and a design response spectrum. The response spectral shape is anchored at a PGA of 0.15 g (15 percent of the acceleration due to earth's gravity). This anchor point for the SSE is based on an evaluation of the ground motion intensity from the maximum regional earthquake, which for McGuire is the 1886 Charleston earthquake. In addition, the licensee stated that the McGuire site SSE is based on a Newmark-type spectral shape, as indicated in the Updated Final Safety Analysis Report (UFSAR) (Duke Energy, 2013).

In Section 3.2 of its SHSR, the licensee specified that the SSE control point is defined in the McGuire UFSAR (Duke Energy, 2013) at the top of sound rock. The licensee stated that the elevation of the top of sound rock varies throughout the site and all major Category 1 structures

are founded on sound rock. Therefore, the licensee used an SSE control point elevation of 716.5 ft (218.4 m) located at the top of the base of the mat foundation of the reactor buildings).

The NRC staff reviewed the licensee's description of its SSE for the McGuire site in the SHSR. With regard to the SSE for the McGuire site, based on its review of the SHSR and UFSAR (Duke Energy, 2013), the NRC staff confirmed that the licensee's SSE is a Newmark-type spectrum anchored at 0.15 g. Finally, based on review of the SHSR and the UFSAR (Duke Energy, 2013), the NRC staff confirmed that the licensee's control point elevation for McGuire site SSE is 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). The licensee used a minimum magnitude (**M**) of 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 miles (640 km) around the site and included the Charleston, Commerce, Eastern Rift Margin Fault northern and southern segments, Marianna, New Madrid Fault System, and Wabash Valley repeated large magnitude earthquake (RLME) sources, which lie within 621 mi (1,000 km) of the site. The RLME sources are those source areas or faults for which more than one large magnitude ($\mathbf{M} \geq 6.5$) 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 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 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 conditions at the McGuire 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 McGuire site. In addition, the NRC staff included RLME sources which lie within 621 mi (1,000 km) of the site. For each of the CEUS-SSC sources used in the PSHA, the NRC 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 review of the SHSR, the NRC staff concludes that the licensee followed guidance provided in the SPID for selecting 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 generic or reference 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 licensees perform a site response analysis.

Detailed site response analyses were not typically performed for many of older the 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 cited in the UFSAR (Duke Energy, 2013). The licensee stated that the upland portion of the site where the main power block structures are located consists of approximately 20.5 ft (6.2 m) of firm rock overlying hard metamorphic basement rock at a depth of about 64 ft (19.5 m). The licensee described four major rock types appearing at the site: dark green meta-gabbro, light gray fine to medium grained granite, black and white fine grained diorite and black and white coarse grained diorite.

In Table 2.3.2-1 of the SHSR, the licensee provided the shear-wave velocities for the rock below the control point elevation of 56.5 ft (17.2 m) to the reference or baserock depth of 64 ft (19.5 m). These velocity measurements for the upper rock layers are based on downhole geophysical measurements and then an extrapolated value for the deeper rock. As described by the licensee, these geophysical surveys indicate that the shear-wave velocity in the upper 64 ft (19.5 m) ranges from 800 to 7,200 fps (244 to 2,286 m/sec). To develop its base case velocity profile, the licensee used these downhole measurements (AMEC, 2012) to estimate an average seismic shear-wave velocity of 4,750 fps (448 m/sec) for rock at the the control point to a depth of 6.5 ft (2 m). For the rock below this depth, the licensee estimated a shear-wave velocity of 7,200 fps (2,286 m/sec) to the assumed baserock depth of 20.5 ft (6.2 m).

To characterize the uncertainty in the subsurface rock properties, the licensee developed three site base case profiles at the McGuire site. The licensee developed the upper and lower base case profiles by assuming a natural log standard deviation of 0.20 about the middle or best case

profile. Figure 3.3-1 of this assessment shows the licensee's three shear-wave velocity base case profiles for the McGuire site.

As described in Section 2.3.2.1 of its SHSR, the licensee followed the SPID guidance for rock sites and selected two alternative characterizations for the site-specific dynamic material behavior. For the first characterization, the licensee assumed non-linear behavior for the rock and used the generic EPRI rock shear modulus and damping curves. For the second characterization, the licensee assumed the rock behaved linearly with a low strain damping value of about 3 percent. The licensee assigned equal weights to these two characterizations.

The licensee also considered the impact of kappa, or small strain damping, on the 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 McGuire site, the licensee used the low strain damping values, shear-wave velocities, layer thicknesses, and bedrock damping to arrive at kappa values for the best estimate, upper, and lower base case velocity profiles of 0.0062, 0.0063, and 0.0062 sec, respectively.

To account for randomness in material properties across the McGuire site, the licensee stated in Section 2.3.3 of its SHSR that it developed 30 random shear-wave velocity profiles from each of the base case profiles. In addition, as stated in Section 2.3.2 of its SHSR, the licensee randomized the depth to bedrock by ±4 ft (±1.2 m), which corresponds to 20 percent of the total profile thickness. The licensee stated that this randomization did not represent the actual uncertainty in the depth to bedrock, but was used to broaden the spectral peaks.

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 soil and 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 NRC staff performed site response calculations for the McGuire site. The NRC staff reviewed the licensee's site response analysis and performed confirmatory calculations to independently test the licensee's calculation

following the guidance in 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 staff conducted sensitivity tests to evaluate the licensee's location of the control point, use of multiple base case velocity profiles, and shear-wave velocity randomization. For all tests the staff randomized its lower, base, and upper case shear-wave velocity profiles using the guidance provided in the Appendix B of the SPID in order to account for aleatory variability. In addition, to capture the uncertainty in the depth to base rock, the staff randomized the depth to bedrock by ±4 ft (±1.2 m), which corresponds 20 percent of the total profile thickness. To account for randomness in the material properties across the plant site, the staff randomized its base case shear-wave velocity profiles in accordance with Appendix B of the SPID. Figure 3.3-1 of this assessment illustrates the velocity profiles the staff used in its confirmatory analysis. The staff determined both the upper and lower base case shear-wave velocity profiles using a natural log standard deviation of 0.2.

In the absence of any site-specific dynamic material property measurements, the NRC staff followed the SPID guidance for rock sites and selected two alternative characterizations of site-specific dynamic material behavior. In one characterization, the staff modeled non-linear behavior using the generic EPRI rock shear modulus and damping curves over the entire profile. In the second characterization, the NRC staff modeled linear behavior with a low strain damping value from the EPRI rock damping curves. The NRC staff assigned equal weights to the two characterizations.

To determine kappa for its final case profiles, the NRC staff used the low strain damping values, shear-wave velocities, layer thicknesses, and bedrock damping to arrive at kappa values for the best estimate, upper, and lower base case velocity profiles of 0.0062, 0.0063, and 0.0062 sec, respectively, which are similar to the licensee's.

Figure 3.3-2 of this assessment shows a comparison of the NRC staff's and licensee's median site amplification functions and uncertainties (±1 standard deviation) for two of the eleven input loading levels. Due to the use of very low damping values and modeling of the rock behavior as essentially linear for the range of input loading levels, the NRC staff's confirmatory amplification factors are essentially one for the entire frequency range. Although the licensee assumed non-linear behavior for the firm rock for the entire profile, as well as higher damping values to model the linear behavior, because the profile is relatively shallow, the licensee's amplification functions are also flat over the entire frequency range for the two loading levels shown in the SHSR.

As described above, the NRC staff conducted multiple confirmatory sensitivity tests to evaluate the licensee's characterization of the site subsurface properties, as well as the uncertainties associated with the rock properties. The sensitivity tests conducted by the NRC staff did not produce significant changes to the hazard at the site. Based on the sensitivity analyses and the NRC staff's confirmatory calculations, the NRC staff concludes that the licensee's evaluation for the McGuire site adequately captures the site amplification occurring as a result of bedrock ground motions traveling upward through the rock column to the control point elevation.

Overall, the licensee's approach to modeling the subsurface rock properties and to modeling their uncertainty results in similar amplification factors as those developed by the NRC staff. As shown in Figure 3.3-3 of this assessment, the NRC staff notes these differences in the site response do not have a large impact on the control point seismic hazard curves or the resulting GMRS, as 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 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 McGuire 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) 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 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 NRC staff.

As shown in Figure 3.4-1, the licensee's GMRS shape is generally similar to that calculated by the NRC staff at frequencies less than 45 Hz. However, the NRC staff's confirmatory GMRS is somewhat higher than the licensees at frequencies above 45 Hz. As described above in Section 3.3, the NRC staff concludes that these minor differences over the higher frequency range are primarily due to the differences in the site response analyses performed by the licensee and staff. The NRC staff concludes that the differences between the two GMRS 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 McGuire 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 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 McGuire 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 McGuire site. Based on its review, the NRC 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 the comparison portion of Item (4) identified in Enclosure 1 of the 50.54(f) letter. Information for Enclosure 1 of the 50.54(f) letter Items (6), (8) and (9), are required because the reevaluated seismic hazard level is not bounded by the design-basis SSE for frequencies between 1 to 10 Hz. 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 confirmed the licensee's conclusion that the licensee's GMRS for the McGuire site exceeds the SSE in the 1 to 10 Hz range, and also in the frequency range above 10 Hz. As such, a seismic risk evaluation, a high-frequency confirmation and SFP evaluation are merited. The NRC staff review and acceptance of Duke's seismic risk evaluation, high frequency confirmation, interim ESEP evaluation and SFP evaluation (i.e., Items (4), (6), (8), and (9)) for McGuire, Units 1 and 2 will complete the Seismic Hazard Evaluation identified in Enclosure 1 of the 50.54(f) letter.

REFERENCES

Note: ADAMS Accession Nos. refers to documents available through NRC's Agencywide 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.

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.

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

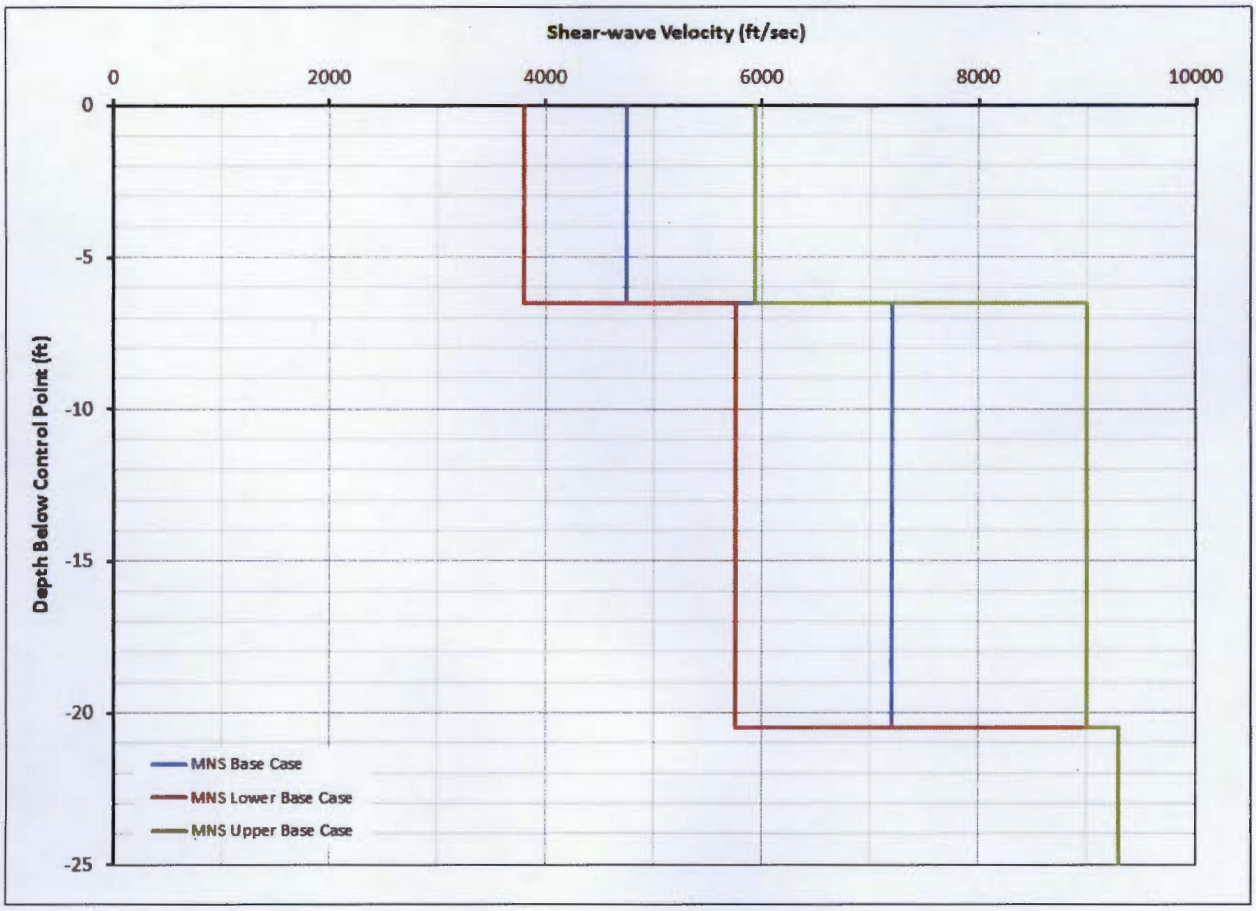

Figure 3.3-2 Plot Comparing the Staff's and the License's Median Amplification Functions and Uncertainties for two input loading levels for the McGuire site

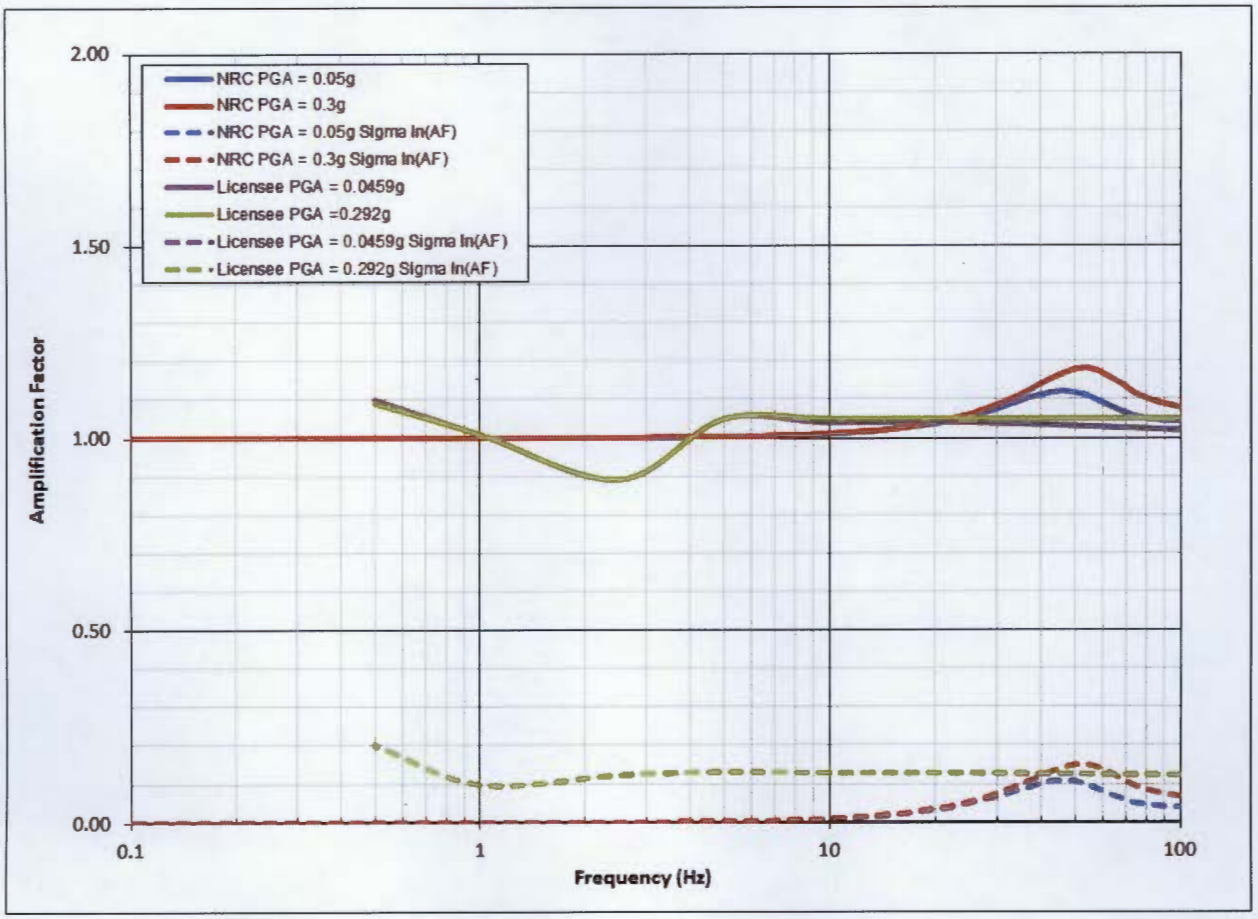

Figure 3.3-3 Plot Comparing the Staff's and the Licensee's Mean Control Point Hazard Curves at a Variety of Frequencies for the McGuire site

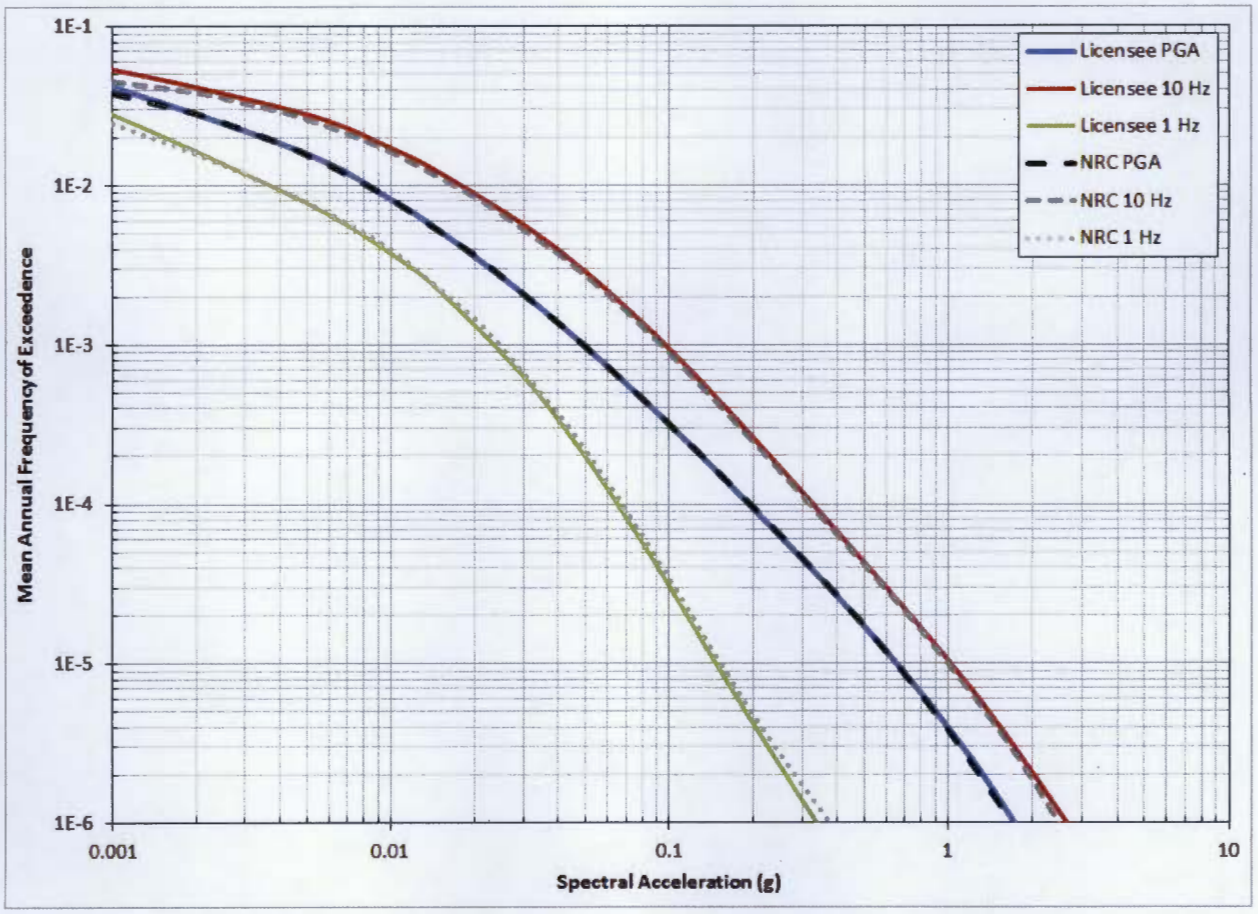

Figure 3.4-1 Comparison of the Staff's GMRS with Licensee's GMRS and the SSE for the McGuire site

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 Nos. 50-369 and 50-370

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