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

April 27, 2015

Mr. Bryan Hanson
Senior Vice President
Exelon Generation Company, LLC
President and Chief Nuclear Office
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: DRESDEN NUCLEAR POWER STATION, UNITS 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 RELATING TO RECOMMENDATION 2.1 OF THE NEAR-TERM TASK FORCE REVIEW OF INSIGHTS FROM THE FUKUSHIMA DAI-ICHI ACCIDENT (TAC NOS. MF3877 AND MF3878)

Dear Mr. Hanson:

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

By letter dated March 31, 2014, Exelon Generation Company, LLC (Exelon) responded to this request for Dresden Nuclear Power Station, Units 2 and 3 (Dresden).

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

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

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

Sincerely,

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

Docket Nos. 50-237 and 50-249

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

DRESDEN NUCLEAR POWER STATION, UNITS 2 AND 3

DOCKET NOS. 50-237 and 50-249

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,

---

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

(4) Comparison of the GMRS and SSE (If the GMRS is completely bounded by the SSE, an interim action plan or risk evaluation is not necessary. However if the GMRS exceeds the SSE only at higher frequencies, information related to the functionality of high-frequency sensitive SSCs is requested),

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

(6) Interim evaluation and actions taken or planned to address the higher seismic hazard relative to the design basis, as appropriate, prior to completion of the risk evaluation (if necessary),

(7) 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 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 September 12, 2013 (Kaegi, 2013), Exelon Generation Company, LLC (Exelon, the licensee) submitted at least partial site response information for Dresden Nuclear Power Station Dresden Units 2 and 3(Dresden). By letter dated March 31, 2014 (Kaegi, 2014), Exelon submitted its SHSR.

2.0 REGULATORY EVALUATION

The structures, systems, and components (SSCs) important to safety in operating nuclear power plants are designed either in accordance with, or meet the intent of Appendix A to 10 CFR Part 50, General Design Criteria (GDC) 2: "Design Bases for Protection Against Natural Phenomena;" and Appendix A to 10 CFR Part 100, "Reactor Site Criteria." GDC 2 states that SSCs important to safety at nuclear power plants shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions.

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).

Dresden, Units 2 and 3 were licensed using the Principal Design Criteria to evaluate the design bases. Exelon performed an evaluation of their design bases against the draft proposed "General Design Criteria for Nuclear Power Plant Construction Permits" issued by the Atomic Energy Commission in July 1967. The design bases was later evaluated against the final "General Design Criteria for Nuclear Power Plants," published as 10 CFR 50, Appendix A in July 1971. The Principal Design Criteria used to develop the design bases for Dresden is consistent with 10 CFR Part 100 and meets the intent of GDC 2.

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

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

2.1 Screening Evaluation Results

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

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 confirmatory GMRS, developed by the staff, exceed the SSE for Dresden, Units 2 and 3 over the frequency range of 5 to 100 Hz. Therefore, Dresden screens-in for conducting a seismic risk evaluation. Additionally, a SFP evaluation and a high frequency confirmation are merited for Dresden, Units 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 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 Dresden, Units 2 and 3. The licensee stated that the SSE for Dresden, Units 2 and 3 is based on a postulated earthquake having a Modified Mercalli Intensity of VII. Based on this earthquake intensity, the response spectral shape is anchored at a PGA of 0.20 g (20 percent of the acceleration due to earth's gravity).

The licensee specified that the SSE control point is located at the top of the Pottsville Formation at a mean sea level elevation of 515 ft [74.7 m]. In absence of a control point definition in the updated final safety analysis report (UFSAR), the licensee relied on UFSAR Chapter 2, which states that the reactor foundation is located on sound rock, along with guidance provided in Section 2.4.2 of the SPID to define the control point.

The staff performed its screening evaluation for Dresden, Units 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. Based on review of the SHSR and the UFSAR, the staff confirmed that the licensee's control point elevation for the Dresden, Units 2 and 3 SSE 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_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 Commerce, Eastern Rift Margin Fault northern segment, Eastern Rift Margin southern segment, 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 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 assessment.

As part of its confirmatory analysis of the licensee's GMRS, the staff performed PSHA calculations for base rock conditions at the Dresden 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, and the licensee's approach, the staff included all CEUS-SSC background seismic sources within a 310 mi [500 km] radius of the Dresden site. In addition, the staff included all of the RLME sources falling within a 620 mi [1000 km] radius of the site, which includes the Commerce, Eastern Rift Margin Fault northern segment, Eastern Rift Margin southern segment, Marianna, New Madrid Fault System, and Wabash Valley 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 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 appropriately followed the guidance provided in the SPID for selecting the PSHA input models and parameters for the site. This includes the licensee's use and implementation of the CEUS-SSC model and the updated EPRI GMM.

3.3 Site Response Evaluation

After completing PSHA calculations for reference rock 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 base rock conditions as defined in the GMM 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 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 provided in the Dresden UFSAR (Exelon, 2013), the plant design and analysis report (PDAR), and a study for the independent spent fuel storage installation (Dames and Moore). The licensee stated that the site is underlain by approximately 1,085 ft [331 m] of post-Cambrian sedimentary rocks consisting of sandstones, shales, dolomites, and limestones. The near surface rock is of Pennsylvanian age and is underlain by Ordovician age sedimentary rock. Overlying the bedrock is glacial drift and topsoil.

Geophysical investigations for the Dresden site consisted of compression wave measurements. As such, seismic shear wave velocities for the upper approximately 360 ft [60 m] of sedimentary rock are based on compression wave measurements and assumed Poisson ratios. At greater depths, the licensee used a gradient velocity consistent with guidance in the SPID. Near surface shear wave velocities range between approximately 2000 ft/s [610 m/s] to 3200 ft/s [976 m/s] and generally increase with depth. The licensee noted that information on the thicknesses of the Cambrian and Precambrian rocks beneath the Dresden site is not available. Therefore, the licensee accommodated the uncertainty in depth to the Precambrian rock, which is assumed to be the base or reference rock layer (where the shear wave velocity reaches 9285 ft/s [2830 m/s]), by using two depths, 1000 ft [305 m] and 5000 ft [1524 m].

For each of these two best estimate profiles with different depths to the base rock layer, the licensee developed upper and lower base case profiles for a total of six site base case profiles. The licensee developed the upper and lower base case profiles for each of the two best estimate profiles using a natural log standard deviation of 0.20 for the upper 360 ft [110 m] and 0.35 for greater depths. Figure 3.3-1 of this assessment shows the licensee's shear-wave velocity base case profiles.

As indicated in Section 2.3.2.1 of its SHSR, the licensee assumed that the rock material over the upper 500 ft [152 m] could be modeled as either linear or non-linear. To model the potential non-linear behavior of the rock, the licensee used the generic EPRI shear modulus reduction and hysteretic damping curves. To model the linear behavior of the rock over the upper 500 ft [152 m], the licensee used the low strain damping values (approximately 3 percent) from the EPRI rock curves for each of the rock layers. The licensee weighted these alternative material behaviors equally, assigning 50 percent to each case.

The licensee also considered the impact of kappa, or small strain damping, on site response. Kappa is measured in units of seconds (sec), and is the damping contributed by both intrinsic hysteretic damping as well as scattering due to wave propagation in heterogeneous material. The licensee used two approaches for estimating kappa for the two sets of base case profiles. For the base case profiles with a shallower depth to the base rock layer, to determine kappa the licensee used the EPRI rock small strain damping value (about 3 percent) over the upper 500 ft [152 m] and a quality factor, Q, of 40 between 500 and 1000 ft [152 – 305 m]. This approach resulted in a kappa value of 0.016 sec. For the base case profiles with a deeper depth to the base rock layer, the licensee used an empirical relationship from the SPID to obtain a kappa value of 0.021 sec, which is dependent on the shear wave velocity over the upper 100 ft [30 m] of the profile. To capture the uncertainty in its estimate of kappa, the licensee applied a scale factor of 1.68 to obtain lower and upper estimates, ranging from 0.009 to 0.027 sec for the base case profiles with a shallower depth to base rock and 0.012 to 0.035 sec for the deeper profiles.

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. With the depth to base rock at 1,000 ft [305 m], the licensee randomized this depth by ±300 ft (±91 m). With the depth to base rock at 5,000 ft [1524 m], the licensee randomized this depth by ±1,500 ft (±457 m). These randomized depths correspond to 30 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. In Section 2.3.5 of its

SHSR, 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, 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 site response calculations for the Dresden site. The staff independently developed a shear-wave velocity profile, damping values, and modeled the potential nonlinear behavior of the rock using geologic information provided in the Dresden UFSAR (Exelon, 2009), velocity data from Leeds (1974) and EPRI (2008), and guidance from 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.

Because limited velocity information is available for the Dresden site, the staff used three shear wave velocity profiles. For the depth interval between the control point and 50 ft [15 m] below the control point, the staff used an average of the measured compression wave velocities and then assumed a Poisson's ratio to develop its shear wave velocity profile. For depths between 50 ft [15 m] below the control point and the base of the profile, the staff assumed the shear wave velocity increased linearly, consistent with guidance from the SPID. To capture the uncertainty in the depth to base rock, the staff used a depth of 4,100 ft [1250 m] for its lower and middle base case profiles and a depth to base rock of 1,500 ft [457 m] for its upper base case profile. The staff introduced additional uncertainty in the depth to base rock by randomizing the depth to base rock by ±30 percent of the total profile thickness. Figure 3.3-1 of this assessment shows the staff velocity profiles compared to the profiles developed by the licensee.

The largest difference between the staff's and licensee's velocity profiles is in the upper 35 to 360 ft [11 – 110 m], which is primarily due to defining the control point at slightly different elevations and the staff applying larger uncertainty to develop its lower and upper base case profiles. Regarding the control point elevation, the reactor building foundation is supported on Ordovician Divine limestone at an elevation of 472.5 ft [144 m]. The staff used the top of this geologic unit as the control point, while the licensee used the top of the uppermost rock unit, the Pennsylvanian Pottsville Formation sandstone as the control point (515 ft [74.7 m]). Additionally, rather than develop six base case profiles, the staff developed only three profiles, as described above. To develop its lower and upper base case velocity profiles, the staff used a natural log standard deviation of 0.35, which is the value recommended by the SPID for sites with limited subsurface data.

Similar to the approach used by the licensee, the staff assumed both linear and non-linear behavior for the rock beneath the Dresden site in response to the range of input loading motions. The staff used generic EPRI rock shear modulus and damping curves to model the non-linear behavior of the rock over the upper 500 ft [152 m] of the site profile. To model the linear behavior of the rock, the staff used a low strain damping value equivalent to the low strain EPRI rock curves in the upper 500 ft.

The staff used the SPID guidance to determine kappa for each base case profile. The empirical model relating kappa to an average shear wave velocity was used for the lower base case and middle or best estimate base case profiles. Using this relationship from the SPID, the staff's estimates of kappa for the lower base case and middle base case profiles are 0.021 and 0.013 sec, respectively. For the upper shallower base case profile, the staff used a damping value of 1.25 percent to estimate a total kappa of 0.006 sec. To model the uncertainty in kappa, a natural log standard deviation of 0.40 was used to calculate lower and upper values for each base case profile.

Figure 3.3-2 of this assessment shows a comparison of the staff's and licensee's median site amplification functions and uncertainties (±1 standard deviation) for two of the eleven input loading levels. The comparison of amplification functions is for the licensee's profile P1 and the staff's base case profile. The licensee's amplification functions are moderately higher than the staff's amplification functions near 1 Hz and between 5 – 15 Hz. The differences above 5 Hz are primarily due to the different control point elevations assumed by the staff and licensee while the differences at 1 Hz are due to the licensee's use of two sets of profiles with different depths to bedrock at 1,000 ft [305 m] and 5,000 ft [1524 m]. The staff used a depth to base rock of 4,100 ft [1250 m] for its lower and middle base case profiles and a depth to base rock of 1,500 ft [YYY m] for its upper base case profile.

Overall, the licensee's approach to modeling the subsurface rock properties and their uncertainty results in higher site amplification factors, particularly at high frequencies. As shown in Figure 3.3-3 of this assessment, these differences in the site response analysis do not have a significant impact at 1 Hz and only a moderate impact above 5 Hz on the control point seismic hazard curves and 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, alternative approaches in performing site response analyses, including the modeling of uncertainty, are acceptable for this application.

In summary, the staff concludes that the licensee's site response was conducted using present-day guidance and methodology, including the NRC-endorsed SPID. The staff performed independent calculations 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 Dresden 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 below, the licensee's GMRS shape is generally similar to that calculated by the staff at frequencies less than 5 Hz. However, NRC staff's confirmatory GMRS is somewhat lower than the licensee's at frequencies above 5 Hz. As described above in Section 3.3, the staff concludes that these differences over the higher frequency range are primarily due to the differences in the site response analyses performed by the licensee and staff. The staff concludes that these differences are acceptable for this application because the licensee followed the guidance provided in the SPID with respect to both the PSHA and site response analysis for the Dresden 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 generally 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 Dresden 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 Dresden site. Based on its review, the staff concludes that the licensee conducted the hazard reevaluation using present-day methodologies and guidance, it appropriately characterized the site given the information available, and met the intent of the guidance for determining the reevaluated seismic hazard. Based upon the preceding analysis, the NRC staff concludes that the licensee provided an acceptable response to Requested Information Items (1) – (3), (5), (7), and a partial response to Item (4), identified in Enclosure 1 of the 50.54(f) letter. Further, the licensee's reevaluated seismic hazard is acceptable to address other actions associated with NTTF Recommendation 2.1, "Seismic."

In reaching this determination, staff confirms the licensee's conclusion that the licensee's GMRS for the Dresden site exceeds the SSE in the 1 to 10 Hz range. As such, Dresden screens in to perform a seismic risk evaluation. The staff also confirms the licensee's conclusion that because the GMRS exceeds the SSEs above 10 Hz, Dresden will perform a high-frequency confirmation (i.e., Item (4) of the Seismic Hazard Evaluation), which the licensee indicated would be performed as part of its seismic risk evaluation. A SFP evaluation is also merited. NRC review and acceptance of Exelon's seismic risk evaluation which includes the high frequency confirmation, an ESEP interim evaluation and a SFP evaluation (i.e., Items (4), (6), (8), and (9)) for Dresden, Units 2 and 3 will complete the Seismic Hazard Evaluation identified in Enclosure 1 of the 50.54(f) letter.

REFERENCES

Note: ADAMS Accession Nos. refer 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), 2011a, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," Commission Paper SECY-11-0093, July 12, 2011, ADAMS Accession No. ML11186A950.

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

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

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

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

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

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

NRC (U.S. Nuclear Regulatory Commission), 2013b, letter from David L. Skeen, Director, Japan Lessons-Learned Directorate, to Joseph E. Pollock, Executive Director, Nuclear Energy Institute, Endorsement of Electric Power Research Institute Draft Report 1025287, "Seismic Evaluation Guidance," February 15, 2013, ADAMS Accession No. ML12319A074.

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

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

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

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

Other References

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

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

Electric Power Research Institute (EPRI) 2008. EPRI Report 1016736, "Assessment of Seismic Hazard at 34 U.S. Nuclear Plant Sites." Palo Alto, CA, 2008.

Electric Power Research Institute (EPRI), 2012. EPRI Report 1025287 "Seismic Evaluation Guidance, Screening, Prioritization and Implementation Details [SPID] for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic" November 27, 2012, ADAMS Accession No. ML12333A170.

Electric Power Research Institute (EPRI), 2013. EPRI Ground Motion Model Review Final Report, June 3, 2013, ADAMS Accession No. ML13170A378.

Exelon 2009 Dresden Nuclear Power Station Updated Final Safety Analysis Report (UFSAR), Revision 8.

Exelon 2013 Dresden Nuclear Power Station Updated Final Safety Analysis Report (UFSAR), Revision 10.

Keithline, 2012, Letter from Kimberly Keithline, Senior Project Manager, NEI, to David L. Skeen, Director, Japan Lessons Learned Project Directorate, NRC, Final Draft of Industry

Seismic Evaluation Guidance (EPRI 1025287), November 27, 2012, ADAMS Accession No. ML12333A168.

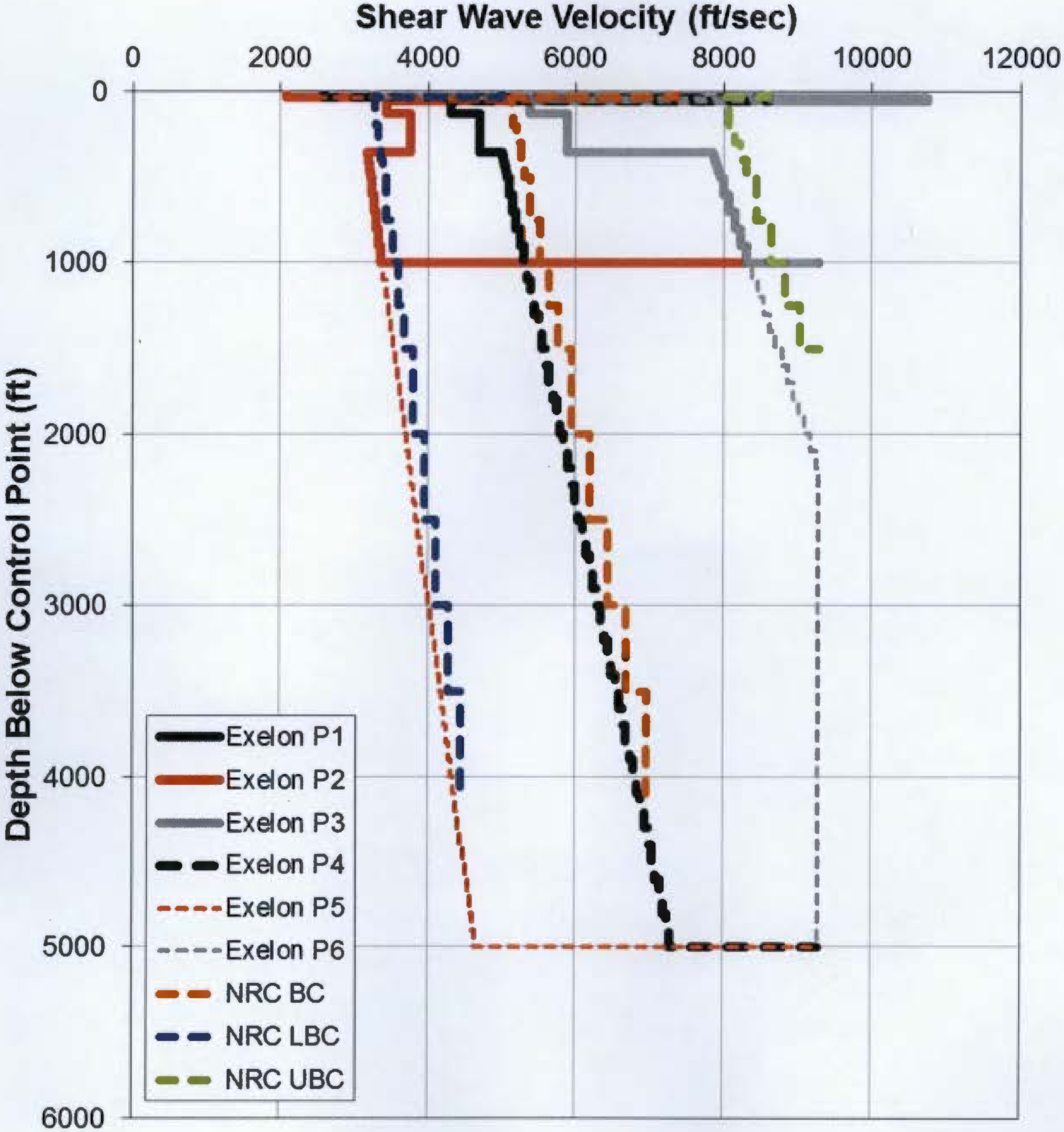
Kaegi, G. T., 2014, Letter from Glen T. Kaegi to NRC, Dresent Station, Units 2 & 3 - Exelon Generation Company, LLC, Seismic Hazard and Screening Report (CEUS Sites), Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, March 31, 2014, ADAMS Accession No. ML14091A012.

Leeds, D. J. 1974. "Site Parameter Study GASSAR Seismic Design for General Atomic Company," Dames and Moore letter report. April 29, 1974.

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

Figure 3.3-1 Plot of Staff's and Licensee's Base Case Shear-Wave Velocity Profiles: (a) Velocity profiles to a depth of 5000 ft [1524 m], (b) Velocity profiles to a depth of 500 ft [152 m] for the Dresden site

(a)



(b)

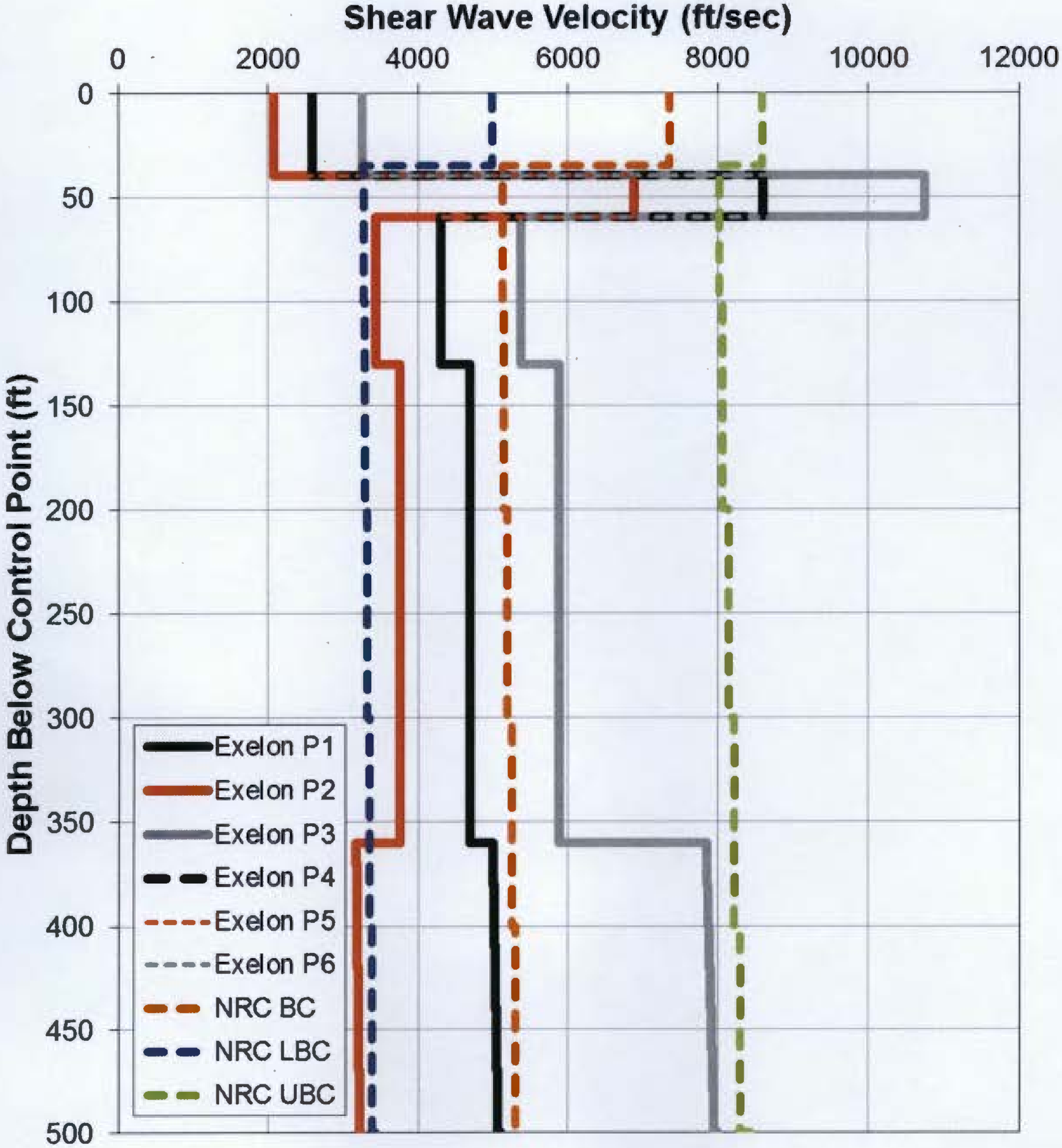

Shear Wave Velocity (ft/sec)
0
2000
4000
6000
8000
10000
12000
Depth Below Control Point (ft)
0
50
100
150
200
250
300
350
400
450
500
Exelon P1
Exelon P2
Exelon P3
Exelon P4
Exelon P5
Exelon P6
NRC BC
NRC LBC
NRC UBC

Figure 3.3- 1 Plot Comparing the Staff's and the License's Median Amplification Functions and Uncertainties for two input loading levels for the Dresden site

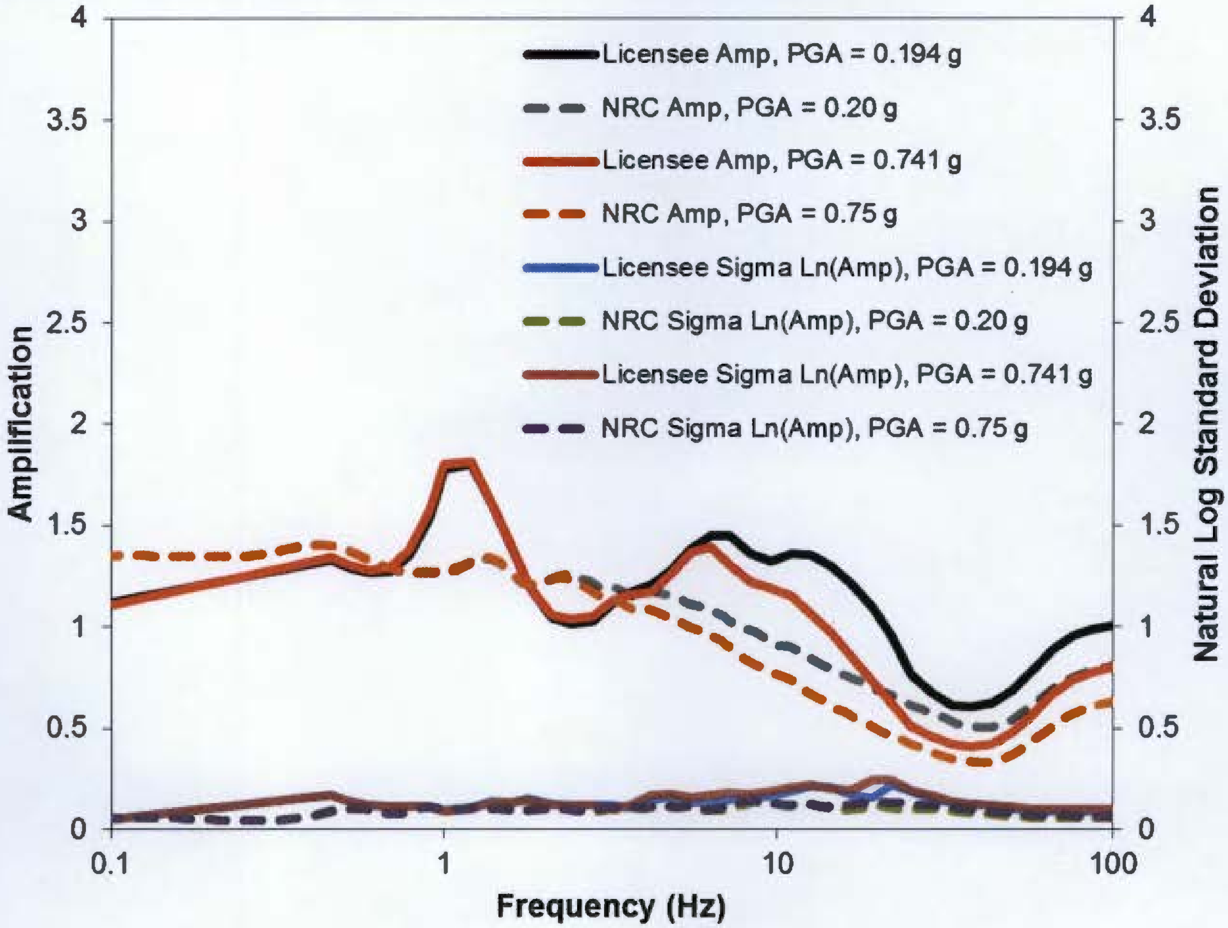


Figure 3.3-2 Plot Comparing the Staff's and the Licensee's Mean Control Point Hazard Curves at a Variety of Frequencies for the Dresden site

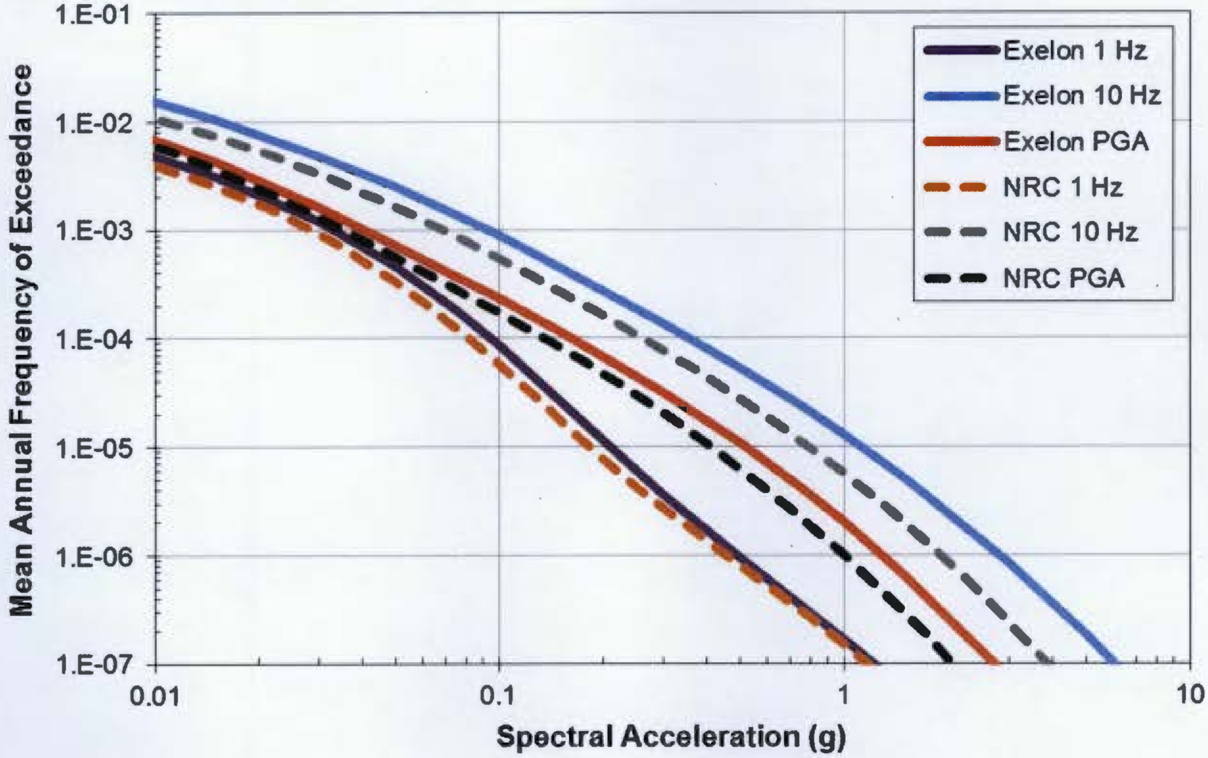
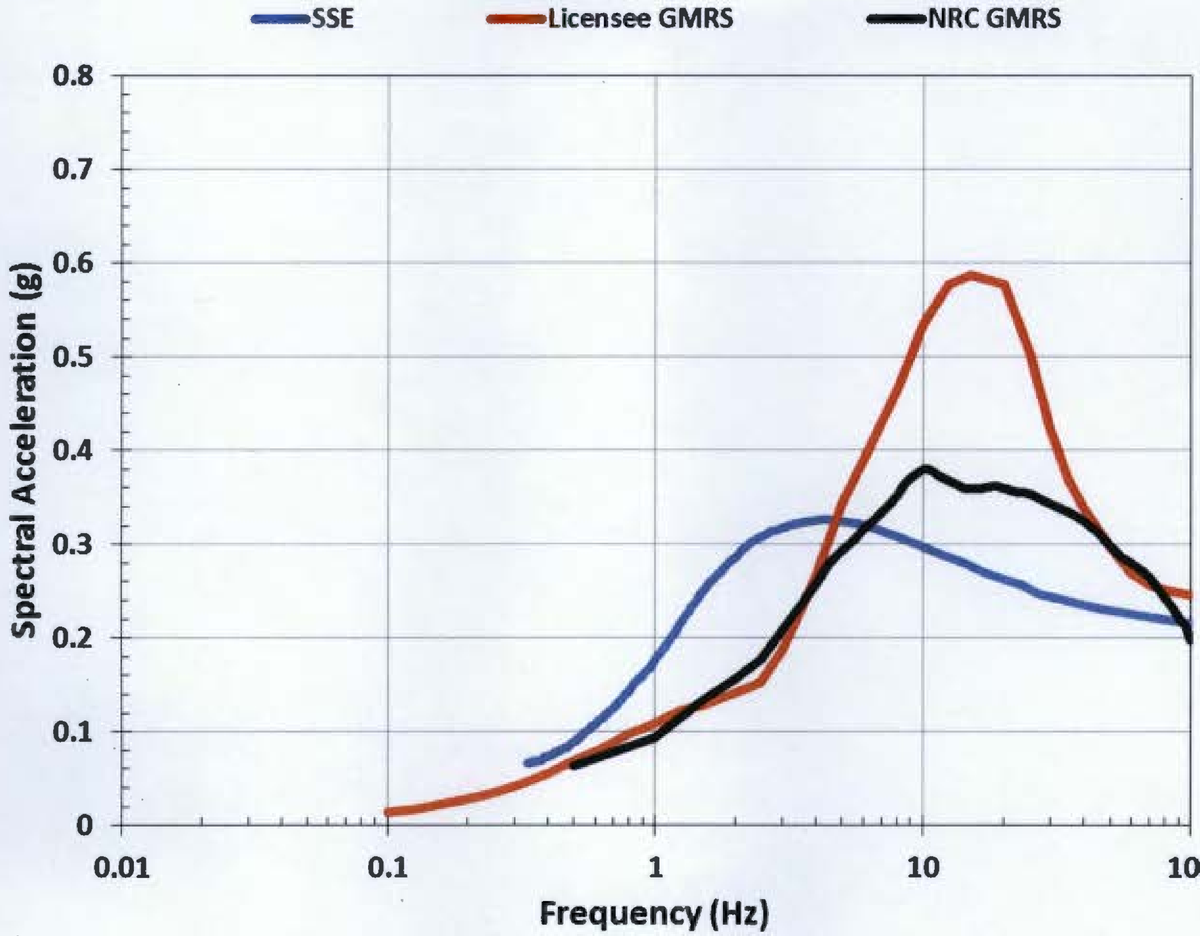


Figure 3.4-1 Comparison of the Staff's GMRS with Licensee's GMRS and the SSEs for the Dresden site



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

Sincerely,

/RA/

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

Docket Nos. 50-237 and 50-249

Enclosure:
Staff Assessment of Seismic
Hazard Evaluation and Screening Report

cc w/encl: Distribution via Listserv

DISTRIBUTION:
PUBLIC
JHMB R/F
RidsNrrDorlLpl3-2 Resource
RidsNrrPMDresden Resource
RidsNrrLASLent Resource
RidsAcrsAcnw_MailCTR Resource
FVega, NRR
NDiFranceso, NRR
DJackson, NRO
MShams, NRR
TGovan, NRR

ADAMS Accession No.: ML15097A519 ***via email**

OFFICE	NRR/JLD/JHMB/PM	NRR/JLD/LA	NRO/DSEA/RGS1/BC*	OGC
NAME	TGovan	SLent	DJackson	BHarris
DATE	04/20/15	04/17/15	03/09/15	04/22/15
OFFICE	NRR/DORL/LPL3-2*	NRR/JLD/JHMB/BC	NRR/JLD/JHMB/PM	
NAME	BMozafari	MShams	TGovan	
DATE	04/15/15	04/25/15	04/27/15	

OFFICIAL RECORD COPY