Exelon Generation

RS-14-065 10 CFR 50.54(f)

March 31, 2014

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
11555 Rockville Pike,
Rockville, MD 20852

Byron Station, Units 1 and 2
Facility Operating License Nos. NPF-37 and NPF-66
NRC Docket Nos. STN 50-454 and STN 50-455

Subject: Exelon Generation Company, LLC, Seismic Hazard and Screening Report (Central and Eastern United States (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

References:

1. NRC Letter, Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, dated March 12, 2012
2. NEI Letter, Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations, dated April 9, 2013
3. NRC Letter, Electric Power Research Institute Final Draft Report XXXXXX, "Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic," as an Acceptable Alternative to the March 12, 2012, Information Request for Seismic Reevaluations, dated May 7, 2013
4. Exelon Generation Company, LLC letter to the NRC, Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Seismic Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident – 1.5 Year Response for CEUS Sites, dated September 12, 2013
5. 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
6. NRC Letter, Endorsement of Electric Power Research Institute Final Draft Report 1025287, "Seismic Evaluation Guidance," dated February 15, 2013
7. EPRI Technical Report 3002000704, "Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic," dated May 2013

On March 12, 2012, the Nuclear Regulatory Commission (NRC) issued Reference 1 to all power reactor licensees and holders of construction permits in active or deferred status. Enclosure 1 of Reference 1 requested each addressee located in the Central and Eastern United States (CEUS) to submit a Seismic Hazard Evaluation and Screening Report within 1.5 years from the date of Reference 1.

In Reference 2, the Nuclear Energy Institute (NEI) requested NRC agreement to delay submittal of the final CEUS Seismic Hazard Evaluation and Screening Reports so that an update to the Electric Power Research Institute (EPRI) ground motion attenuation model could be completed and used to develop that information. NEI proposed that descriptions of subsurface materials and properties and base case velocity profiles be submitted to the NRC by September 12, 2013, with the remaining seismic hazard and screening information submitted by March 31, 2014. NRC agreed with that proposed path forward in Reference 3. In Reference 4, Exelon Generation Company, LLC (EGC) provided the description of subsurface materials and properties and base case velocity profiles for Byron Station, Units 1 and 2.

Reference 5 contains industry guidance and detailed information to be included in the Seismic Hazard Evaluation and Screening Report submittals. NRC endorsed this industry guidance in Reference 6.

The enclosed Seismic Hazard Evaluation and Screening Report for the Byron Generating Station, Units 1 and 2, provides the information described in Section 4 of Reference 5 in accordance with the schedule identified in Reference 2. As described in Enclosure 1, Byron Station, Units 1 and 2, meet the requirements of SPID Section 3.3 (Reference 5) and therefore screen out and no Seismic Risk Assessment is needed. Byron Station, Units 1 and 2 will provide an Expedited Seismic Evaluation Process (ESEP) Report in accordance with Reference 7, by December 31, 2014. Additionally, Byron Station, Units 1 and 2, will perform a High Frequency Confirmation evaluation, a full scope detailed review of Relay Chatter to complete IPEEE Adequacy requirements of SPID (EPRI 1025287), Section 3.3.1, and a Spent Fuel Pool evaluation as determined by NRC prioritization following submittal of all nuclear power plant Seismic Hazard Re-evaluations per Reference 1.

A list of regulatory commitments contained in this letter is provided in Enclosure 2. If you have any questions regarding this report, please contact Ron Gaston at (630) 657-3359.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 31st day of March 2014.

Respectfully submitted,

Glen T. Kaegi

Glen T. Kaegi
Director - Licensing & Regulatory Affairs
Exelon Generation Company, LLC

Enclosures:

1. Byron Generating Station, Units 1 and 2, Seismic Hazard and Screening Report
2. Summary of Regulatory Commitments

cc: Director, Office of Nuclear Reactor Regulation
Regional Administrator - NRC Region III
NRC Senior Resident Inspector - Byron Station
NRC Project Manager, NRR - Byron Station
Ms. Jessica A. Kratchman, NRR/JLD/PMB, NRC
Mr. Eric E. Bowman, NRR/DPR/PGCB, NRC or Ms. Eileen M. McKenna, NRO/DSRA/BPTS, NRC
Illinois Emergency Management Agency - Division of Nuclear Safety

Enclosure 1

Byron Generating Station, Units 1 and 2

Seismic Hazard and Screening Report

(98 pages)

SEISMIC HAZARD AND SCREENING REPORT

IN RESPONSE TO THE 50.54(f) INFORMATION REQUEST REGARDING FUKUSHIMA NEAR-TERM TASK FORCE RECOMMENDATION 2.1: SEISMIC

for the

Byron Generating Station, Units 1 and 2
4450 North German Church Road
Byron, Illinois 61010-9794
Facility Operating License Nos. NPF-37 and NPF-66
NRC Docket Nos. STN 50-454 and STN 50-455
Correspondence No.: RS-14-065

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Report Number: SL-012185, Revision 0

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Corporate Acceptance:	Jeffrey S. Clark	[signature]	3/17/14

* Signature not required per Ed. Blondin, DBC 3/16/14.

Exelon®

Sargent & Lundy LLC

Seismic Hazard and Screening Report – Byron Units 1 and 2

Report No.: SL-012185
Revision 0 – Initial Issue

S&L Project No.: 11332-182
Nuclear Non-Safety Related

Sections: Executive Summary, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, Appendix A, and Appendix B	
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RECORD OF REVISIONS

Revision	Affected Pages	Description
0	All	Initial Issue

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Executive Summary

Purpose

Following the accident at the Fukushima Daiichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the Nuclear Regulatory Commission (NRC) issued a 50.54(f) letter (Reference 1) requesting information in response to NRC Near-Term Task Force (NTTF) recommendations intended to clarify and strengthen the regulatory framework for protection against natural phenomena. The 50.54(f) letter (Reference 1) requests that licensees and holders of construction permits under Title 10 Code of Federal Regulations Part 50 (Reference 2) reevaluate the seismic hazards at their sites against present-day NRC requirements. This report provides the information requested in items (1) through (7) of the "Requested Information" section and Attachment 1 of the 50.54(f) letter (Reference 1) pertaining to NTTF Recommendation 2.1 for Byron Nuclear Generating Station Units 1 and 2 in accordance with the documented intention of Exelon Generating Company transmitted to the NRC via letter dated April 29, 2013 (Reference 16).

Scope

In response to the 50.54(f) letter (Reference 1) and following the Screening, Prioritization, and Implementation Details (SPID) industry guidance document (Reference 3), a seismic hazard reevaluation for Byron station was performed to develop a Ground Motion Response Spectrum (GMRS) for comparison with the Safe Shutdown Earthquake (SSE) and the Byron station Individual Plant Examination of External Events (IPEEE) high-confidence-of-low-probability-of-failure (HCLPF) Spectra. The IPEEE HCLPF Spectra is referred to as IHS. The new GMRS represents a beyond-design-basis seismic demand developed by more modern techniques than were used for plant licensing. Consistent with NRC letter dated February 20, 2014, (Reference 33) the seismic hazard reevaluations performed in response to the 50.54(f) letter (Reference 1) are distinct from the current design or licensing bases of operating plants. Therefore, the results generally do not call into question the operability or functionality of SSCs and are not expected to be reportable pursuant to 10 CFR 50.72, "Immediate notification requirements for operating nuclear power reactors," and 10 CFR 50.73, "Licensee event report system."

Section 2 provides a summary of the regional and local geology, seismicity, other major inputs to the seismic hazard reevaluation, and detailed seismic hazard results including definition of the GMRS. Seismic hazard analysis, including the site response evaluation and GMRS development (Sections 2.2, 2.3, and 2.4 of this report), was performed by the Electric Power Research Institute (EPRI) (Reference 13). A more in-depth discussion of the calculation methods used in the seismic hazard reevaluation is not included in this report but can be found in References 3, 7, 8, 10 and 29. Section 3 describes the characteristics of the appropriate plant-level SSE and IHS. Section 4 provides a comparison of the GMRS to the SSE and IHS. Sections 5 and 6 discuss interim actions and conclusions, respectively.

CONCLUSIONS

The screening evaluation comparison demonstrates that the GMRS exceeds the SSE for a portion of the frequency range of 1 Hz to 10 Hz. However, the IHS is greater than or approximately equal to the GMRS[1] in the frequency range of 1 Hz to 10 Hz. An IPEEE Adequacy review was performed in accordance with the SPID guidance (Reference 3) and it was determined that the IHS can be used for screening (see Attachment B). Based on screening with the IHS, a risk evaluation will not be performed for Byron station. Since the GMRS exceeds the SSE for a portion of the frequency range of 1 Hz to 10 Hz, a spent fuel pool integrity evaluation will be performed. As an interim action/assessment, an Expedited Seismic Evaluation Process (ESEP) will be performed for Byron station in conformance with the "Augmented Approach" guidance document (Reference 4). These evaluations will be conducted on the schedule for central and eastern United States (CEUS) nuclear plants provided via letter from the industry to the NRC dated April 9, 2013 (Reference 6) as agreed to by the NRC in the May 7, 2013 letter to the industry (Reference 31).

Due to the GMRS exceeding the SSE and the IHS in the frequency range above 10 Hz, high frequency confirmations will be performed for Byron station in accordance with the SPID (Reference 3) based upon the schedule for central and eastern United States (CEUS) nuclear plants provided via letter from the industry to the NRC dated April 9, 2013 (Reference 6).

Since the IHS is used for screening, the SPID (Reference 3) requires full scope relay chatter reviews be performed for plants where a focused scope IPEEE was completed. Therefore, Byron will perform full scope relay chatter reviews on the same schedule as high frequency confirmations.

[1]In the frequency range of 1 Hz to 10 Hz, the IHS exceeds the GMRS with the exception at exactly 10 Hz where the GMRS is approximately equal to the IHS. The less than 1% exceedance of the IHS by the GMRS at 10 Hz is considered negligible.

1 Introduction

Following the accident at the Fukushima Daiichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the NRC Commission established a Near Term Task Force (NTTF) to conduct a systematic review of NRC processes and regulations and to determine if the agency should make additional improvements to its regulatory system. The NTTF developed a set of recommendations intended to clarify and strengthen the regulatory framework for protection against natural phenomena. Subsequently, the NRC issued a 50.54(f) letter that requests information to assure that these recommendations are addressed by all U.S. nuclear power plants (Reference 1). The 50.54(f) letter (Reference 1) requests that licensees and holders of construction permits under 10 CFR Part 50 (Reference 2) reevaluate the seismic hazards at their sites against present-day NRC requirements. Depending on the comparison between the reevaluated seismic hazard and the current design basis, the result is either no further risk evaluation or the performance of a seismic risk assessment. Risk assessment approaches acceptable to the staff include a seismic probabilistic risk assessment (SPRA), or a seismic margin assessment (SMA). Based upon the risk assessment results, the NRC staff will determine whether additional regulatory actions are necessary.

This report provides the information requested in items (1) through (7) of the "Requested Information" section and Attachment 1 of the 50.54(f) letter (Reference 1), pertaining to NTTF Recommendation 2.1 for the Byron Generating Station Units 1 and 2 (Byron station), located in Ogle County, Illinois. In providing this information, Exelon followed the guidance provided in the *Seismic Evaluation Guidance: Screening, Prioritization, and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic* (Reference 3). The Augmented Approach, *Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic* (Reference 4), has been developed as the process for evaluating critical plant equipment as an interim action to demonstrate additional plant safety margin, prior to performing the complete plant seismic risk evaluations. The SPID (Reference 3) and the Augmented Approach (Reference 4) have been endorsed by the NRC in letters to NEI (Reference 30 and Reference 31).

The original geologic and seismic siting investigations for the Byron station were performed in accordance with Appendix A of Title 10 Code of Federal Regulations Part 100 (Reference 5) and meet General Design Criterion 2 in Appendix A of Reference 2. The Safe Shutdown Earthquake (SSE) ground motion was developed in accordance with Appendix A of Reference 5 and is used for the design of seismic Category I systems, structures and components. See Section 3 of this report for further discussion on the development of the SSE.

In response to the 50.54(f) letter (Reference 1) and following the SPID guidance (Reference 3), a seismic hazard reevaluation for Byron station was performed. For screening purposes, a Ground Motion Response Spectrum (GMRS) was developed.

2

Seismic Hazard Reevaluation

Byron station is located in north central Illinois in an upland position about 2 miles east of the Rock River and approximately 3 miles southwest of Byron in Ogle County. The site is located within the Till Plains Section of the Central Lowlands Physiographic Province, which is characterized in general by the presence of glacial deposits overlying the bedrock surface. The site is underlain by Ordovician- and Cambrian-aged strata consisting of dolomites, sandstones, and shales. The main plant power block structures are founded on bedrock in the Ordovician Dunleith Formation. (Section 2.5, Reference 11)

The Byron station site and the entire 200-miles radius site region lie within the Central Stable Region of the North American Continent. Historical seismic activity reviewed during the original plant licensing determined that a Modified Mercalli Intensity (MMI) VII was the maximum earthquake experienced in the region and a safe shutdown earthquake (SSE) corresponding to a maximum ground acceleration of 0.13g. Subsequently, during the review of the construction permit, the NRC considered a MMI VIII earthquake equally probable. Therefore, an SSE with a 0.2g peak ground acceleration was considered at the bedrock-soil interface. (Section 2.5, Reference 11)

2.1 Regional and Local Geology

The Byron station site is located within the Till Plains Section of the Central Lowlands Physiographic Province. The Till Plains Section is further subdivided into subsections. The site area is located in the Rock River Hill Country physiographic subsection, which is characterized by gently rolling, dissected uplands covered by thin deposits of glacial drift overlain by a thin cap of loess with a well-developed drainage pattern. The soil units in the region adjacent to the plant site area are generally relatively thin and locally absent. The rock units include a sedimentary sequence of Cretaceous-, Pennsylvanian-, Mississippian-, Devonian-, Silurian-, Ordovician-, and Cambrian-aged strata and an igneous and metamorphic complex of Precambrian-aged rocks. (Section 2.5, Reference 11)

Byron station is located in north central Illinois in an upland position about 2 miles east of the Rock River and approximately 3 miles southwest of Byron in Ogle County. The site is located within the Rock River Hill Country subsection of the Till Plains Section of the Central Lowlands Physiographic Province. The Till Plains section is characterized by the presence of glacial deposits overlying the bedrock surface. Unconsolidated sediments in the site area include alluvium, loess, till and residuum. These unconsolidated deposits were removed in the vicinity of the main power block during construction. The unconsolidated deposits overlie approximately 2500 to 3000 feet of Ordovician and Cambrian sedimentary strata which are in turn underlain by a Precambrian igneous basement rock complex. The Sandwich Fault Zone and the Plum River Fault Zone are the two major faults in the proximity of the site area. Analysis of small displacement faults discovered during the main plant excavation indicated that these features were noncapable. (Section 2.5, Reference 11)

2.2 Probabilistic Seismic Hazard Analysis

2.2.1 Probabilistic Seismic Hazard Analysis Results

In accordance with the 10CFR 50.54(f) letter (Reference 1) and following the guidance in the SPID (Reference 3), a probabilistic seismic hazard analysis (PSHA) was completed using the recently developed Central and Eastern United States Seismic Source Characterization (CEUS-SSC) for Nuclear Facilities (Reference 7) together with the updated EPRI Ground-Motion Model (GMM) for the CEUS (Reference 8). For the PSHA, a lower-bound moment magnitude of 5.0 was used, as specified in the 50.54(f) letter (Reference 1).

For the PSHA, the CEUS-SSC background seismic sources out to a distance of 400 miles around Byron station were included. This distance exceeds the 200 mile recommendation contained in Regulatory Guide 1.208 (Reference 29) and was chosen for completeness. Background sources included in this site analysis are the following:

1. Illinois Basin Extended Basement (IBEB)
2. Mesozoic and younger extended prior – narrow (MESE-N)
3. Mesozoic and younger extended prior – wide (MESE-W)
4. Midcontinent-Craton alternative A (MIDC_A)
5. Midcontinent-Craton alternative B (MIDC_B)
6. Midcontinent-Craton alternative C (MIDC_C)
7. Midcontinent-Craton alternative D (MIDC_D)
8. Non-Mesozoic and younger extended prior – narrow (NMESE-N)
9. Non-Mesozoic and younger extended prior – wide (NMESE-W)
10. Paleozoic Extended Crust wide (PEZ_W)
11. Reelfoot Rift (RR)
12. Reelfoot Rift including the Rough Creek Graben (RR-RCG)
13. Study region (STUDY_R)

For sources of large magnitude earthquakes, designated Repeated Large Magnitude Earthquake (RLME) sources in CEUS-SSC (Reference 7), the following sources lie within 621 miles (1,000 km) of the site and were included in the analysis:

1. Commerce
2. Eastern Rift Margin Fault northern segment (ERM-N)
3. Eastern Rift Margin Fault southern segment (ERM-S)
4. Marianna
5. New Madrid Fault System (NMFS)
6. Wabash Valley

For each of the above background and RLME sources, the mid-continent version of the updated CEUS EPRI GMM was used.

2.2.2 Base Rock Seismic Hazard Curves

Consistent with the SPID (Reference 3), base rock seismic hazard curves are not provided as the site amplification approach, referred to as Method 3, has been used. Seismic hazard curves are shown in Section 2.3.7 at the SSE control point elevation.

2.3 SITE RESPONSE EVALUATION

Following the guidance contained in Enclosure 1 of the 10CFR 50.54(f) letter (Reference 1) and the SPID (Reference 3) for nuclear power plant sites that are not founded on hard rock (hard rock is defined as having a shear wave velocity of at least 9285 ft/s), a site response analysis was performed for Byron station.

2.3.1 Description of Subsurface Material

Byron station is located in north central Illinois. The general site conditions consist of about 5 feet of loess and till soils overlying Ordovician dolomites, shales, and sandstones. Precambrian basement is at a depth of 2,500 to 3,000 feet.

Byron station consists of two units with the containment buildings supported on continuous firm rock of the Dunleith Formation (Reference 19). Table 2.3.1-1 shows the geotechnical properties for the site.

In general, the site is underlain by a regular sequence of units marked by remarkable uniformity and continuity. The unconsolidated deposits, which have been removed from the vicinity of the main power block, overlie approximately 2500 to 3000 feet of Ordovician and Cambrian sedimentary strata featuring a sedimentary sequence of Cretaceous-, Pennsylvanian-, Mississippian-, Devonian-, Silurian-, Ordovician-, and Cambrian-aged dolomites, sandstones, and shales, which are in turn underlain by a Precambrian igneous basement rock complex of granites and granodiorites (References 11 and 23).

The Pleistocene age soil deposits in the upland areas are undifferentiated Peoria Loess, a windblown silt, generally 0 to 3 feet in thickness at the plant site. The Pleistocene-post-Ordovician soil deposits consist of loose to very dense, yellow, silty dolomitic sand with some dolomite gravel, ranging in thickness from 0 to 5.5 feet (Reference 11).

The bedrock elevation at the plant location ranges from 876 feet to 850 feet MSL (Reference 11). The Ordovician deposits comprise ten layers (the Dunleith, Guttenberg, Quimbys Mill, Nachusa, Grad Detour, Mifflin, Pecatonica, Glenwood and St. Peters Formations) of dolomite, shale and sandstone. The thicknesses and composition of the various formations are described in detail in UFSAR 2.5.1.2.3.2.1.

The Cambrian age soil deposits are classified into five formations (see UFSAR Section 2.5.1.2.3.2.5):

- Potosi: 25 to 50 feet thick, finely crystalline, slightly argillaceous, brown to light gray dolomite.
- Franconia: est. 100 feet thick, fine grained, dolomitic sandstone, glauconitic, silty and argillaceous
- Ironton: approx. 105 feet thick, medium-grained, poorly sorted, white sandstone; grade downward to slightly silty, fine-grained sandstone
- Eau Claire: est. 400 feet thick, fine-grained, well sorted sandstone, beds of shale, siltstone, dolomite; glauconitic
- Mt. Simon: est. 1500 feet thick, coarse-grained, poorly sorted, friable sandstone

No holes have reached the Precambrian in Ogle County. The estimated depth to the top of the Precambrian is about 2500 to 3000 feet (Reference 23). Available data indicate that the basement rock should consist largely of medium to coarse-grained pink to light gray granites and granodiorites. Other rock types reported are quartz monzonite, rhyolite, porphyry, and felsite (References 11 and 23).

Table 2.3.1-1: Summary of geotechnical profile data for Byron station (Reference 24)

Elevations of Layer Boundaries At Reactor Buildings (ft, MSL)	Range in Thickness Across Site (ft)	Soil/Rock Description and Age	Density (pcf)	Shear Wave Velocity (fps)	Compressional Wave Velocity (fps)	Poisson's Ratio
N/A	0-8	Pleistocene overburden, clayey silt, clayey sand, and silty sand with some gravel	110-130	330-450	1000-2200	0.44
869[a] to 772[b]	30-105	Ordovician Dunleith Formation, slightly to moderately weathered dolomite	147-164	2800-3650	7500-11000	0.37-0.41
772 to 768	3-7	Ordovician Guttenberg Formation, Dolomite	150-157	3000-6000	9500-15250	0.33-0.41
768 to 755	10-15	Ordovician Quimbys Mill Formation, Dolomite	156-166	4500-9500	12000-15250	0.33-0.41
755 to 740	13-24	Ordovician Nachusa Formation, Dolomite	162-168	9500	15500	0.19-0.23
740 to 698	30-46	Ordovician Grand Detour Formation, dolomite	156-177	9500	15500	0.19-0.23
698 to 682	13-26	Ordovician Mifflin Formation, Dolomite	165-166	9500	15500	0.19-0.23
682 to 657	15-31	Ordovician Pecatonica Formation, Dolomite	146-160	9500	15500	0.19-0.23
657 to 655	2-5	Ordovician Glenwood Formation, Harmony Hill Member, shale	116-129	9500	15500	0.19-0.23
655 to 635	17-32	Ordovician Glenwood Formation, Daysville Member, dolomite and sandstone	155-167	9500	15500	0.19-0.23
635 to 408	100-450	Ordovician St. Peter Formation, poorly graded, poorly cemented, friable sandstone	130-132	9500	15500	0.19-0.23
408 to -1622	1500-2500	Cambrian dolomite and sandstone	152-159	11000	18300	0.22
-1622 and below	N/A	Precambrian metamorphic and igneous basement	162	12000	19000	0.18

[a] Surface of finish grade is nominally at El. 869 feet MSL in the vicinity of the main power block. This is the control point elevation for the SSE and the IPEEE HCLPF.
[b] Bottom of the deepest foundation in the vicinity of the main power block is at El. 792 feet MSL, within the Ordovician Dunleith Formation.

2.3.2 Development of Shear-Wave Velocity Profiles

Table 2.3.1-1 shows the recommended shear-wave velocity and density versus depth for the best estimate profile (P1). Based on Table 2.3.1-1 and the specified location of the SSE, at the top of the Ordovician Dunleith Formation at an elevation of 869 feet, the base-case profile P1 consists of about 114 feet of firm rock overlying Ordovician Nachusa and deeper formations with shear-wave velocity assumed[1] to represent hard reference rock conditions (shear-wave velocity of at least 9,285 ft/s).

Shear-wave velocities reflected in Table 2.3.1-1 were based on refraction surveys (likely compressional-wave velocities and assumed[1] Poisson ratios) as well as uphole and downhole seismic tests. Consideration was also given to the shear-wave velocities determined for the nearby ISFSI (Reference 20).

The ranges in velocities and unit weights listed in Table 2.3.1-1 were based on variability across the site and accommodated in the randomization process (Section 2.3.3). Mean base-case values for both unit weights as well as shear-wave velocities were based on Formation averages (lognormal for shear-wave velocities). Based on the consideration the measurements likely reflect depths where velocity ranges were provided, two scale factors were adopted. For the top 114 feet below the SSE, a scale factor of 1.25 was adopted to reflect upper- and lower-range based-cases. Below that depth a larger scale factor 1.57 was used to reflect increased epistemic uncertainty.

The scale factors of 1.25 and 1.57 reflect a $\sigma_{\mu ln}$ of about 0.2 and 0.35 respectively based on the SPID (Reference 3) 10^{th} and 90^{th} fractiles which implies a 1.28 scale factor on σ_{μ}.

Using the shear-wave velocities specified in Table 2.3.1-1, three base-profiles were developed using the scale factors of 1.25 and 1.57. The specified shear-wave velocities were taken as the mean or best estimate base-case profile (P1) with lower and upper range base-cases profiles P2 and P3 respectively. Base-case profiles P1 and P3 were taken to have a mean depth below the SSE of 114 feet to hard reference rock, based on the high shear-wave velocity estimates (Table 2.3.1-1). Below 114 feet the velocity was set equal to the hard reference rock value of 9,285 ft/sec to a depth of 3,000 feet and randomized ± 900 feet. The lower range base-case profile P2 was taken to extend to a depth below the SSE of 2,674 feet to hard reference rock, randomized ± 802 feet. The depth randomization reflects ± 30% of the depth and was included to provide a realistic broadening of the fundamental resonance at deep sites rather than reflect actual random variations to basement shear-wave velocities across a footprint. The base-case profiles (P1, P2, and P3) are shown in Figure 2.3.2-1 and listed in Table 2.3.2-1.

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[1] Assumptions discussed in Section 2 are provided by EPRI engineers (Reference 13) in accordance with implementation of the SPID (Reference 3) methodology.

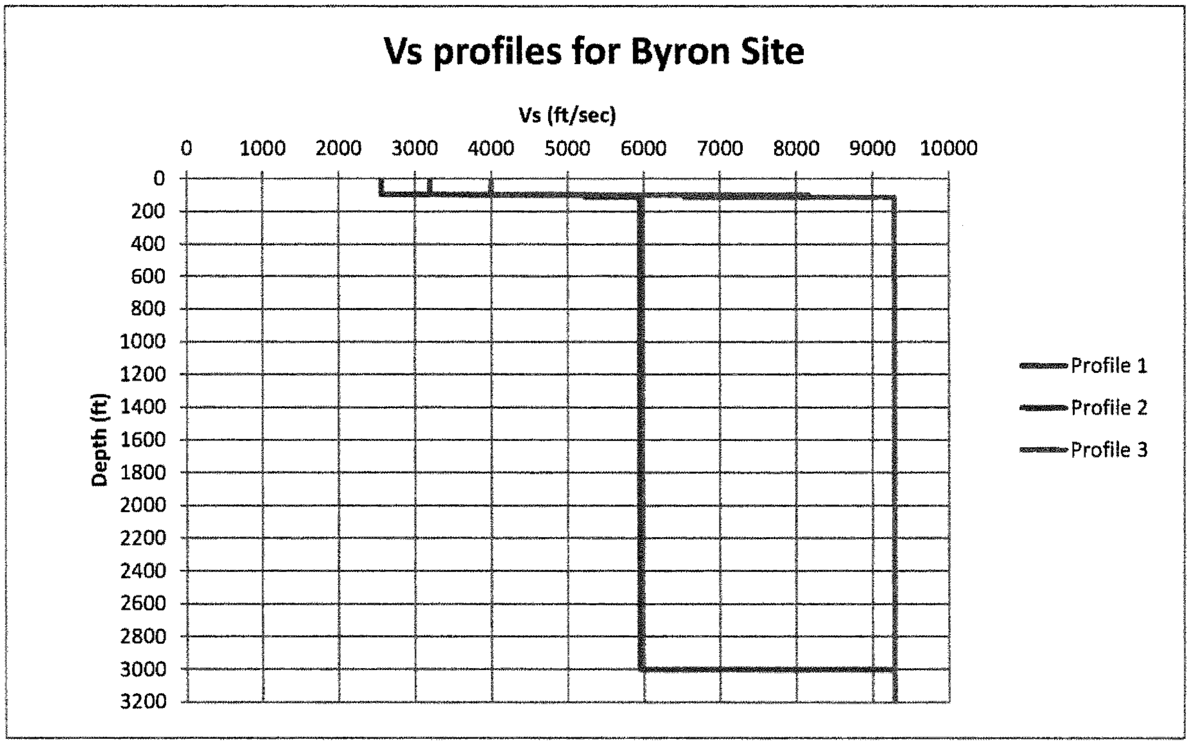


Figure 2.3.2-1: Shear-wave velocity (Vs) profiles for Byron station (Reference 24)

Table 2.3.2-1: Layer thicknesses, depths, and shear-wave velocities (Vs) for 3 profiles at Byron station (Reference 24)

Profile 1			Profile 2			Profile 3		
Thickness(ft)	Depth (ft)	Vs(ft/s)	Thickness(ft)	Depth (ft)	Vs(ft/s)	Thickness(ft)	Depth (ft)	Vs(ft/s)
	0	3197		0	2557		0	3996
10.0	10.0	3197	10.0	10.0	2557	10.0	10.0	3996
10.0	20.0	3197	10.0	20.0	2557	10.0	20.0	3996
10.0	30.0	3197	10.0	30.0	2557	10.0	30.0	3996
10.0	40.0	3197	10.0	40.0	2557	10.0	40.0	3996
10.0	50.0	3197	10.0	50.0	2557	10.0	50.0	3996
10.0	60.0	3197	10.0	60.0	2557	10.0	60.0	3996
10.0	70.0	3197	10.0	70.0	2557	10.0	70.0	3996
10.0	80.1	3197	10.0	80.1	2557	10.0	80.1	3996
10.0	90.1	3197	10.0	90.1	2557	10.0	90.1	3996
7.0	97.0	3197	7.0	97.0	2557	7.0	97.0	3996
4.0	101.0	4242	4.0	101.0	3394	4.0	101.0	5303
6.5	107.5	6536	6.5	107.5	5229	6.5	107.5	8170
6.5	114.0	6536	6.5	114.0	5229	6.5	114.0	8170
5.9	120.0	9285	5.9	120.0	5942	5.9	120.0	9285
26.0	146.0	9285	26.0	146.0	5942	26.0	146.0	9285
26.0	172.0	9285	26.0	172.0	5942	26.0	172.0	9285
26.0	198.0	9285	26.0	198.0	5942	26.0	198.0	9285
26.0	224.0	9285	26.0	224.0	5942	26.0	224.0	9285
26.0	250.1	9285	26.0	250.1	5942	26.0	250.1	9285
38.4	288.5	9285	38.4	288.5	5942	38.4	288.5	9285
38.4	326.9	9285	38.4	326.9	5942	38.4	326.9	9285
38.4	365.3	9285	38.4	365.3	5942	38.4	365.3	9285
38.4	403.7	9285	38.4	403.7	5942	38.4	403.7	9285
38.4	442.2	9285	38.4	442.2	5942	38.4	442.2	9285
57.8	500.0	9285	57.8	500.0	5942	57.8	500.0	9285
106.2	606.2	9285	106.2	606.2	5942	106.2	606.2	9285
164.0	770.2	9285	164.0	770.2	5942	164.0	770.2	9285
164.0	934.3	9285	164.0	934.3	5942	164.0	934.3	9285
164.0	1098.3	9285	164.0	1098.3	5942	164.0	1098.3	9285
164.0	1262.4	9285	164.0	1262.4	5942	164.0	1262.4	9285
164.0	1426.4	9285	164.0	1426.4	5942	164.0	1426.4	9285
164.0	1590.4	9285	164.0	1590.4	5942	164.0	1590.4	9285
164.0	1754.5	9285	164.0	1754.5	5942	164.0	1754.5	9285
164.0	1918.5	9285	164.0	1918.5	5942	164.0	1918.5	9285
164.0	2082.6	9285	164.0	2082.6	5942	164.0	2082.6	9285
164.0	2246.6	9285	164.0	2246.6	5942	164.0	2246.6	9285
164.0	2410.7	9285	164.0	2410.7	5942	164.0	2410.7	9285
164.0	2574.7	9285	164.0	2574.7	5942	164.0	2574.7	9285
164.0	2738.7	9285	164.0	2738.7	5942	164.0	2738.7	9285
262.5	3001.2	9285	262.5	3001.2	5942	262.5	3001.2	9285
3280.8	6282.0	9285	3280.8	6282.0	9285	3280.8	6282.0	9285

2.3.2.1 Shear Modulus and Damping Curves

No site-specific nonlinear dynamic material properties were available for the firm rock materials for Byron station. The rock material over the upper 500 feet was assumed[1] to have behavior that could be modeled as either linear or non-linear. To represent this potential for either case in the upper 500 feet of firm rock at Byron station, two sets of shear modulus reduction and hysteretic damping curves were used. Consistent with the SPID (Reference 3), the EPRI rock curves (model M1) were considered to be appropriate to represent the upper range nonlinearity likely in the materials at this site; and linear analyses (model M2) was assumed[1] to represent an equally plausible alternative rock response across loading level. For the linear analyses, the low strain damping from the EPRI rock curves were used as the constant damping values in the upper 500 feet.

2.3.2.2 Kappa

For the Byron station profile of either 114 feet or 3,001 feet of firm rock over hard reference rock, the kappa value of 0.006s for hard rock was combined with the low strain damping in the hysteretic damping curves and, as appropriate, a Q_S of 40 below a depth of 500 feet to give the values listed in Table 2.3.2-3 (Reference 3). The low strain kappa values range from 0.008s for the stiffest profiles (P1 and P3) to 0.023s for the softest and deepest profile (P2) (Table 2.3.2-3). The mean base case profile P1 has a total kappa of 0.008s.

Table 2.3.2-2: Kappa values and weights used for site response analyses (Reference 13)

Velocity Profile	Kappa(s)
P1	0.008
P2	0.023
P3	0.008
Velocity Profile	Weights
P1	0.4
P2	0.3
P3	0.3
G/G_{max} and Hysteretic Damping Curves	
M1	0.5
M2	0.5

[1] Assumptions discussed in Section 2 are provided by EPRI engineers (Reference 13) in accordance with implementation of the SPID (Reference 3) methodology.

2.3.3 Randomization of Base Case Profiles

To account for the aleatory variability in dynamic material properties that is expected to occur across a site at the scale of a typical nuclear facility, variability in the assumed[1] shear-wave velocity profiles has been incorporated in the site response calculations. For Byron station, random shear wave velocity profiles were developed from the base case profiles shown in Figure 2.3.2-1. Consistent with the discussion in Appendix B of the SPID (Reference 3), the velocity randomization procedure made use of random field models which describe the statistical correlation between layering and shear wave velocity. The default randomization parameters developed in Toro (Reference 10) for USGS "A" site conditions were used for this site. Thirty random velocity profiles were generated for each base case profile. These random velocity profiles were generated using a natural log standard deviation of 0.25 over the upper 50 feet and 0.15 below that depth. As specified in the SPID (Reference 3), correlation of shear wave velocity between layers was modeled using the footprint correlation model. In the correlation model, a limit of +/- 2 standard deviations about the median value in each layer was assumed[1] for the limits on random velocity fluctuations.

2.3.4 Input Spectra

Consistent with the guidance in Appendix B of the SPID (Reference 3), input Fourier amplitude spectra were defined for a single representative earthquake magnitude (**M** 6.5) using two different assumptions[1] regarding the shape of the seismic source spectrum (single-corner and double-corner). A range of 11 different input amplitudes (median peak ground accelerations (PGA) ranging from 0.01g to 1.50g) were used in the site response analyses. The characteristics of the seismic source and upper crustal attenuation properties assumed[1] for the analysis of Byron station were the same as those identified in Tables B-4, B-5, B-6 and B-7of the SPID as appropriate for typical CEUS sites.

2.3.5 Methodology

To perform the site response analyses for Byron station, a random vibration theory (RVT) approach was employed. This process utilizes a simple, efficient approach for computing site-specific amplification functions and is consistent with existing NRC guidance and the SPID (Reference 3). The guidance contained in Appendix B of the SPID (Reference 3) on incorporating epistemic uncertainty in shear-wave velocities, kappa, non-linear dynamic properties and source spectra for plants with limited at-site information was followed for Byron station.

[1] Assumptions discussed in Section 2 are provided by EPRI engineers (Reference 13) in accordance with implementation of the SPID (Reference 3) methodology.

2.3.6 Amplification Functions

The results of the site response analysis consist of amplification factors (5% critically damped pseudo absolute response spectra) which describe the amplification (or de-amplification) of hard reference rock motion as a function of frequency and input reference rock amplitude. The amplification factors are represented in terms of a median amplification value and an associated standard deviation (sigma) for each spectral frequency and input rock amplitude. Consistent with the SPID a minimum median amplification value of 0.5 was employed in the present analysis. Figure 2.3.6-1 illustrates the median and +/- 1 standard deviation in the predicted amplification factors developed for the eleven loading levels parameterized by the median reference (hard rock) peak acceleration (0.01g to 1.50g) for profile P1 and SPID rock G/G_{max} and hysteretic damping curves. The variability in the amplification factors results from variability in shear-wave velocity, depth to hard rock, and modulus reduction and hysteretic damping curves. To illustrate the effects of nonlinearity at Byron station firm rock site, Figure 2.3.6-2 shows the corresponding amplification factors developed with linear site response analyses (model M2). Between the linear and nonlinear (equivalent-linear) analyses, Figures 2.3.6-1 and Figure 2.3.6-2 respectively show only relatively minor difference across structural frequency as well as loading level. Tabulated values of amplification factors are provided in Tables A-2b1 and A-2b2 in Appendix A.

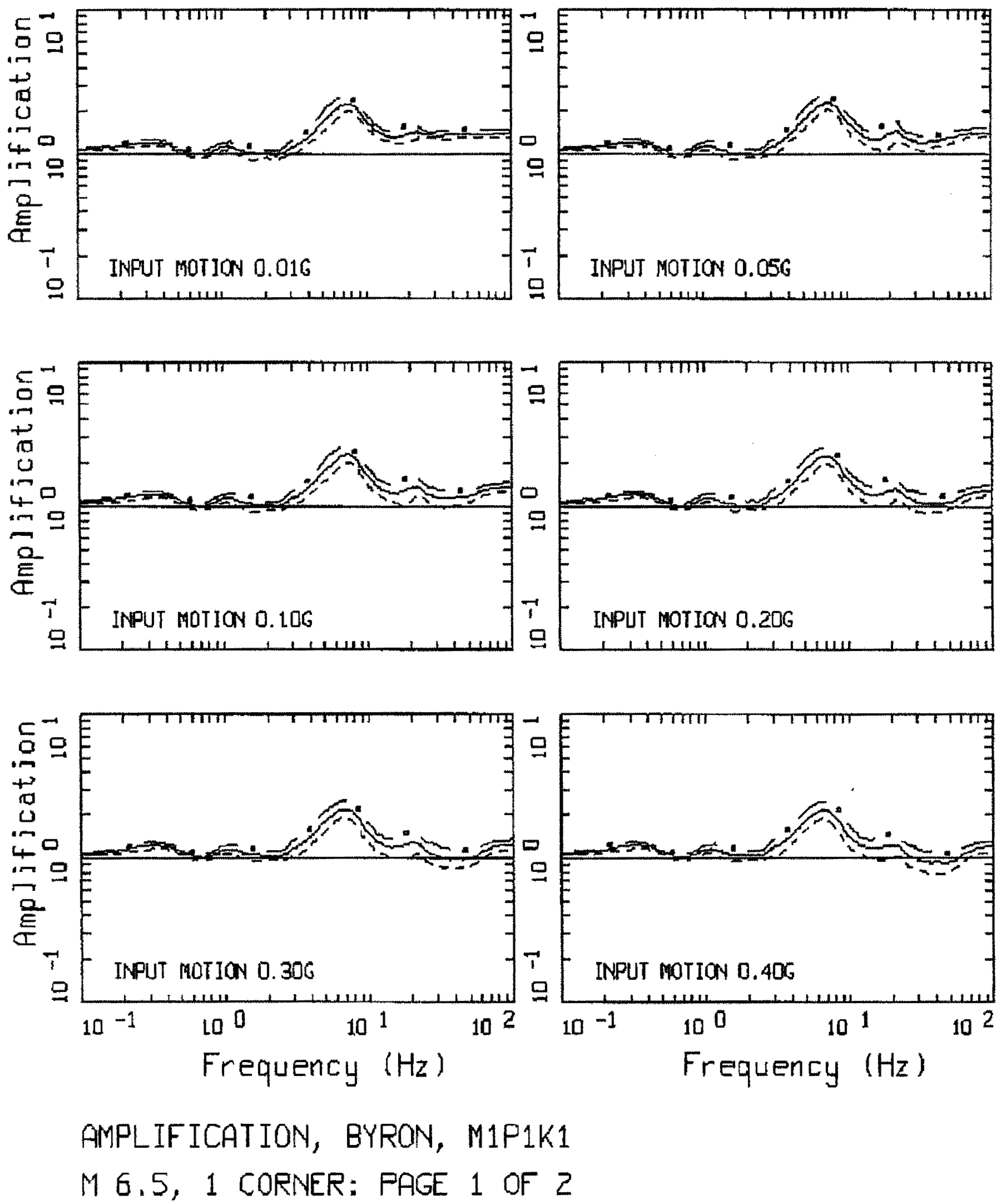
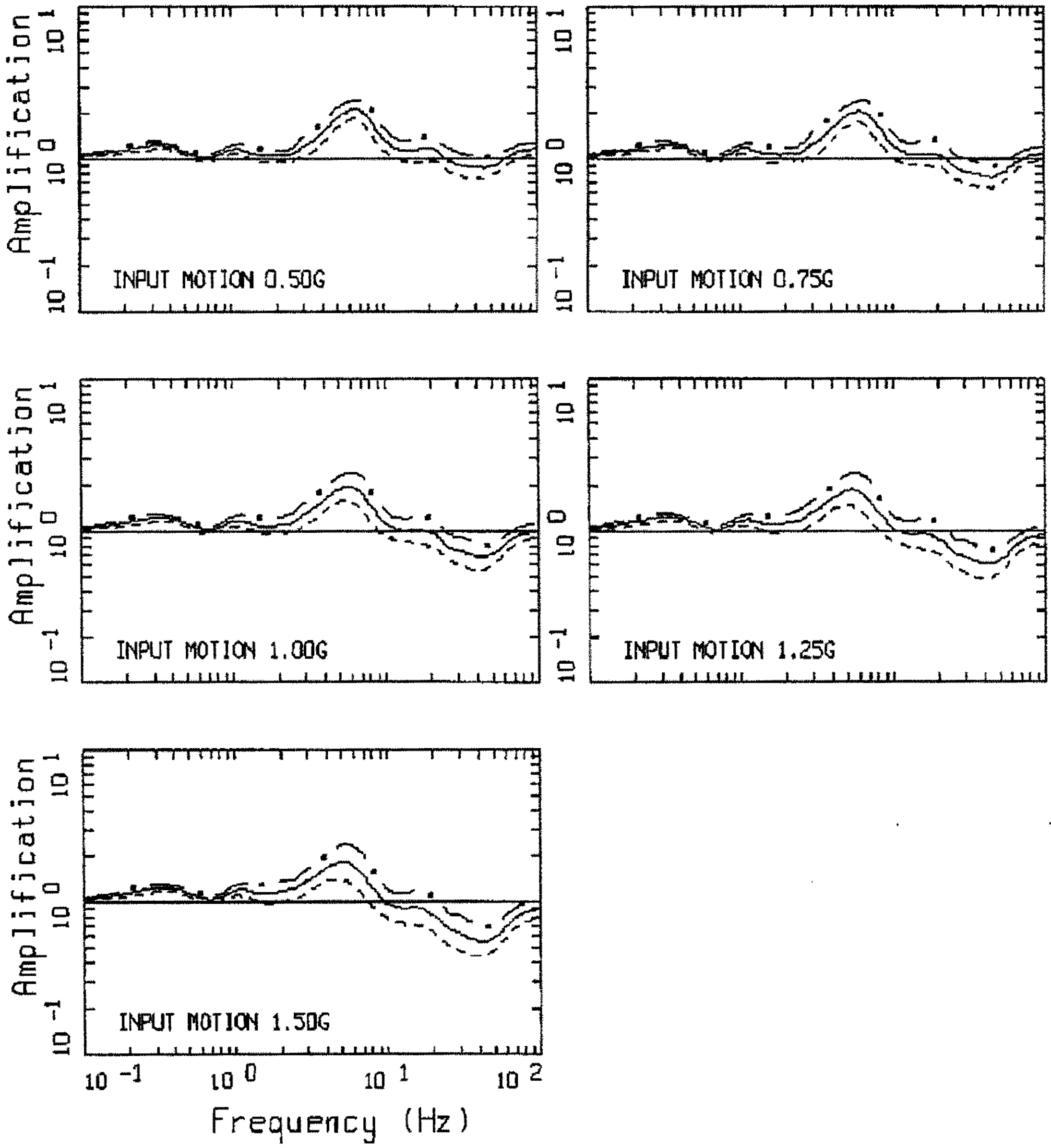


Figure 2.3.6-1: Example suite of amplification factors (5% of critical damping pseudo absolute acceleration spectra) developed for the mean base-case profile (P1), EPRI rock modulus reduction and hysteretic damping curves (model M1), and base-case kappa at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g. **M** 6.5 and single-corner source model (Reference 3) (Reference 13)



AMPLIFICATION, BYRON, M1P1K1

M 6.5, 1 CORNER: PAGE 2 OF 2

Figure 2.3.6-1:(cont.)

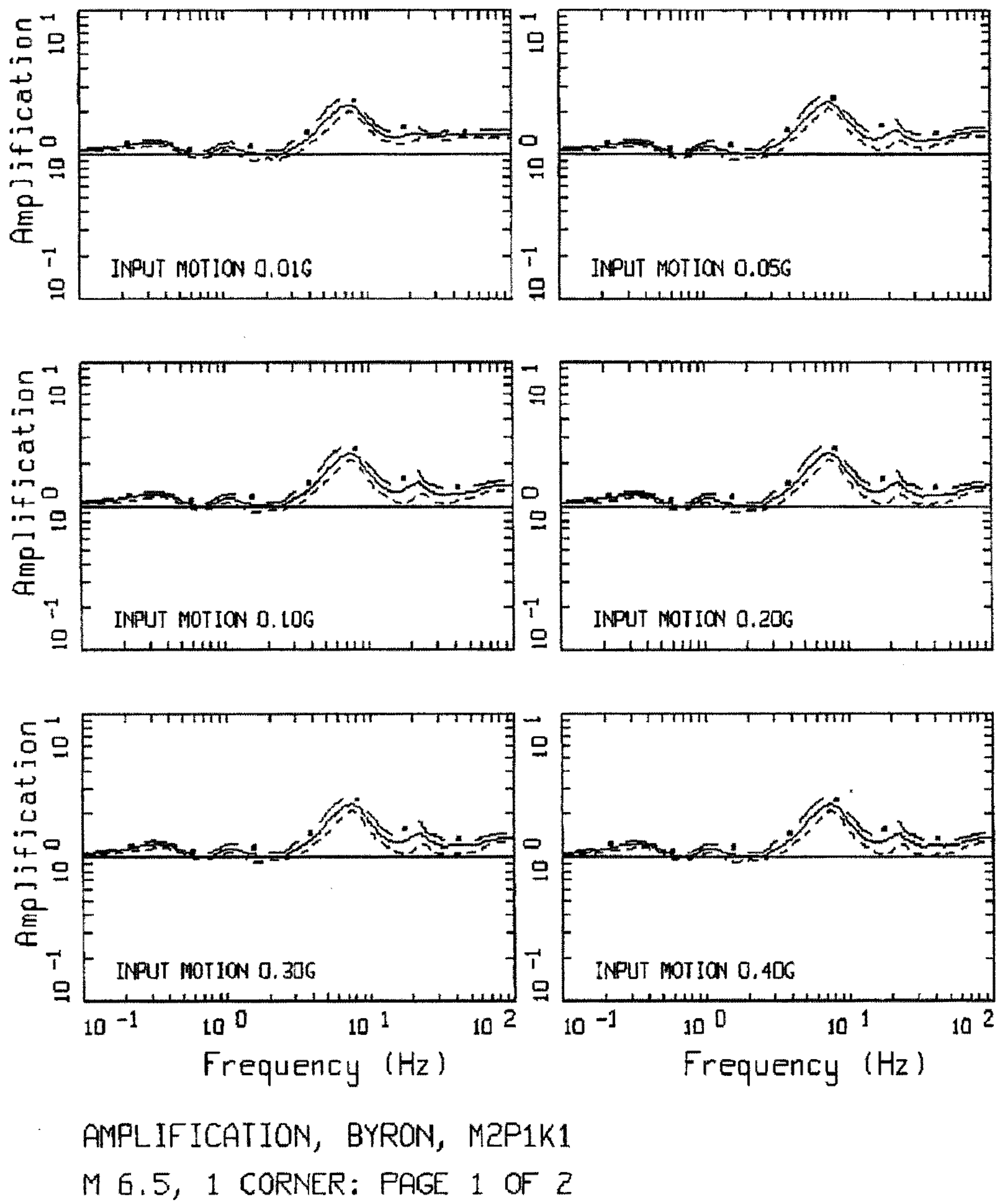


Figure 2.3.6-2: Example suite of amplification factors (5% of critical damping pseudo absolute acceleration spectra) developed for the mean base-case profile (P1), linear site response (model M2), and base-case kappa at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g. **M** 6.5 and single-corner source model (Reference 3) (Reference 13)

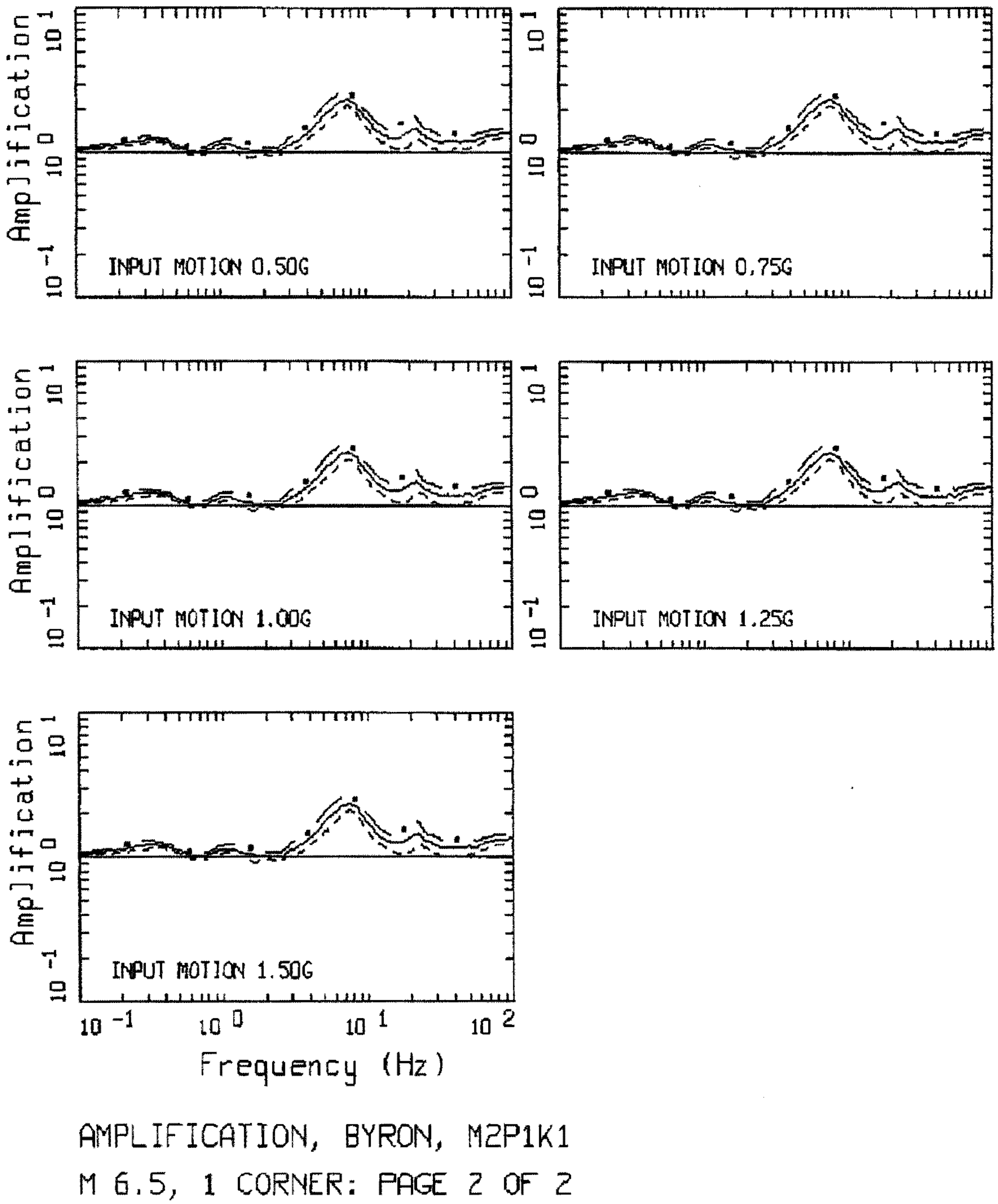


Figure 2.3.6-2:(cont.)

2.3.7 *Control Point Seismic Hazard Curves*

The procedure to develop probabilistic site-specific control point hazard curves used in the present analysis follows the methodology described in Section B-6.0 of the SPID (Reference 3). This procedure (referred to as Method 3) computes a site-specific control point hazard curve for a broad range of spectral accelerations given the site-specific bedrock hazard curve and site-specific estimates of soil or soft-rock response and associated uncertainties. This process is repeated for each of the seven spectral frequencies for which ground motion equations are available. The dynamic response of the materials below the control point was represented by the frequency- and amplitude-dependent amplification functions (median values and standard deviations) developed and described in the previous section. The resulting control point mean hazard curves for Byron station are shown in Figure 2.3.7-1 for the seven spectral frequencies for which ground motion equations are defined. Tabulated values of mean and fractile seismic hazard curves and site response amplification functions are provided in Appendix A.

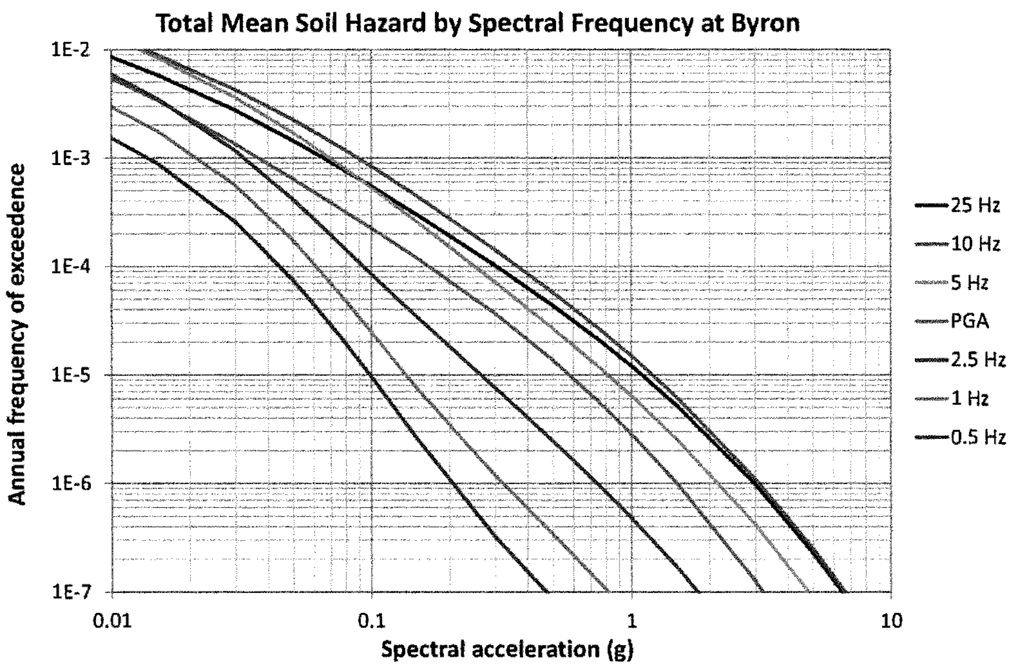


Figure 2.3.7-1: Control point mean hazard curves for spectral frequencies of 0.5, 1, 2.5, 5, 10, 25 and 100 Hz (PGA) at Byron station (5% of critical damping) (Reference 13)

2.4 CONTROL POINT RESPONSE SPECTRA

The control point hazard curves described above have been used to develop uniform hazard response spectra (UHRS) and the ground motion response spectrum (GMRS). The UHRS were obtained through linear interpolation in log-log space to estimate the spectral acceleration at each spectral frequency for the 1E-4 and 1E-5 per year hazard levels.

The 1E-4 and 1E-5 UHRS, along with a design factor (DF), are used to compute the GMRS at the control point using the criteria in Regulatory Guide 1.208 (Reference 29). Table 2.4-1 shows the UHRS and GMRS spectral accelerations for a range of spectral frequencies.

Table 2.4-1: UHRS and GMRS at the control point for Byron (5% of critical damping) (Reference 13)

Freq. (Hz)	10^{-4} UHRS (g)	10^{-5} UHRS (g)	GMRS (g)
100	1.67E-01	5.78E-01	2.70E-01
90	1.67E-01	5.81E-01	2.72E-01
80	1.69E-01	5.89E-01	2.75E-01
70	1.73E-01	6.09E-01	2.84E-01
60	1.83E-01	6.61E-01	3.07E-01
50	2.11E-01	7.93E-01	3.65E-01
40	2.50E-01	9.47E-01	4.35E-01
35	2.71E-01	1.01E+00	4.67E-01
30	2.92E-01	1.08E+00	4.97E-01
25	3.04E-01	1.10E+00	5.08E-01
20	3.11E-01	1.10E+00	5.14E-01
15	3.00E-01	1.04E+00	4.88E-01
12.5	3.19E-01	1.08E+00	5.08E-01
10	3.66E-01	1.20E+00	5.68E-01
9	3.79E-01	1.23E+00	5.81E-01
8	3.82E-01	1.23E+00	5.83E-01
7	3.61E-01	1.16E+00	5.51E-01
6	3.10E-01	1.01E+00	4.77E-01
5	2.50E-01	8.12E-01	3.85E-01
4	1.79E-01	5.64E-01	2.69E-01
3.5	1.49E-01	4.55E-01	2.18E-01
3	1.21E-01	3.55E-01	1.72E-01
2.5	9.36E-02	2.65E-01	1.29E-01
2	8.63E-02	2.30E-01	1.13E-01
1.5	7.30E-02	1.81E-01	9.04E-02
1.25	6.82E-02	1.61E-01	8.12E-02
1	6.13E-02	1.36E-01	6.97E-02

Table 2.4-1: (cont.)

Freq. (Hz)	10^{-4} UHRS (g)	10^{-5} UHRS (g)	GMRS (g)
0.9	5.78E-02	1.29E-01	6.58E-02
0.8	5.41E-02	1.21E-01	6.17E-02
0.7	5.06E-02	1.13E-01	5.77E-02
0.6	4.74E-02	1.06E-01	5.40E-02
0.5	4.44E-02	9.87E-02	5.05E-02
0.4	3.55E-02	7.90E-02	4.04E-02
0.35	3.11E-02	6.91E-02	3.53E-02
0.3	2.66E-02	5.92E-02	3.03E-02
0.25	2.22E-02	4.94E-02	2.52E-02
0.2	1.77E-02	3.95E-02	2.02E-02
0.15	1.33E-02	2.96E-02	1.51E-02
0.125	1.11E-02	2.47E-02	1.26E-02
0.1	8.87E-03	1.97E-02	1.01E-02

The 1E-4 and 1E-5 UHRS are used to compute the GMRS at the control point and are shown in Figure 2.4-1.

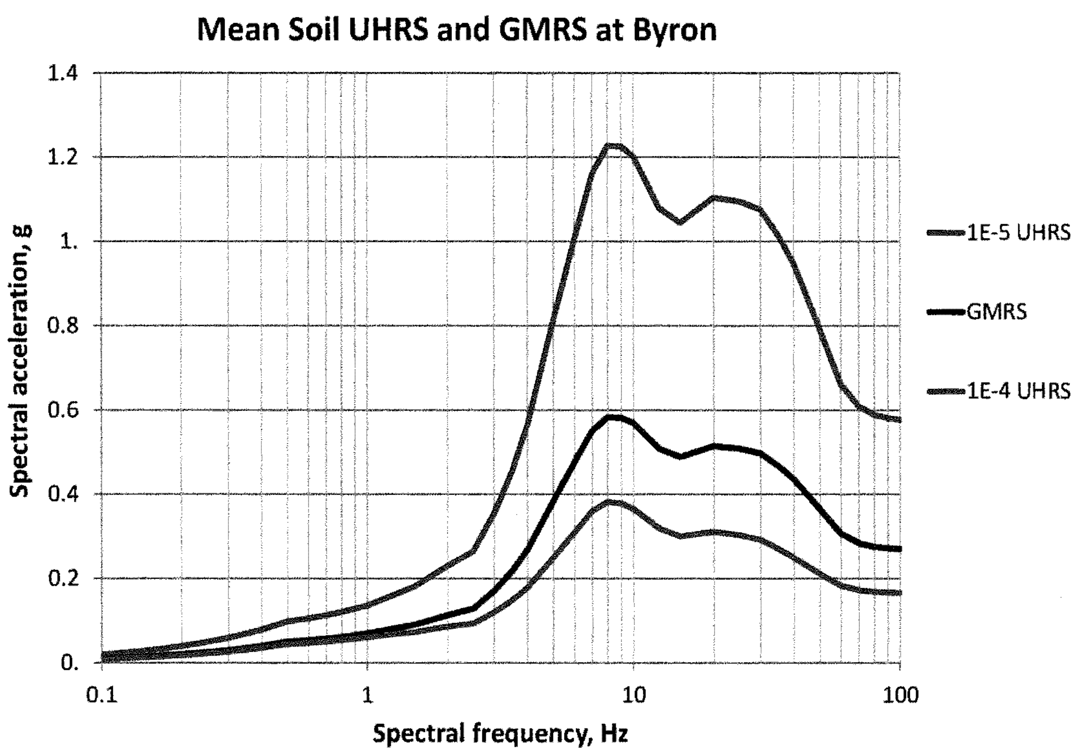


Figure 2.4-1: Plots of 1E-4 and 1E-5 UHRS and GMRS at control point for Byron (5% of critical damping) (Reference 13)

3 Plant Design Basis and Beyond Design Basis Evaluation Ground Motion

The recommended safe shutdown earthquake (SSE) was defined as the occurrence of an MMI VII event near the site. This near field event would produce maximum horizontal ground accelerations of 0.13g. However, at the time of the review of the construction permit application, the NRC considered the occurrence of an earthquake of MMI VIII to be equally probable (a low order of probability) at any place in the Eastern Central Stable Region. The NRC also took the position that, based on the postulated occurrence of an MMI VIII at the site, a safe shutdown earthquake of 0.2g at the bedrock-soil interface was adequately conservative for the Byron station. (Section 2.5, Reference 11)

Section 2.5.2.6 of the Byron station UFSAR (Reference 11) states that plant is designed for a SSE of 0.20g at the bedrock-soil interface. This value was applied at the foundation level. Using the subsurface properties, the corresponding ground surface acceleration was found to be 0.21g. Seismic design of Byron station is based upon a ground surface acceleration of 0.21g and Regulatory Guide 1.60 response spectra shape for SSE. The following description is provided in Section 3.7.1.1 of the UFSAR for the design response spectra for the design basis of Byron station:

> "During the review of the FSAR for an Operating License, the Byron/Braidwood seismic design was reevaluated using the Regulatory Guide 1.60 spectra without the application of a deconvolution analysis. Attachment 3.7A contains the specific NRC questions / responses on seismic design. These questions and responses document the historical evolution of certain aspects of the Byron/Braidwood seismic design. Attachment 3.7A also provides the details and results of this reevaluation. It is concluded that the present seismic design of Byron / Braidwood is conservative. Based on the reevaluation described in Attachment 3.7A, the Byron / Braidwood seismic design basis is acceptable and will therefore be used for all future seismic evaluations." (Reference 11)

Based on the above summary description of Byron station seismic design, the following is concluded:

- The seismic design is based on ground surface acceleration of 0.21g and Regulatory Guide 1.60 response spectra shape.
- The seismic design also satisfies 0.20g and Regulatory Guide 1.60 response spectra shape at the bedrock-soil interface. Per Subsection 3.7.1.2 of the UFSAR, the bedrock-soil interface is on an average 16 feet below the grade elevation.

The reevaluation criteria used for Byron station considering a 0.2g PGA Regulatory Guide 1.60 response spectra shape at the bedrock-soil interface was accepted by the NRC and therefore is used for the GMRS comparison.

3.1 SSE Description of Spectral Shape

The SSE is defined in terms of a PGA and a design response spectrum. The SSE is defined as a Reg. Guide 1.60 (Reference 17) spectrum anchored to a horizontal PGA of 0.20g. The 5% critically damped horizontal SSE for Byron station provided in Table 3.1-1 shows the spectral acceleration values as a function of frequency for the 5% critically damped horizontal SSE of Reg. Guide 1.60 for select frequencies.

Table 3.1-1: Horizontal Safe Shutdown Earthquake response spectrum for Byron station (5% of critical damping)

Frequency (Hz)	Spectral Acceleration (g)
0.35	0.124
0.5	0.167
1	0.295
1.25	0.354
2	0.521
2.5	0.626
3	0.610
4	0.586
5	0.567
6	0.553
7	0.541
8	0.531
9	0.522
10	0.483
12	0.422
12.5	0.410
13	0.398
15	0.358
20	0.289
25	0.246
28	0.226
30	0.215
33	0.200
40	0.200
50	0.200
100	0.200

3.2 CONTROL POINT ELEVATION

In accordance with Section 2.4.2 of the SPID (Reference 3), the licensing design basis definition of the SSE control point for Byron Station is used for comparison to the GMRS. Section 3.7.1.1 of the site UFSAR (Reference 11), states that the 0.20g Reg. Guide 1.60 (Reference 17) site response spectra is defined at the bedrock-soil interface elevation (EL. 869 feet MSL).

3.3 IPEEE DESCRIPTION AND CAPACITY RESPONSE SPECTRUM

A focused-scope Seismic Margins Assessment (SMA) was performed to support the IPEEE for Byron station using the EPRI SMA methodology, EPRI NP-6041-SL (Reference 9) with the enhancements identified in NUREG-1407 (Reference 22), where applicable. Byron station is a focused scope 0.3g peak ground acceleration (PGA) plant per NUREG-1407 (Reference 22). The review level earthquake (RLE) was a median rock NUREG/CR-0098 (Reference 32) spectrum anchored to 0.3g PGA (Reference 12).

The SMA determined that all items on the success path equipment list (SPEL) were found to have a seismic capacity greater than or equal to 0.30g PGA, and the plant was assigned a seismic capacity High Confidence Low Probability of Failure (HCLPF) of 0.3g PGA. Therefore, the IHS is the same as the RLE spectrum and is anchored to 0.3g PGA. The results of the IPEEE were submitted to the NRC in Reference 12. Results of the NRC review are documented in Reference 15. Table 3.3-1 shows the spectral acceleration values for the 5% critically damped IHS for select frequencies. Figure 3.3-1 illustrates the SSE and IHS ground response spectra.

The IPEEE was reviewed for adequacy utilizing the guidance provided in Section 3.3 of the SPID (Reference 3). The IPEEE Adequacy Evaluation according to SPID Section 3.3.1 is included in Appendix B.

The results of the IPEEE Adequacy Evaluation have shown, in accordance with the criteria established in SPID Section 3.3, that the IPEEE is adequate to support screening of the updated seismic hazard for Byron station using the IHS shown in Table 3.3-1. The adequacy evaluation also concluded that the risk insights obtained from the IPEEE are still valid under the current plant configuration.

The full scope detailed review of relay chatter that is required in SPID Section 3.3.1 (Reference 3) has not been completed. NEI letter, "Relay Chatter Reviews for Seismic Hazard Screening" dated October 3, 2013 (Reference 18) states that full scope relay chatter reviews will be completed on the same schedule as the High Frequency Confirmation as proposed in the NEI letter to NRC dated April 9, 2013 (Reference 6) and accepted in NRC's reponse dated May 7, 2013 (Reference 31).

Table 3.3-1: IHS for Byron station (5% of critical damping)

Freq. (Hz)	Spectral Acceleration (g)
0.34	0.098
0.5	0.145
1	0.290
1.25	0.363
2	0.580
2.2	0.636
2.5	0.636
3	0.636
4	0.636
5	0.636
6	0.636
7	0.636
8	0.636
9	0.597
10	0.565
12	0.513
12.5	0.502
15	0.456
20	0.391
25	0.348
30	0.316
33	0.300
40	0.300
50	0.300
100	0.300

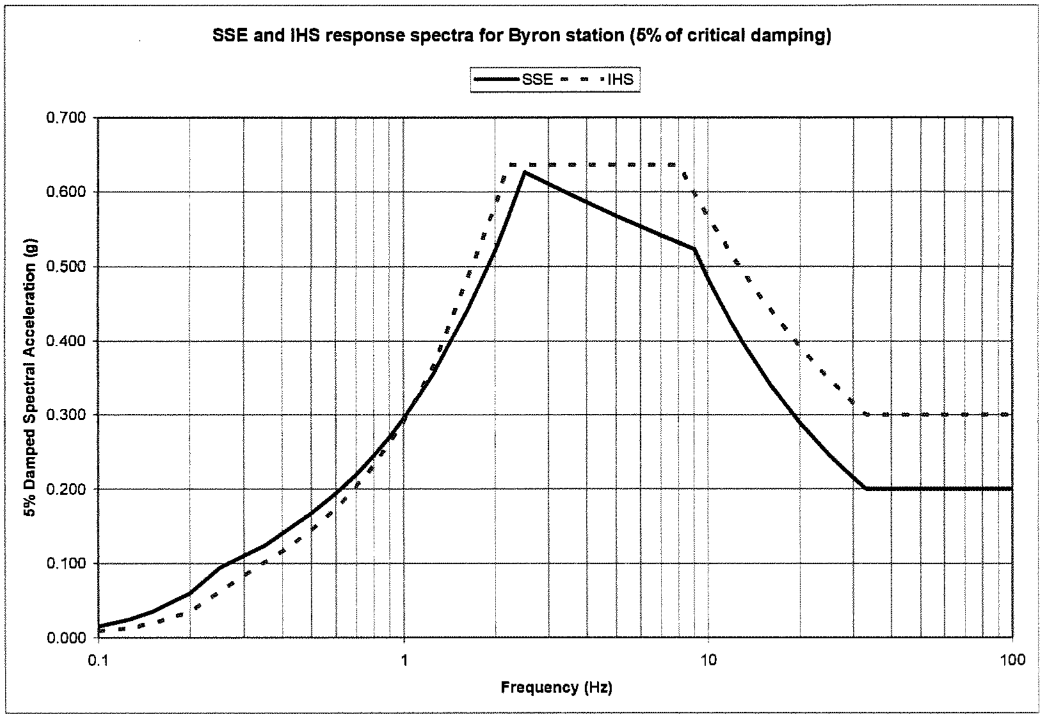


Figure 3.3-1: SSE and IHS response spectra for Byron station (5% of critical damping)

4 Screening Evaluation

Following completion of the seismic hazard reevaluation, as requested in the 50.54(f) letter (Reference 1), a screening process is required to determine if a risk assessment is needed. The horizontal GMRS determined from the hazard reevaluation is used to characterize the amplitude of the new seismic hazard at each of the nuclear power plant sites. The screening evaluation compares the GMRS with the 5% critically damped horizontal SSE and IHS.

4.1 Risk Evaluation Screening (1 to 10 Hz)

The 5% of critical damping GMRS, horizontal SSE, and IHS for Byron station are shown in Table 2.4-1, Table 3.1-1, and Table 3.3-1, respectively. In the frequency range of 1 Hz to 10 Hz, the GMRS exceeds the SSE. However, in the frequency range of 1 Hz to 10 Hz, the IHS exceeds the GMRS with the exception at 10 Hz where the GMRS is approximately equal to the IHS. The less than 1% exceedance of the IHS by the GMRS at 10 Hz is considered negligible. Therefore, a seismic risk evaluation will not be performed.

4.2 High Frequency Screening (> 10 Hz)

The GMRS exceeds the SSE and the IHS in the frequency range above 10 Hz. Therefore, the seismic adequacy of components in the high-frequency range will be evaluated. A high frequency confirmation will be performed.

Since, the IPEEE submittal report (Reference 12) for Byron station was a focused scope review, the SPID requires that focused scope IPEEE plants be upgraded to meet the full scope relay review requirements. Relay chatter reviews will be performed as discussed in Section 3.3.

Section 3.4 of the SPID (Reference 3) discusses high-frequency exceedances. It discusses the impact of high-frequency ground motion on plant components and identifies the component groups that are sensitive to high-frequency vibration. A two-phase test program is described, which is currently ongoing, that will develop data to support the high-frequency confirmation.

The SPID concludes that high-frequency vibration is not damaging, in general, to components with strain- or stress-based failure modes, based on EPRI Report NP-7498 (Reference 21). But components, such as relays, subject to electrical functionality failure modes have unknown acceleration sensitivity for frequencies above 16 Hz.

EPRI Report 1015108 (Reference 25) provides evidence that supports the conclusion that high-frequency motions are not damaging to the majority of nuclear plant components, excluding relays and other electrical devices whose output signals may be affected by high-frequency vibration. EPRI Report 1015109 (Reference 26) provides guidance for identifying and evaluating potentially high-frequency sensitive components. Guidance from these documents is considered in the SPID (Reference 3) report for identifying components that are sensitive to high-frequency vibration. Component types listed in Table 2-1 of EPRI Report 300200706 (Reference 28) will require high-frequency confirmation. Those component types are:

- Electro-mechanical relays
- Circuit breakers
- Control switches
- Process switches and sensors
- Electro-mechanical contactors
- Auxiliary contacts
- Transfer switches
- Potentiometers

4.3 Spent Fuel Pool Evaluation Screening (1 to 10 Hz)

In the 1 Hz to 10 Hz part of the response spectrum, the GMRS exceeds the SSE. Therefore, a spent fuel pool evaluation will be performed.

5 Interim Actions

Based on the screening evaluation outcome described in Section 4, the IHS is greater than or equal to the GMRS in the frequency range of 1 Hz to 10 Hz. Therefore, a risk evaluation will not be performed for Byron station. However, the GMRS exceeds the SSE in the frequency range of 1 Hz to 10 Hz. Therefore, interim actions will be performed in accordance with the ESEP guidance (Reference 4). Due to high frequency exceedances, additional testing and confirmations are required.

5.1 Expedited Seismic Evaluation Process

Based on the screening evaluation, the expedited seismic evaluation described in EPRI 3002000704 (Reference 4) will be performed as proposed in a letter to NRC dated April 9, 2013 (Reference 6) and agreed to by NRC in a letter dated May 7, 2013 (Reference 31).

The ESEP addresses the 50.54(f) letter (Reference 1) request for "interim evaluations 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." Specifically, the ESEP focuses initial industry efforts on short term evaluations that will lead to prompt modifications to some of the most important components that could improve plant seismic safety. Although a risk evaluation will not be performed for Byron station, the ESEP will be performed based on screening requirements.

5.2 Interim Evaluation of Seismic Hazard

Consistent with NRC letter dated February 20, 2014, (Reference 33) the seismic hazard reevaluations presented herein are distinct from the current design and licensing bases of Byron station. Therefore, the results do not call into question the operability or functionality of SSCs and are not reportable pursuant to 10 CFR 50.72, "Immediate notification requirements for operating nuclear power reactors" (Reference 38), and 10 CFR 50.73, "Licensee event report system" (Reference 39).

The NRC letter also requests that licensees provide an interim evaluation or actions to demonstrate that the plant can cope with the reevaluated hazard while the expedited approach and risk evaluations are conducted. In response to that request, NEI letter dated March 12, 2014 (Reference 34), provides seismic core damage risk estimates using the updated seismic hazards for the operating nuclear plants in the Central and Eastern United States. These risk estimates continue to support the following conclusions of the NRC GI-199 Safety/Risk Assessment (Reference 35):

Overall seismic core damage risk estimates are consistent with the Commission's Safety Goal Policy Statement because they are within the subsidiary objective of 10^{-4}/year for core damage frequency. The GI-199 Safety/Risk Assessment, based in part on information from the U. S. Nuclear Regulatory Commission's (NRC's) Individual Plant Examination of External Events (IPEEE) program, indicates that no concern exists regarding adequate protection and that the current seismic design of operating reactors provides a safety margin to withstand potential earthquakes exceeding the original design basis.

Byron station is included in the March 12, 2014 risk estimates (Reference 34). Using the methodology described in the NEI letter, all plants were shown to be below 10^{-4}/year; thus, the above conclusions apply.

5.3 SEISMIC WALKDOWN INSIGHTS

In response to NTTF Recommendation 2.3, the 50.54(f) letter (Reference 1) requested licensees to perform seismic walkdowns in order to, in the context of seismic response: 1) verify that the current plant configuration is consistent with the licensing basis, 2) verify the adequacy of current strategies, monitoring, and maintenance programs, and 3) identify degraded, nonconforming, or unanalyzed conditions. Seismic walkdown guidance (EPRI 1025286, Reference 37) was developed and endorsed by the NRC as a means for all plants to provide a uniform and acceptable industry response to NTTF 2.3 seismic walkdowns.

Seismic walkdowns in response to NTTF 2.3 for Byron station have been performed as documented in Reference 14. The seismic walkdowns for Byron station determined that no adverse anchorage conditions, no adverse seismic spatial interactions, and no other adverse seismic conditions existed for equipment examined during the walkdowns. Any potentially degraded, nonconforming, or unanalyzed conditions identified during the seismic walkdown program were assessed in accordance with the plant corrective action program, and were identified as being minor issues.

Plant vulnerabilities identified in the Byron station seismic Individual Plant Examination of External Events (IPEEE) (Reference 12) were assessed as part of the seismic walkdowns (Reference 14). Plant improvements were identified in Sections 3 and 7 of the IPEEE (Reference 12). Table G-1 in Appendix G of the seismic walkdown reports (Reference 14) lists the plant improvements, the IPEEE proposed resolution, the actual resolution and resolution date. The seismic walkdown reports confirm that no open items exist as a result of the seismic portion of the IPEEE program (References 12 and 15).

5.4 BEYOND-DESIGN-BASIS SEISMIC INSIGHTS

A beyond-design-basis seismic margin assessment (SMA) was performed for the seismic portion of the Byron station IPEEE using the EPRI SMA methodology, EPRI NP-6041-SL (Reference 9) with the enhancements identified in NUREG-1407 (Reference 22), where applicable (Reference 12). Byron station is a focused scope 0.3g peak ground acceleration (PGA) plant per NUREG-1407 (Reference 22). The review level earthquake (RLE) was a median rock NUREG/CR-0098 (Reference 32) spectrum anchored to 0.3g PGA (Reference 12).

The SMA determined that all items on the success path equipment list (SPEL) were found to have a seismic capacity greater than or equal to 0.30g PGA, and the plant was assigned a seismic capacity High Confidence Low Probability of Failure (HCLPF) of 0.3g PGA. No programmatic issues were identified as a result of the SMA. No weak links were identified among buildings, distribution systems (which include piping and cable trays), or relays. Given Byron's design, and based on experiences with actual industrial facilities in moderate to severe earthquakes, it was concluded that Byron station possesses significant margin with respect to its design basis earthquake (References 12). See Appendix B for the IPEEE Adequacy Evaluation which was performed in order to use the IHS for screening.

6 Conclusions

In accordance with the 50.54(f) letter (Reference 1), a seismic hazard and screening evaluation was performed for the Byron station. This reevaluation followed the SPID guidance (Reference 3) in order to develop a GMRS for the site. The GMRS was developed solely for the purpose of screening for additional evaluation requirements in accordance with the SPID (Reference 3). The GMRS represents a beyond-design-basis seismic demand and does not constitute a change in the plant design or licensing basis.

The screening evaluation comparison demonstrates that the GMRS exceeds the SSE in the frequency range of 1 Hz to 10 Hz. Further, Byron station has performed the IPEEE Adequacy Evaluation in accordance with the SPID guidance (Reference 3) and determined that the IHS can be used for screening (see Attachment B). The IHS exceeds the GMRS in the frequency range of 1 Hz to 10 Hz, with the exception of at exactly 10 Hz were the GMRS exceeds the IHS by less than 1%. This exceedance is considered negligible. Based on the comparison of the IHS and GMRS, a risk evaluation will not be performed for Byron station.

Byron station will perform a spent fuel pool integrity evaluation because the GMRS exceeds the SSE in the frequency range of 1 Hz to 10 Hz. The spent fuel pool integrity evaluation will be performed on a schedule consistent with NRC prioritization and the NEI letter dated April 9, 2013 (Reference 6) as endorsed by the NRC in the letter to NEI dated May 7, 2013 (Reference 31).

Byron station will perform near-term ESEP evaluations following the ESEP guidance (Reference 4). This is an action to establish beyond-design-basis safety margin. These evaluations will be conducted on the schedule for central and eastern United States (CEUS) nuclear plants provided via letter from the industry to the NRC dated April 9, 2013 (Reference 6) as endorsed by the NRC in the letter to NEI dated May 7, 2013 (Reference 31).

The GMRS exceeds the SSE and the IHS in the frequency range beyond 10 Hz. Additional high frequency confirmation evaluations are required due to the high frequency exceedances. Also, full scope relay chatter reviews will be performed as part of the IPEEE Adequacy effort. The high frequency confirmation and relay chatter evaluations will be performed on a schedule consistent with NRC prioritization and the NEI letter dated April 9, 2013 (Reference 6) as endorsed by the NRC in the letter to NEI dated May 7, 2013 (Reference 31).

7 References

1. NRC Letter (E. J. Leeds) to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status, *Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident,* March 2012

2. NRC Regulations Title 10, Code of Federal Regulations, Part 50 - Domestic Licensing of Production and Utilization Facilities

3. EPRI Technical Report 1025287, *Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic*, dated November 2012

4. EPRI Technical Report 3002000704, *Seismic Evaluation Guidance: Augmented Aproach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic,* dated May 2013

5. NRC Regulations Title 10, Code of Federal Regulations, Part 100 - Reactor Site Criteria

6. NEI Letter (A. R. Pietrangelo) to the NRC, *Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations,* April 2013

7. EPRI Technical Report 1021097 (NUREG-2115), *Central and Eastern United States Seismic Source Characterization for Nuclear Facilities*, dated January 2012

8. EPRI Technical Report 3002000717, *EPRI (2004, 2006) Ground-Motion Model (GMM) Review Project*, dated June 2013

9. EPRI NP-6041-SL, *A Methodology for Assessment of Nuclear Power Plant Seismic Margin (Revision 1)*, dated August 1991

10. Silva, W.J., N. Abrahamson, G. Toro and C. Costantino, *Description and validation of the stochastic ground motion model*, Report Submitted to Brookhaven National Laboratory, Associated Universities, Inc. Upton, New York 11973, Contract No. 770573, dated 1997

11. Byron Station Updated Final Safety Analysis Report (UFSAR), Revision 14

12. Exelon, *Byron Nuclear Generating Station, Individual Plant Examination for External Events*, December 1996

13. EPRI RSM-112013-025, LCI Report, *Byron Seismic Hazard and Screening Report*, dated November 27, 2013

14. NRC Correspondence RS-12-161, Enclosures 1 and 2, Byron Generating Station Units 1 and 2 Seismic Walkdown Reports , November, 2012

15. Staff Evaluation By The Office of Nuclear Reactor Regulation Related to Generic Letter 88-20, Supplement 4, Individual Plant Examination of External Events, Exelon Generation Company, LLC, Byron station, Units 1 and 2, May, 2001

16. Exelon Generation Company letter to the NRC, *Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Seismic Aspects of Recommendation 2.1, 2.3, and 9.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident*, RS-13-102, dated April 29, 2013

17. U.S. Nuclear Regulatory Commission Reg. Guide 1.60. "Design Response Spectra for Seismic Design of Nuclear Power Plants," 1973

18. NEI Letter to the NRC, *Relay Chatter Reviews for Seismic Hazard Screening,* dated October 3, 2012

19. *Review of Existing Site Response Parameter Data for the Exelon Nuclear Fleet—Revision 1,* Simpson Gumpertz & Heger Rept. No. 128018-R-01 dated July 17, 2012, transmitted by letter from J. Clark to J. Hamel on July 18, 2012

20. Professional Services Industries, Inc., *Geotechnical Engineering Services Report, Proposed ISISFI Pad, Exelon Byron Nuclear Power Station, Byron, Illinois, PSI Project No. 042-75031C,* November, 2007

21. EPRI NP-7498, "Industry Approach to Severe Accident Policy Implementation," November, 1991

22. U.S. Nuclear Regulatory Commission, NUREG-1407, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities", June 1991

23. Bradbury, J.C., Atherton, E. (1965). "The Precambrian Basement of Illinois," Circular 382, Illinois State Geological Survey

24. Attachment 2 to Letter from Glen T. Kaegi of Exelon to U.S. Nuclear Regulatory Commission, dated September 12, 2013 "Byron Station, Units 1 and 2, Descriptions of Subsurface Materials and Properties and Base Case Velocity Profiles (RS-13-205, RA-13-075, and TMI-13-104)

25. EPRI Report 1015108, "Program on Technology Innovation: The Effects of High-Frequency Ground Motion on Structures, Components and Equipment in Nuclear Power Plants", June 2007

26. EPRI Report 1015109, "Program on Technology Innovation: Seismic Screening of Components Sensitive to High-Frequency Vibratory Motions", October 2007

27. EPRI Report NP-7148-SL, "Procedure for Evaluating Nuclear Power Plant Relay Seismic Functionality", December 1990

28. EPRI Report 3002000706, "High Frequency Program, Phase 1 Seismic Test Summary", September 2013

29. U.S. Nuclear Regulatory Commission Reg. Guide 1.208, "A performance-based approach to define the site-specific earthquake ground motion," 2007

30. NRC Letter, Endorsement of EPRI Final Draft Report 1025287, "Seismic Evaluation Guidance," dated February 15, 2013

31. NRC Letter, EPRI Final Draft Report XXXXXX, "Seismic Evaluation Guidance: Augmented Approach for the Resolution of Near-Term Task Force Recommendation 2.1: Seismic," as an Acceptable Alternative to the March 12,2012, Information Request for Seismic Reevaluations, dated May 7, 2013

32. NUREG/CR-0098, "Development of Criteria for Seismic Review of Selected Nuclear Power Plant", May 1978

33. NRC Letter (E. J. Leeds) to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status, Supplemental Information Related to Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Seismic Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Forece Review of Insights From the Fukushima Dai-Ichi Accident, February 20, 2014

34. NEI Letter (A. R. Pietrangelo) to the NRC, *Seismic Risk Evaluations for Plants in the Central and Eastern United States*, March 12, 2014

35. NUREG-0933, "A Prioritization of Generic Safety Issues;" Supplement 34, "Resolution of Generic Safety Issues;" Issue 199: Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants, Revision 1, September, 2011

36. E-mail from R. Kassawaral (EPRI) to J. Clark (Exelon) dated February 27, 2014, Subject: Amp Tables

37. EPRI Technical Report 1025286, *Seismic Walkdown Guidance for Resolution of Fukushima Near-Term Task Force Recommendation 2.3: Seismic*, June 2012

38. Title 10 Code of Federal Regulations Part 50 Section 72, "Immediate notification requirements for operating nuclear power reactors"

39. Title 10 Code of Federal Regulations Part 50 Section 73, "Licensee event report system"

A

Additional Tables

Table A-1a: Mean and fractile seismic hazard curves for 100 Hz (PGA) at Byron, 5% of critical damping (Reference 13)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	5.86E-02	2.53E-02	4.13E-02	5.83E-02	7.77E-02	8.85E-02
0.001	4.12E-02	1.53E-02	2.60E-02	4.01E-02	5.75E-02	6.83E-02
0.005	1.08E-02	3.84E-03	6.17E-03	9.79E-03	1.49E-02	2.22E-02
0.01	5.45E-03	1.82E-03	2.80E-03	4.70E-03	7.66E-03	1.23E-02
0.015	3.42E-03	1.10E-03	1.60E-03	2.80E-03	4.83E-03	8.60E-03
0.03	1.35E-03	3.52E-04	5.27E-04	9.93E-04	1.87E-03	4.07E-03
0.05	6.41E-04	1.27E-04	2.10E-04	4.37E-04	9.24E-04	2.04E-03
0.075	3.49E-04	5.66E-05	1.01E-04	2.29E-04	5.35E-04	1.15E-03
0.1	2.26E-04	3.28E-05	6.09E-05	1.44E-04	3.52E-04	7.45E-04
0.15	1.20E-04	1.53E-05	3.01E-05	7.45E-05	1.90E-04	3.95E-04
0.3	3.68E-05	3.84E-06	8.23E-06	2.25E-05	5.91E-05	1.20E-04
0.5	1.37E-05	1.08E-06	2.60E-06	8.00E-06	2.25E-05	4.50E-05
0.75	5.66E-06	3.14E-07	8.60E-07	3.14E-06	9.51E-06	1.92E-05
1.	2.85E-06	1.11E-07	3.47E-07	1.44E-06	4.83E-06	1.01E-05
1.5	9.93E-07	1.98E-08	7.66E-08	4.31E-07	1.69E-06	3.79E-06
3.	1.26E-07	5.35E-10	3.01E-09	3.33E-08	2.04E-07	5.42E-07
5.	2.14E-08	1.04E-10	2.35E-10	3.23E-09	3.05E-08	9.93E-08
7.5	4.37E-09	9.11E-11	1.01E-10	4.43E-10	5.12E-09	2.04E-08
10.	1.27E-09	9.11E-11	1.01E-10	1.51E-10	1.32E-09	6.00E-09

Table A-1b: Mean and fractile seismic hazard curves for 25 Hz at Byron, 5% of critical damping (Reference 13)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	6.46E-02	3.52E-02	4.70E-02	6.45E-02	8.23E-02	9.24E-02
0.001	4.91E-02	2.25E-02	3.33E-02	4.83E-02	6.45E-02	7.66E-02
0.005	1.56E-02	6.09E-03	8.98E-03	1.42E-02	2.13E-02	3.19E-02
0.01	8.56E-03	3.14E-03	4.56E-03	7.55E-03	1.18E-02	1.84E-02
0.015	5.85E-03	2.10E-03	2.96E-03	5.05E-03	8.23E-03	1.31E-02
0.03	2.76E-03	8.85E-04	1.27E-03	2.19E-03	4.01E-03	6.93E-03
0.05	1.45E-03	3.73E-04	5.83E-04	1.10E-03	2.10E-03	3.90E-03
0.075	8.28E-04	1.72E-04	2.88E-04	6.09E-04	1.23E-03	2.29E-03
0.1	5.47E-04	9.79E-05	1.74E-04	3.95E-04	8.35E-04	1.53E-03
0.15	2.99E-04	4.50E-05	8.47E-05	2.10E-04	4.77E-04	8.60E-04
0.3	1.02E-04	1.23E-05	2.49E-05	6.83E-05	1.72E-04	3.05E-04
0.5	4.37E-05	4.31E-06	9.51E-06	2.84E-05	7.45E-05	1.34E-04
0.75	2.11E-05	1.64E-06	3.95E-06	1.34E-05	3.73E-05	6.64E-05
1.	1.21E-05	7.77E-07	1.95E-06	7.45E-06	2.16E-05	3.90E-05
1.5	5.17E-06	2.35E-07	6.73E-07	2.96E-06	9.37E-06	1.74E-05
3.	9.73E-07	2.04E-08	7.55E-08	4.50E-07	1.82E-06	3.73E-06
5.	2.30E-07	2.35E-09	1.11E-08	8.12E-08	4.19E-07	9.65E-07
7.5	6.33E-08	4.01E-10	1.98E-09	1.67E-08	1.10E-07	2.84E-07
10.	2.33E-08	1.57E-10	5.50E-10	4.83E-09	3.73E-08	1.07E-07

Table A-1c: Mean and fractile seismic hazard curves for 10 Hz at Byron, 5% of critical damping (Reference 13)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	7.44E-02	5.05E-02	5.66E-02	7.45E-02	9.11E-02	9.93E-02
0.001	6.33E-02	3.84E-02	4.70E-02	6.26E-02	8.00E-02	8.98E-02
0.005	2.45E-02	1.10E-02	1.49E-02	2.32E-02	3.37E-02	4.31E-02
0.01	1.32E-02	5.50E-03	7.66E-03	1.21E-02	1.87E-02	2.46E-02
0.015	8.95E-03	3.52E-03	4.98E-03	8.12E-03	1.27E-02	1.72E-02
0.03	4.26E-03	1.51E-03	2.13E-03	3.68E-03	6.26E-03	8.98E-03
0.05	2.26E-03	7.13E-04	1.04E-03	1.84E-03	3.37E-03	5.35E-03
0.075	1.28E-03	3.63E-04	5.42E-04	1.01E-03	1.92E-03	3.19E-03
0.1	8.38E-04	2.10E-04	3.33E-04	6.45E-04	1.25E-03	2.13E-03
0.15	4.45E-04	9.37E-05	1.62E-04	3.37E-04	6.83E-04	1.16E-03
0.3	1.42E-04	2.32E-05	4.37E-05	1.04E-04	2.32E-04	3.90E-04
0.5	5.76E-05	7.89E-06	1.60E-05	4.07E-05	9.65E-05	1.64E-04
0.75	2.68E-05	3.05E-06	6.64E-06	1.82E-05	4.56E-05	7.89E-05
1.	1.50E-05	1.44E-06	3.33E-06	9.79E-06	2.57E-05	4.56E-05
1.5	6.16E-06	4.31E-07	1.08E-06	3.79E-06	1.08E-05	1.98E-05
3.	1.09E-06	3.14E-08	1.01E-07	5.42E-07	2.01E-06	4.01E-06
5.	2.51E-07	2.68E-09	1.11E-08	9.51E-08	4.56E-07	1.04E-06
7.5	6.84E-08	3.37E-10	1.46E-09	1.92E-08	1.20E-07	3.05E-07
10.	2.52E-08	1.25E-10	3.57E-10	5.50E-09	4.13E-08	1.15E-07

Table A-1d: Mean and fractile seismic hazard curves for 5 Hz at Byron, 5% of critical damping (Reference 13)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	7.53E-02	5.12E-02	5.83E-02	7.55E-02	9.24E-02	9.93E-02
0.001	6.49E-02	3.90E-02	4.77E-02	6.45E-02	8.23E-02	9.37E-02
0.005	2.52E-02	1.10E-02	1.51E-02	2.39E-02	3.57E-02	4.37E-02
0.01	1.30E-02	5.50E-03	7.66E-03	1.21E-02	1.84E-02	2.32E-02
0.015	8.41E-03	3.42E-03	4.90E-03	7.89E-03	1.20E-02	1.53E-02
0.03	3.60E-03	1.31E-03	1.90E-03	3.23E-03	5.35E-03	7.23E-03
0.05	1.70E-03	5.58E-04	8.23E-04	1.42E-03	2.53E-03	3.84E-03
0.075	8.76E-04	2.64E-04	3.95E-04	7.03E-04	1.27E-03	2.10E-03
0.1	5.31E-04	1.46E-04	2.29E-04	4.19E-04	7.77E-04	1.31E-03
0.15	2.56E-04	6.17E-05	1.01E-04	1.98E-04	3.84E-04	6.45E-04
0.3	7.11E-05	1.34E-05	2.46E-05	5.50E-05	1.15E-04	1.87E-04
0.5	2.68E-05	4.25E-06	8.35E-06	2.01E-05	4.43E-05	7.23E-05
0.75	1.18E-05	1.60E-06	3.33E-06	8.72E-06	1.98E-05	3.28E-05
1.	6.40E-06	7.55E-07	1.67E-06	4.56E-06	1.08E-05	1.84E-05
1.5	2.53E-06	2.32E-07	5.50E-07	1.69E-06	4.31E-06	7.66E-06
3.	4.15E-07	2.04E-08	5.91E-08	2.32E-07	7.23E-07	1.42E-06
5.	8.89E-08	2.35E-09	8.00E-09	3.95E-08	1.53E-07	3.37E-07
7.5	2.27E-08	4.01E-10	1.31E-09	7.77E-09	3.68E-08	9.37E-08
10.	7.95E-09	1.53E-10	3.68E-10	2.19E-09	1.21E-08	3.42E-08

Table A-1e: Mean and fractile seismic hazard curves for 2.5 Hz at Byron, 5% of critical damping (Reference 13)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	6.52E-02	4.01E-02	4.83E-02	6.45E-02	8.23E-02	9.37E-02
0.001	4.87E-02	2.53E-02	3.23E-02	4.70E-02	6.54E-02	7.77E-02
0.005	1.30E-02	5.66E-03	7.77E-03	1.20E-02	1.84E-02	2.32E-02
0.01	5.96E-03	2.35E-03	3.37E-03	5.58E-03	8.60E-03	1.10E-02
0.015	3.55E-03	1.21E-03	1.82E-03	3.19E-03	5.35E-03	7.03E-03
0.03	1.17E-03	3.09E-04	4.77E-04	9.24E-04	1.84E-03	2.88E-03
0.05	4.15E-04	9.37E-05	1.53E-04	3.09E-04	6.36E-04	1.15E-03
0.075	1.66E-04	3.37E-05	5.75E-05	1.21E-04	2.60E-04	4.70E-04
0.1	8.58E-05	1.60E-05	2.84E-05	6.17E-05	1.38E-04	2.42E-04
0.15	3.44E-05	5.42E-06	1.02E-05	2.46E-05	5.75E-05	9.65E-05
0.3	7.61E-06	7.77E-07	1.74E-06	5.05E-06	1.31E-05	2.32E-05
0.5	2.46E-06	1.60E-07	4.13E-07	1.44E-06	4.31E-06	8.23E-06
0.75	9.64E-07	3.84E-08	1.16E-07	4.98E-07	1.69E-06	3.42E-06
1.	4.80E-07	1.27E-08	4.31E-08	2.19E-07	8.35E-07	1.82E-06
1.5	1.69E-07	2.35E-09	9.24E-09	6.26E-08	2.88E-07	6.83E-07
3.	2.32E-08	1.60E-10	4.98E-10	4.98E-09	3.57E-08	1.07E-07
5.	4.34E-09	1.01E-10	1.16E-10	6.09E-10	5.66E-09	2.01E-08
7.5	9.78E-10	9.11E-11	1.01E-10	1.57E-10	1.13E-09	4.50E-09
10.	3.10E-10	8.60E-11	9.51E-11	1.11E-10	3.63E-10	1.42E-09

Table A-1f: Mean and fractile seismic hazard curves for 1 Hz at Byron, 5% of critical damping (Reference 13)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.27E-02	1.90E-02	2.64E-02	4.13E-02	5.91E-02	6.93E-02
0.001	2.67E-02	1.05E-02	1.57E-02	2.53E-02	3.73E-02	4.63E-02
0.005	6.16E-03	2.13E-03	3.33E-03	5.75E-03	8.98E-03	1.16E-02
0.01	2.96E-03	7.13E-04	1.23E-03	2.60E-03	4.70E-03	6.54E-03
0.015	1.79E-03	3.14E-04	5.83E-04	1.42E-03	3.05E-03	4.56E-03
0.03	5.59E-04	5.91E-05	1.21E-04	3.42E-04	1.01E-03	1.74E-03
0.05	1.74E-04	1.44E-05	3.05E-05	9.11E-05	2.88E-04	6.09E-04
0.075	5.79E-05	4.25E-06	9.11E-06	2.92E-05	8.98E-05	2.13E-04
0.1	2.50E-05	1.67E-06	3.73E-06	1.25E-05	3.90E-05	9.37E-05
0.15	7.56E-06	4.13E-07	1.04E-06	3.63E-06	1.27E-05	2.84E-05
0.3	1.18E-06	3.05E-08	9.79E-08	4.77E-07	1.98E-06	4.77E-06
0.5	3.42E-07	3.47E-09	1.49E-08	1.04E-07	5.35E-07	1.51E-06
0.75	1.25E-07	5.75E-10	2.96E-09	2.76E-08	1.84E-07	5.83E-07
1.	5.93E-08	2.01E-10	8.98E-10	1.01E-08	8.00E-08	2.80E-07
1.5	1.93E-08	1.05E-10	2.04E-10	2.13E-09	2.22E-08	8.98E-08
3.	2.23E-09	9.11E-11	1.01E-10	1.72E-10	1.79E-09	9.37E-09
5.	3.64E-10	8.12E-11	9.11E-11	1.01E-10	2.68E-10	1.32E-09
7.5	7.41E-11	8.12E-11	9.11E-11	1.01E-10	1.11E-10	2.84E-10
10.	2.20E-11	8.12E-11	9.11E-11	1.01E-10	1.11E-10	1.32E-10

Table A-1g: Mean and fractile seismic hazard curves for 0.5 Hz at Byron, 5% of critical damping (Reference 13)

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	2.10E-02	9.51E-03	1.36E-02	2.01E-02	2.80E-02	3.52E-02
0.001	1.21E-02	5.20E-03	7.55E-03	1.15E-02	1.67E-02	2.19E-02
0.005	3.11E-03	6.83E-04	1.23E-03	2.76E-03	4.98E-03	6.83E-03
0.01	1.53E-03	1.62E-04	3.57E-04	1.13E-03	2.80E-03	4.25E-03
0.015	8.97E-04	5.91E-05	1.44E-04	5.35E-04	1.69E-03	2.92E-03
0.03	2.57E-04	8.23E-06	2.25E-05	1.02E-04	4.56E-04	1.04E-03
0.05	7.49E-05	1.67E-06	4.63E-06	2.32E-05	1.15E-04	3.28E-04
0.075	2.35E-05	4.13E-07	1.20E-06	6.36E-06	3.33E-05	1.02E-04
0.1	9.61E-06	1.42E-07	4.37E-07	2.46E-06	1.34E-05	4.13E-05
0.15	2.60E-06	2.80E-08	1.01E-07	6.09E-07	3.79E-06	1.13E-05
0.3	3.23E-07	1.32E-09	6.54E-09	5.27E-08	4.19E-07	1.57E-06
0.5	8.58E-08	1.74E-10	6.93E-10	8.60E-09	8.60E-08	4.31E-07
0.75	3.10E-08	1.01E-10	1.62E-10	1.82E-09	2.42E-08	1.49E-07
1.	1.47E-08	1.01E-10	1.11E-10	6.09E-10	9.24E-09	6.64E-08
1.5	4.86E-09	9.11E-11	1.01E-10	1.67E-10	2.19E-09	1.90E-08
3.	5.90E-10	8.12E-11	9.11E-11	1.01E-10	2.01E-10	1.67E-09
5.	1.01E-10	8.12E-11	9.11E-11	1.01E-10	1.11E-10	2.72E-10
7.5	2.15E-11	8.12E-11	9.11E-11	1.01E-10	1.11E-10	1.13E-10
10.	6.57E-12	8.12E-11	9.11E-11	1.01E-10	1.01E-10	1.11E-10

Table A-2a: Amplification Functions for Byron, 5% of critical damping (Reference 13)

100 Hz (PGA)	Median AF	Sigma ln(AF)	25 Hz	Median AF	Sigma ln(AF)	10 Hz	Median AF	Sigma ln(AF)	5 Hz	Median AF	Sigma ln(AF)
1.00E-02	1.35E+00	6.91E-02	1.30E-02	1.26E+00	7.75E-02	1.90E-02	1.57E+00	1.06E-01	2.09E-02	1.58E+00	1.44E-01
4.95E-02	1.29E+00	7.47E-02	1.02E-01	1.10E+00	1.26E-01	9.99E-02	1.56E+00	1.20E-01	8.24E-02	1.62E+00	1.44E-01
9.64E-02	1.24E+00	7.74E-02	2.13E-01	1.06E+00	1.36E-01	1.85E-01	1.54E+00	1.23E-01	1.44E-01	1.62E+00	1.44E-01
1.94E-01	1.19E+00	8.04E-02	4.43E-01	1.03E+00	1.42E-01	3.56E-01	1.51E+00	1.26E-01	2.65E-01	1.64E+00	1.43E-01
2.92E-01	1.16E+00	8.25E-02	6.76E-01	1.01E+00	1.46E-01	5.23E-01	1.48E+00	1.30E-01	3.84E-01	1.64E+00	1.41E-01
3.91E-01	1.14E+00	8.38E-02	9.09E-01	9.88E-01	1.49E-01	6.90E-01	1.46E+00	1.33E-01	5.02E-01	1.65E+00	1.39E-01
4.93E-01	1.12E+00	8.54E-02	1.15E+00	9.71E-01	1.53E-01	8.61E-01	1.44E+00	1.35E-01	6.22E-01	1.65E+00	1.38E-01
7.41E-01	1.09E+00	8.88E-02	1.73E+00	9.35E-01	1.58E-01	1.27E+00	1.39E+00	1.41E-01	9.13E-01	1.65E+00	1.41E-01
1.01E+00	1.06E+00	9.17E-02	2.36E+00	9.03E-01	1.61E-01	1.72E+00	1.35E+00	1.45E-01	1.22E+00	1.65E+00	1.55E-01
1.28E+00	1.03E+00	9.60E-02	3.01E+00	8.75E-01	1.67E-01	2.17E+00	1.32E+00	1.51E-01	1.54E+00	1.63E+00	1.81E-01
1.55E+00	1.01E+00	1.03E-01	3.63E+00	8.51E-01	1.72E-01	2.61E+00	1.29E+00	1.58E-01	1.85E+00	1.61E+00	2.07E-01
2.5 Hz	**Median AF**	**Sigma ln(AF)**	**1 Hz**	**Median AF**	**Sigma ln(AF)**	**0.5 Hz**	**Median AF**	**Sigma ln(AF)**			
2.18E-02	1.03E+00	8.63E-02	1.27E-02	1.15E+00	7.02E-02	8.25E-03	1.16E+00	9.34E-02			
7.05E-02	1.05E+00	8.63E-02	3.43E-02	1.16E+00	6.93E-02	1.96E-02	1.17E+00	9.13E-02			
1.18E-01	1.05E+00	8.62E-02	5.51E-02	1.16E+00	6.89E-02	3.02E-02	1.17E+00	9.06E-02			
2.12E-01	1.06E+00	8.67E-02	9.63E-02	1.17E+00	6.87E-02	5.11E-02	1.17E+00	9.02E-02			
3.04E-01	1.06E+00	8.81E-02	1.36E-01	1.17E+00	6.87E-02	7.10E-02	1.17E+00	9.02E-02			
3.94E-01	1.07E+00	8.99E-02	1.75E-01	1.17E+00	6.88E-02	9.06E-02	1.17E+00	9.03E-02			
4.86E-01	1.08E+00	9.23E-02	2.14E-01	1.18E+00	6.91E-02	1.10E-01	1.17E+00	9.03E-02			
7.09E-01	1.09E+00	1.02E-01	3.10E-01	1.18E+00	7.00E-02	1.58E-01	1.18E+00	9.04E-02			
9.47E-01	1.11E+00	1.16E-01	4.12E-01	1.18E+00	7.04E-02	2.09E-01	1.18E+00	9.07E-02			
1.19E+00	1.13E+00	1.24E-01	5.18E-01	1.19E+00	7.17E-02	2.62E-01	1.18E+00	9.10E-02			
1.43E+00	1.14E+00	1.56E-01	6.19E-01	1.19E+00	7.67E-02	3.12E-01	1.18E+00	9.08E-02			

Tables A-2b1 and A-2b2 are tabular versions of the typical amplification factors provided in Figures 2.3.6-1 and 2.3.6-2. Values are provided for two input motion levels at approximately 10^{-4} and 10^{-5} mean annual frequency of exceedance. These tables concentrate on the frequency range of 0.5 Hz to 25 Hz, with values up to 100 Hz included, with a single value at 0.1 Hz included for completeness. These factors are unverified and are provided for information only. The figures should be considered the governing information.

Table A-2b1. Median AFs and sigmas for Model 1, Profile 1, for 2 PGA levels (Reference 36)

M1P1K1	Rock PGA=0.0964			M1P1K1	PGA=0.493		
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
100.0	0.131	1.359	0.072	100.0	0.572	1.161	0.087
87.1	0.133	1.349	0.072	87.1	0.580	1.142	0.089
75.9	0.136	1.332	0.073	75.9	0.595	1.110	0.092
66.1	0.141	1.297	0.076	66.1	0.624	1.048	0.099
57.5	0.153	1.231	0.084	57.5	0.682	0.957	0.115
50.1	0.173	1.185	0.099	50.1	0.775	0.894	0.137
43.7	0.198	1.154	0.120	43.7	0.895	0.872	0.161
38.0	0.217	1.137	0.126	38.0	0.992	0.889	0.174
33.1	0.232	1.130	0.135	33.1	1.050	0.900	0.172
28.8	0.245	1.176	0.136	28.8	1.091	0.946	0.167
25.1	0.264	1.240	0.110	25.1	1.156	1.006	0.170
21.9	0.283	1.375	0.168	21.9	1.226	1.135	0.163
19.1	0.272	1.319	0.215	19.1	1.222	1.160	0.192
16.6	0.250	1.245	0.181	16.6	1.151	1.149	0.187
14.5	0.241	1.238	0.125	14.5	1.076	1.135	0.158
12.6	0.250	1.307	0.125	12.6	1.050	1.148	0.145
11.0	0.275	1.461	0.136	11.0	1.088	1.229	0.157
9.5	0.314	1.730	0.130	9.5	1.191	1.419	0.184
8.3	0.352	2.082	0.118	8.3	1.328	1.727	0.193
7.2	0.360	2.252	0.110	7.2	1.441	2.014	0.171
6.3	0.326	2.155	0.149	6.3	1.416	2.119	0.141
5.5	0.279	1.917	0.172	5.5	1.268	1.998	0.147
4.8	0.238	1.662	0.152	4.8	1.108	1.793	0.150
4.2	0.202	1.442	0.123	4.2	0.940	1.577	0.164
3.6	0.174	1.274	0.121	3.6	0.795	1.376	0.167
3.2	0.150	1.158	0.122	3.2	0.668	1.233	0.159
2.8	0.134	1.084	0.086	2.8	0.585	1.141	0.114
2.4	0.116	1.011	0.063	2.4	0.496	1.053	0.084
2.1	0.107	1.021	0.062	2.1	0.449	1.053	0.067
1.8	0.096	1.021	0.081	1.8	0.398	1.047	0.087
1.6	0.085	1.038	0.111	1.6	0.348	1.059	0.111
1.4	0.075	1.060	0.078	1.4	0.303	1.077	0.078
1.2	0.070	1.117	0.088	1.2	0.279	1.131	0.089
1.0	0.065	1.141	0.066	1.0	0.256	1.153	0.067

Table A-2b1: (cont.)

M1P1K1	Rock PGA=0.0964			M1P1K1	PGA=0.493		
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
0.91	0.057	1.095	0.061	0.91	0.222	1.106	0.060
0.79	0.049	1.031	0.051	0.79	0.188	1.042	0.050
0.69	0.043	1.006	0.048	0.69	0.162	1.017	0.047
0.60	0.038	1.029	0.054	0.60	0.144	1.039	0.053
0.52	0.035	1.082	0.050	0.52	0.128	1.091	0.050
0.46	0.031	1.143	0.038	0.46	0.112	1.150	0.039
0.10	0.001	1.074	0.020	0.10	0.004	1.070	0.020

Table A-2b2. Median AFs and sigmas for Model 2, Profile 1, for 2 PGA levels (Reference 36)

M2P1K1	PGA=0.0964			M2P1K1	PGA=0.493		
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
100.0	0.136	1.406	0.070	100.0	0.672	1.364	0.075
87.1	0.137	1.397	0.070	87.1	0.686	1.350	0.076
75.9	0.141	1.382	0.070	75.9	0.712	1.328	0.077
66.1	0.147	1.351	0.072	66.1	0.764	1.283	0.081
57.5	0.160	1.290	0.079	57.5	0.863	1.210	0.095
50.1	0.183	1.255	0.095	50.1	1.038	1.196	0.116
43.7	0.210	1.224	0.109	43.7	1.208	1.178	0.134
38.0	0.231	1.213	0.128	38.0	1.321	1.183	0.145
33.1	0.245	1.193	0.124	33.1	1.366	1.171	0.139
28.8	0.259	1.242	0.126	28.8	1.408	1.221	0.141
25.1	0.281	1.321	0.109	25.1	1.503	1.308	0.118
21.9	0.300	1.456	0.180	21.9	1.570	1.453	0.185
19.1	0.281	1.363	0.227	19.1	1.433	1.359	0.235
16.6	0.256	1.274	0.180	16.6	1.270	1.268	0.187
14.5	0.248	1.274	0.117	14.5	1.201	1.266	0.122
12.6	0.260	1.359	0.117	12.6	1.236	1.352	0.122
11.0	0.289	1.536	0.125	11.0	1.355	1.530	0.129
9.5	0.332	1.830	0.116	9.5	1.534	1.828	0.118
8.3	0.371	2.191	0.107	8.3	1.685	2.192	0.108
7.2	0.369	2.312	0.110	7.2	1.657	2.316	0.109
6.3	0.327	2.159	0.155	6.3	1.447	2.165	0.154
5.5	0.277	1.900	0.177	5.5	1.211	1.908	0.175
4.8	0.234	1.635	0.140	4.8	1.015	1.643	0.140
4.2	0.199	1.421	0.114	4.2	0.852	1.429	0.113
3.6	0.172	1.259	0.112	3.6	0.732	1.267	0.112
3.2	0.149	1.148	0.114	3.2	0.626	1.155	0.114
2.8	0.133	1.076	0.082	2.8	0.555	1.083	0.082

Table A-2b2: (cont.)

M2P1K1		PGA=0.0964		M2P1K1		PGA=0.493	
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
2.4	0.115	1.006	0.060	2.4	0.476	1.012	0.060
2.1	0.106	1.017	0.062	2.1	0.437	1.023	0.062
1.8	0.096	1.019	0.080	1.8	0.390	1.025	0.079
1.6	0.085	1.036	0.111	1.6	0.342	1.042	0.110
1.4	0.075	1.058	0.078	1.4	0.299	1.063	0.078
1.2	0.070	1.115	0.088	1.2	0.277	1.121	0.087
1.0	0.065	1.140	0.066	1.0	0.254	1.145	0.066
0.91	0.057	1.094	0.061	0.91	0.221	1.100	0.060
0.79	0.049	1.030	0.051	0.79	0.187	1.037	0.050
0.69	0.043	1.006	0.048	0.69	0.162	1.013	0.048
0.60	0.038	1.028	0.054	0.60	0.143	1.035	0.053
0.52	0.035	1.082	0.050	0.52	0.127	1.088	0.050
0.46	0.031	1.143	0.038	0.46	0.112	1.147	0.038
0.10	0.001	1.074	0.020	0.10	0.004	1.068	0.020

B
IPEEE Adequacy Evaluation

Seismic Hazard IPEEE Adequacy Evaluation, Byron Units 1 & 2

Prepared by Sargent & Lundy, LLC

S&L Report No. SL-012188

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Section **Page**

Executive Summary

The NRC 50.54(f) letter (Reference 8) has requested all nuclear power plant licensees to reevaluate the seismic hazards at their sites against present-day NRC requirements. Byron Nuclear Generating Station (BNGS) is performing the seismic hazard and screening per the EPRI Screening Prioritization and Implementation Details (SPID) (Reference 7) guidance. A new Ground Motion Response Spectrum (GMRS) has been developed for BNGS per the SPID methodology. Using the SPID guidelines, the GMRS can be compared to the Individual Plant Examination of External Events (IPEEE) High Confidence of a Low Probability of Failure (HCLPF) spectrum (IHS) to screen out of future seismic risk assessments. In order to perform the GMRS to IHS screening, the BNGS IPEEE is subject to an adequacy review to ensure that the IPEEE is of sufficient quality. This report documents the adequacy review performed following the guidance provided in Section 3.3.1 of the SPID.

BNGS is a focused scope plant binned to 0.3g PGA NUREG/CR-0098 (Reference 15) median rock spectrum per NUREG-1407 (Reference 3). The BNGS Units 1 and 2 IPEEE submittal report (Reference 1) was provided to the NRC in December 1996 by ComEd (now Exelon). The NRC conducted a Staff Evaluation Report (SER) of the IPEEE submittal (Reference 6). The IPEEE seismic assessment was performed using a Seismic Margin Assessment (SMA) per the EPRI NP-6041-SL (Reference 2) methodology.

The SPID defines four categories which must be addressed in order to use the IHS for seismic hazard screening. The four categories are General Considerations, Prerequisites, Adequacy Demonstration, and Documentation. The General Considerations, Prerequisites, and Adequacy Demonstration categories were reviewed to determine the adequacy of each for seismic hazard screening purposes. This report provides the Documentation of the IPEEE adequacy review.

The SPID IPEEE adequacy General Considerations requires that focused scope plants perform full scope evaluations of soil failure modes and relay chatter. Consistent with industry guidance (Reference 10) full scope relay chatter reviews will be performed on a schedule consistent with high frequency evaluations and is not addressed in this report. A soil failures evaluation was performed and concludes that liquefaction, slope stability, and settlement are not a concern for structures which contain Success Path Equipment List (SPEL) components.

The SPID requires that four IPEEE adequacy Prerequisites be reviewed. These prerequisites generally relate to closure of any open items from the IPEEE submittal including commitments, plant improvements/modifications, and addressing any weaknesses from the IPEEE submittal. The final prerequisite requires a review of plant modifications since the IPEEE submittal to confirm that the conclusions of the IPEEE are not adversely impacted by plant modifications. All prerequisites were reviewed and were found to be met for seismic hazard screening.

Adequacy Demonstrations must be performed on nine different items from the IPEEE submittal. Each of the Adequacy Demonstration items must evaluate (1) the methodology used, (2) whether the analysis was conducted in accordance with NUREG-1407, and (3) a statement as to whether the results are adequate for screening purposes.

The Adequacy Demonstration determined that the nine categories are adequate for seismic hazard screening. Two categories were considered to have minor weaknesses. The Seismic Models and Structural Response Analysis review determined that cracked concrete sections associated with higher IPEEE input motions and SSI were not considered in the seismic models. Upon further review, based on higher actual concrete compressive strength, $\pm$15% widening of the response spectra at all frequencies, and generation of SMA specific response spectra without accounting for effect of incoherent seismic motion, the impact of SSI and cracking of concrete sections associated with higher IPEEE input motions on SMA was found to be negligible. Thus, the results of the seismic models are considered adequate for seismic hazard screening purposes. The Peer Review had minor weaknesses in that it did not report peer reviews of the systems selection and peer reviews by the licensee personnel. These weaknesses are mitigated by the fact that the IPEEE Adequacy review in this report investigated the systems selection and the licensee participated in the SMA process.

The available documentation from the Byron seismic IPEEE was used to perform the Adequacy review. Some of the original documentation from the IPEEE is not available, but sufficient information was available for each review category to make determinations of the adequacy for each item.

Byron is a focused scope review IPEEE plant and therefore must perform full scope relay chatter reviews. NEI Letter "Relay Chatter Reviews for Seismic Hazard Screening" dated October 3, 2013 (Reference 10) states that full scope relay chatter reviews will be performed on a schedule consistent with high frequency evaluations. Thus, this report does not address relay chatter, but BNGS intends to perform relay chatter reviews on the same schedule as the high frequency confirmations for the plant.

Therefore, the overall Byron IPEEE SMA was determined to be adequate for seismic hazard screening and the risk insights from the IPEEE are valid under current plant configurations. The IHS is a NUREG/CR-0098 median rock spectrum anchored to 0.3g PGA, which will be used for screening of the new GMRS in accordance with the SPID (Reference 7).

1.0 Introduction

Following the accident at the Fukushima Daiichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the NRC Commission established a Near Term Task Force (NTTF) to conduct a systematic review of NRC processes and regulations and to determine if the agency should make additional improvements to its regulatory system. The NTTF developed a set of recommendations intended to clarify and strengthen the regulatory framework for protection against natural phenomena. Subsequently, the NRC issued a 50.54(f) letter that requests information to assure that these recommendations are addressed by all U.S. nuclear power plants (Reference 8). The 50.54(f) letter requests that licensees and holders of construction permits under 10 CFR Part 50 (Reference 9) reevaluate the seismic hazards at their sites against present-day NRC requirements. Depending on the comparison between the reevaluated seismic hazard and the current design basis, the result will determine if a seismic risk assessment is required.

The guidance for developing the seismic hazard, performing the seismic hazard screening, and performing the subsequent seismic risk assessment work are contained in 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"* (Reference 7). A Ground Motion Response Spectra (GMRS) using up to date seismic hazard data and source characterization is developed for each site. This new GMRS is compared to the site design basis response spectra using the SPID guidance. The first method for seismic screening is based on a comparison of GMRS to the site design basis Safe Shutdown Earthquake (SSE) spectrum. The second method for seismic screening is to compare the GMRS to the site Individual Plant Examination of External Events (IPEEE) High Confidence of a Low Probability of Failure (HCLPF) spectrum (IHS). Plants that do not screen out must perform a seismic risk assessment.

In order to perform the GMRS to IHS screening, the site IPEEE is subject to an adequacy review to ensure that the IPEEE is of sufficient quality. The adequacy review guidance is provided in Section 3.3.1 of the SPID.

The purpose of this report is to document the IPEEE adequacy review for Byron Nuclear Generating Station (BNGS) Units 1 and 2 using the criteria of Section 3.3.1 of the SPID.

1.1 SPID Requirements for IPEEE Adequacy

Nuclear power plant licensees were required to perform the Individual Plant Examination of External Events for Severe Accident Vulnerabilities per Generic Letter No. 88-20, Supplement 4 (Reference 5). Seismic hazards were one of the external events evaluated in the IPEEE program. Guidance for performing the IPEEE analysis was provided in NUREG-1407 (Reference 3). The seismic IPEEE was accomplished by performing a Seismic Probabilistic Risk Assessment (SPRA) or Seismic Margins Method (SMM) (also referred to as Seismic Margins Assessment (SMA)).

The SPID (Reference 7) defines four categories which must be addressed in order to use the IHS for seismic hazard screening. The four categories are:

- General Considerations
- Prerequisites
- Adequacy Demonstration
- Documentation

The General Considerations state that reduced scope SMAs can not be used for screening. Focused scope SMAs must complete (1) a full scope review of relay chatter, and (2) a full review of soil failure modes.

Four Prerequisites are defined in the SPID which must be confirmed and documented in the hazard submittal to the NRC. These prerequisites generally relate to closure of any open items from the IPEEE submittal including commitments, plant improvements/modifications, and addressing any weaknesses from the IPEEE submittal. The final prerequisite requires a review of plant modifications since the IPEEE submittal to confirm that the conclusions of the IPEEE are not impacted.

Adequacy Demonstrations must be performed on nine different items from the IPEEE submittal. Each of the Adequacy Demonstration items must evaluate (1) the methodology used, (2) whether the analysis was conducted in accordance with NUREG-1407, and (3) a statement, if applicable, as to whether the results are adequate for screening purposes.

Licensees are also requested to have documentation of the Prerequisites and Adequacy Demonstration and the information used to assess these items available for review at the site for potential staff audits.

1.2 Byron IPEEE Seismic Description

The BNGS Units 1 and 2 IPEEE submittal report (Reference 1) was provided to the NRC in December 1996 by ComEd (now Exelon, henceforth referred to as such). The NRC conducted a Staff Evaluation Report (SER) of the IPEEE submittal (Reference 6).

The IPEEE was performed following the guidance of NUREG-1407 (Reference 3). A seismic margin assessment (SMA) was performed for the seismic portion of the BNGS IPEEE using the EPRI SMA methodology, EPRI NP-6041-SL (Reference 2) with the enhancements identified in NUREG-1407 (Reference 3) where applicable. Byron is a focused scope 0.3g peak ground acceleration (PGA) plant per NUREG-1407. Therefore, the objective of the SMA was to evaluate each item on the Success Path Equipment List (SPEL) in terms of the PGA for the Review Level Earthquake (RLE). No attempts were made to assign a component PGA greater than the 0.3g RLE.

The IPEEE SMA did not identify any overall seismic concerns. No seismic programmatic issues were identified and no weak links were identified among buildings, distribution systems, or relays. All components in the SPEL were identified and screened using EPRI NP-6041-SL methodology. If the equipment did not screen to the RLE, a HCLPF capacity was calculated using the Conservative Deterministic Failure Margin (CDFM) approach per EPRI NP-6041-SL. All structures, equipment and components evaluated were found to have a seismic capacity of at least 0.3g PGA.

2.0 General Considerations

Byron was a focused scope plant for the IPEEE seismic evaluation. The SPID (Reference 7) Section 3.3.1 - General Considerations requires that focused scope plants perform full scope relay chatter reviews and a soil failures evaluation.

2.1 Relay Chatter

Byron is a focused scope review IPEEE plant and therefore must perform full scope relay chatter reviews. NEI Letter "Relay Chatter Reviews for Seismic Hazard Screening" dated October 3, 2013 (Reference 10) states that full scope relay chatter reviews will be performed on a schedule consistent with high frequency evaluations. Thus, this report does not address relay chatter, but BNGS intends to perform relay chatter reviews on the same schedule as the high frequency confirmations for the plant.

2.2 Soil Failure Evaluation

Subsection 3.2.4.3 of NUREG-1407 (Reference 3) requires that the following soil failures need to be addressed for full-scope plant sites:

- Soil Liquefaction
- Foundation Settlement
- Slope Instability (soil instability)

Subsection 3.1.3.2 and Subsection 3.4.1 of the BNGS IPEEE submittal (Reference 1) documents that the following Seismic Category I structures are considered for IPEEE adequacy review:

1. Containment Structure and Internal Structure
2. Auxiliary-Fuel Handling Building Complex
3. Essential Service Water Cooling Tower
4. Main Steam Isolation Valve Buildings and Tunnels

The deep wells, which are screened out for IPEEE review level earthquake (RLE of 0.3g) are also addressed.

Since, the Turbine building (a seismic category 2 structure), was also modeled (for seismic analysis) with the Auxiliary building, the Turbine building is also considered in the IPEEE adequacy review.

Per Subsection 3.1.3.1 of the BNGS IPEEE submittal (Reference 1), the River Screen House (a seismic category I structure) is not considered (not needed) in the seismic margin evaluation. Hence the River Screen House is not considered in the IPEEE adequacy review.

Geological and Geotechnical Information

For Byron Station, Subsection 3.7.2.4 of Byron/Braidwood UFSAR (Reference 12) states that all the structures are supported on bedrock directly except for the River Screen House. Subsection 2.5.4.10.2.3 of Byron/Braidwood UFSAR (Reference 12) states that the Seismic Category I Byron plant structures are all founded on grouted bedrock. Per Subsection 2.5.4.10.2.3 of the UFSAR (Reference 12), the Reactor Containment, Auxiliary Building, Fuel Handling Building, Essential Service Water Cooling Tower, Essential Service Water area, Turbine – Generator Pedestal, and most of the Turbine Building are founded on bedrock.

Soil Liquefaction

EPRI NP-6041-SL (Appendix C, Reference 2) provides the following general definition of soil liquefaction: *"The pore water pressures in a saturated soil can increase under earthquake loading conditions. This increase in pore water pressure can lead to a condition of liquefaction, whereby the excess pore water pressure becomes equal to the effective confining pressure."* Even if the excess pore water pressure is less than the effective confining pressure, the shear strength of the soil can reduce to a value which could result in soil failure. The last paragraph of Subsection 3.2.1 of NUREG-1407 (Reference 3) states that, *"For example, a plant in the full-scope category that is located on a rock site will not perform any soil failure evaluation....".* Therefore, soil liquefaction is not a concern for structures supported on rock.

The following paragraphs from Regulatory Guide 1.198 (Reference 13) describe some types of soil which are susceptible to liquefaction and not susceptible to liquefaction during an earthquake.

"Earthquake-induced liquefaction is most commonly observed in (but not restricted to) the following types of soils: (1) fluvial-alluvial deposits, (2) eolian sands and silts, (3) beach sands, (4) reclaimed land, and (5) uncompacted hydraulic fills.

Cohesive soils with fines content greater than 30 percent and fines that either (1) are classified as clays based on the Unified Soil Classification system or (2) have a Plasticity Index (PI) greater than 30 percent should generally not be considered susceptible to liquefaction.

Sands that have dual Unified Soil Classification systems designation such as CL-ML, SM-SC or GM-GC are potentially liquefiable".

Since, the Reactor Containment, Auxiliary Building, Fuel Handling Building, Essential Service Water Cooling Tower, Essential Service Water area and the Turbine Building are founded on bedrock, soil liquefaction of the foundations of these buildings are precluded for these structures.

Per Section 7 of Reference 17, the deep well is in bedrock and after the well casing was put in place, the gap between the rock and casing was grouted with cement. Hence, there is no soil liquefaction issue for the deep well.

Foundation Settlement

The last paragraph of Subsection 3.2.1 of NUREG-1407 (Reference 3) states that, *"For example, a plant in the full-scope category that is located on a rock site will not perform any soil failure evaluation....".* Therefore, foundation settlement is not a concern for structures supported on rock.

Section 2.5.4.10.2.3 of Byron/Braidwood UFSAR (Reference 12) documents that the Seismic Category I plant structures are all founded on grouted bedrock. The total and differential settlements calculated for the bedrock for static and SSE conditions were based on the elastic moduli of the dolomite. The results of the calculations showed negligible total and differential settlement. Therefore, foundation settlement is not a concern for Byron Station for a ground acceleration of 0.3g.

Slope Instability

Subsection 2.5.5 of Byron/Braidwood UFSAR (Reference 12) provides detail description of stabilities of slopes in Byron Units 1 and 2 plant site. All artificial slopes in the plant site are less than 10 ft in height and no steeper than 3 horizontal to 1 vertical. There are no steep natural slopes present at the plant site. Furthermore, per discussion in Subsection 2.5.5 of Byron/Braidwood UFSAR, there are no slopes around the Containment Structure, Auxiliary-Fuel Handling Building Complex, Essential Service Water Cooling Tower, Main Steam Isolation Buildings and Tunnels and the deep wells. Therefore, for these Byron Station buildings slope stability is not a concern for a ground acceleration of 0.3g.

Soil Failures Evaluation Conclusion

Based on the above evaluations, for 0.3g RLE, the Byron Units 1 and 2 site is not susceptible to any of the soil failure modes discussed in NUREG-1407.

3.0 Prerequisites

In accordance with the requirements of the SPID, the following prerequisites must be addressed in order to use the IPEEE analysis for seismic hazard screening purposes and to demonstrate that the IPEEE results can be used for comparison with the ground motion response spectra (GMRS):

1. Confirm that commitments made under the IPEEE have been met. If not, address and close those commitments.
2. Confirm whether all of the modifications and other changes credited in the IPEEE analysis are in place.
3. Confirm that any identified deficiencies or weaknesses to NUREG-1407 in the plant specific NRC SER are properly justified to ensure that the IPEEE conclusions remain valid.
4. Confirm that major plant modifications since the completion of the IPEEE have not degraded/impacted the conclusion reached in the IPEEE.

Prerequisite 1

The BNGS IPEEE submittal report does not identify any commitments for seismic, other than to resolve seismic plant improvement modifications identified in Section 7. Prerequisite 2 below confirms that plant improvements stated in the IPEEE were resolved. An explicit definition of a seismic vulnerability was not provided in the IPEEE submittal report. Per section 8.1 of the IPEEE submittal, no programmatic issues were identified. There were no weak links identified in the buildings, distribution systems, or relays evaluated.

Prerequisite 2

Plant improvements (i.e. modifications) were identified in Sections 3 and 7 of the IPEEE submittal report (Reference 1). The Fukushima NTTF Recommendation for 2.3 seismic walkdowns required that licensees review IPEEE vulnerabilities and confirm that these vulnerabilities were resolved. The Byron 2.3 seismic walkdown reports for Unit 1 and Unit 2 (Reference 4) confirm that modifications, or "plant improvements" identified from the IPEEE seismic program are resolved. Table G-1 in Appendix G of the seismic walkdown reports list the plant improvements, the IPEEE proposed resolution, the actual resolution and resolution date. All IPEEE modifications are in place and all IPEEE commitments have been met. No open items exist as a result of the seismic portion of the IPEEE program.

Prerequisite 3

There are no deficiencies or weaknesses identified in the IPEEE SER (Reference 6). The SER concludes that the process, methods, and organization of the submittal are consistent with NUREG-1407 and the submittal addressed the major issues relevant to the IPEEE program for a 0.3g focused scope plant.

Prerequisite 4

A review of every modification at BNGS from the time the IPEEE submittal was performed to the end of 2005, with a focus on Success Path Equipment List (SPEL) systems and components as well as key words such as remove, removal, degrade, abandon, install etc. Modifications that were replacements or that improved reliability of SSCs were screened out as not being major changes that could affect the conclusions of the IPEEE submittal. Starting with 2006, the search solely focused on the 50.59 evaluations (due to the availability of the 50.59 evaluation logs) that were performed for modifications that could have degraded or changed equipment that would affect IPEEE submittal conclusions. The list of 50.59 evaluations was used to screen for significant modifications since it includes all modifications that would result in adverse changes to structures, systems and components (SSCs) that are described in the Updated Final Safety Analysis Report (UFSAR). Table 3.1 contains a list of the major modifications that either installed new SSCs that would have been included on the SPEL or could have affected SSCs that were already on the SPEL. The list of major modifications was reviewed for impact on SPEL SSCs which is documented in Table 3.1

All SPEL components evaluated in the original IPEEE submittal (Reference 1) were qualified to the 0.3g PGA RLE. These components were designed and installed to the design basis site seismic design criteria. Modifications are also designed and installed to the site seismic design criteria per the modification process. The site modification process ensures that SSCs are installed or modified with the proper seismic capacity, train separation and seismic clearances. The review process described above, which was used to evaluate impacts of modifications on the IPEEE, only seeks to evaluate the impacts of the modifications on overall SPEL system functionality and does not repeat the IPEEE process as related to computing individual component HCLPFs. There is a high degree of confidence that modified components will meet the RLE of 0.3g PGA since they have been installed per the site modification process and the components installed prior to the IPEEE have been shown to meet the RLE of 0.3g PGA. Therefore, specific component level reviews of the design changes are not required to be performed.

Following the review described above, it has been determined that there have been no major modifications to the plant that have affected the conclusions of the IPEEE submittal.

Prerequisites Review Conclusion

Based on the material presented previously, all four IPEEE Adequacy prerequisites from the EPRI SPID (Reference 7) have been met for BNGS.

Table 3.1: Summary of modifications screened for impact on the BNGS IPEEE seismic evaluation.

EC Number	EC Title	System Code	Notes
77619	REROUTE WELL WATER PIPING TO SX COOLING TOWER BASIN	WW	Only the piping is rerouted but it does not appear any valves or components were changed. Prevents backflow of water. Does not impact IPEEE. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.
77275	RELOCATE ONE DIV. CONT. OF VC TO LCP AND REMOVE IT FROM RSP	VC	This is the fire protection system which is not included on SPEL and should not affect the seismic portion of the IPEEE but may affect the FP portion. However this would only serve to help FP and may remove some minor weakness noted in IPEEE SER.
76662	REMOVE NITROGEN SOLENOIDS & FABRICATE NEW CYLINDER TOP PLATE	FW	Items do not appear on the SPEL. Only the actual FW Iso Valves FW009 are. This has no impact on the IPEEE submittal conclusions.
78808/78809	RH/RY TEMPERATURE MONITORING	RH/RY	There are new temp transmitters installed on RH and Pressurizer systems. These would provide additional information to operators during an event. They may have been on the SPEL if they were installed at the time of IPEEE submittal conclusions. Modification process ensures that components were installed with adequate seismic capacity, train separation and free of any seismic interactions.
76021/76023/78 740/78471	INSTALL RCP VIBRATION MONITORS LOOPS A & D	RC	Temp transmitters on SPEL but vibration ones have now been added. These would have been SPEL items. Modification process ensures that components were installed with adequate seismic capacity, train separation and free of any seismic interactions.
79247/79249/79 248/79246	U-1 ADD TWO-CELL BATTERY RACK TO BATTERY ROOMS	DC	These battery racks would have been included on the original SPEL if they were installed at the time of the IPEEE submittal conclusions.
337255	CONTAINMENT SUMP LEVEL GEMS INSTRUMENTATION	PC	These makes leak detection of the containment sump more reliable. The original components were not on the SPEL but they would have been if they were installed at the time of IPEEE submittal conclusions. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.

EC Number	EC Title	System Code	Notes
79847/8/9	DOWNGRADE 1/2A 1/2B DG AIR COMPRESSOR TO NSR 9901063/9901063	DG	This mod downgrades the air compressors in order to improve reliability and availability of spare parts. Seismic calculation still exists and portions of the compressors are seismic category 1 with the portions that are seismic category 2 being considered. This will not impact the IPEEE submittal conclusions.
356569/359211	REPLACEMENT OF THE UNIT 1 CONTAINMENT SUMP SCREENS AND REMOVAL OF CNMT SUMP LEVEL INSTRUMENTS 1LS-0940A/0941A and light boxes 1LL-SI075A/B	SI	The function of the replacement Containment Recirculating Sump screens will remain the same as the function of the existing screens. However, SPEL items 1LS-0940A and 1LS-0941A have been removed since they are not EQ. EQ Components 1LT-PC06 and 1LT-PC07 are not affected and are still adequate to support operation of ECC system. Therefore, the IPEEE submittal conclusion is not impacted.
388895/6, 389144, 388892/3/4	HELB DAMPERS	VX	Whole new set of dampers. This prevents damage to Aux Building Safety Related Equipment in the manner that the original dampers should have. This does not have a negative impact on the IPEEE submittal. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.
385102	ADD LOCKED-OPEN VALVES IN SERIES WITH 2SI8801A/B	SI	New valves that provide redundancy. They would have been on the SPEL if they were installed at the time of IPEEE submittal. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.
76803	INSTALL VENT LINES ON AF PUMP SUCTION PIPING B/W 006 AND 017	AF	This modification helps detect leakage and allows drainage between valves. This does not degrade the conclusions of the IPEEE submittal. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.
78749	MODIFY EDG FUEL OIL PIPING TO FACILITATE INSTALLATION 9800598/9800598	DG	Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.
339155	INSTALL NEW VALVE DOWNSTR. OF VALVE 2DO076A RELOCATE SAFETY CLASS BREAK DOWNSTREAM TO NEW VALVE (THIS EC REPLACES EC 339149, EQUIVALENT CHANGE PACKAGE)	DO	Improvement - This upgrades equipment to Safety Related. It will not have an impact on the conclusions of the IPEEE submittal. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.

EC Number	EC Title	System Code	Notes
366121	CREDIT SX M/U PUMP DISCHARGE LINE CHECK VALVES	SX	Installs new redundant check valve that protects against SX basin draining and prevents backflow to pump. These do not degrade or impact the conclusion of the IPEEE evaluation. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.
392306/394715	INSTALL DRAIN LINE ON BONNEBT VENT OF 2CV8119	CV	If it existed during the IPEEE evaluation, it would have been on the SPEL. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.
77831	PROVIDE VENT VALVES ON THE TURBOCHARGER LUBE OIL FILTERS	DG	If valves existed during the IPEEE evaluation, it would have been on the SPEL. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.
77844	INSTALL RELIEVING DEVICE AROUND 1RY8030 TO PROVIDE PRESS		Installs new equipment to correct a design deficiency around an item from the SPEL. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.
78766	INSTALL 2" DRAIN AT THE LOW POINT OUTSIDE STEAM TUNNEL	MS	Installs new equipment to correct a design deficiency around an item from the SPEL. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.
77831	PROVIDE VENT VALVES ON THE TURBOCHARGER LUBE OIL FILTERS TO	DG	Installs new equipment to correct a design deficiency around an item from the SPEL. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.
77503	INSTALL PRESSURE RELIEVING DEVICE ON MSIV ACCUMULATORS	MS	Installs new equipment to correct a design deficiency around an item from the SPEL. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.
78712	#2 DG:INSTALL DELTA P (PRESS) INSTRUMENTS FOR DG STRAINERS.	DG	Installs new equipment to correct a design deficiency around an item from the SPEL. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.

EC Number	EC Title	System Code	Notes
78711	#1 DG:INSTALL DELTA P (PRESS) INSTRUMENTS FOR DG STRAINERS.	DG	Installs new equipment to correct a design deficiency around an item from the SPEL. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.
78947	ADD VENT VALVES TO UNIT-1 SI HIGH POINTS	RH	Installs new equipment to correct a design deficiency around an item from the SPEL. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.
78947	ADD VENT VALVES TO UNIT-1 SI HIGH POINTS	SI	
78948	ADD VENT VALVES TO UNIT-2 SI HIGH POINTS	SI	
78948	ADD VENT VALVES TO UNIT-2 SI HIGH POINTS	RH	
77845	INSTALL RELIEVING DEVICE AROUND 2RY8030 TO PROVIDE PRESS	RY	
77832	PROVIDE VENT VALVES ON THE TURBOCHARGER LUBE OIL FILTERS	DG	
77504	INSTALL PRESSURE RELIEVING DEVICE ON MSIV ACCUMULATORS	MS	
77837	INST PRV'S ON WO PENETRATIONS P6,P10 IN RESPONSE TO GL 96-06	WO	
79307	INSTALL CHECK VALVE ON 0B SX MAKEUP PUMP DRIVE FUEL OIL SYS	SX	
78679	U-1 INST PRES RELIEV DEVICES P5.P8 IN RESPONSE TO GL 96-06	WO	
78730	INSTALL DRAIN UPSTREAM OF 2MS163 TO ELIM. WATER HAMMER	MS	
77996	PHS-1 U-2 INSTL/CONTINUE PIPING DOWNSTREAM OF SI ECCS VENTS	SI	This modification installs new piping to correct a design deficiency around an item from the SPEL. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.
367913	REDESIGN OF SX HOT WATER BYPASS LINE CONFIGURATION	SX	This modification replaced piping due to corrosion concerns. This has no impact on the IPEEE submittal. The only accident the change could influence is a moderate energy line break. However, the results of the analysis concluded that a failure is not required to be postulated based on the maximum stress range for the affected pipe continues to be less than 0.4 (1.2Sh + Sa). This modification installs new equipment to correct a design deficiency around an item from the SPEL. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.

EC Number	EC Title	System Code	Notes
364470	REPLACE 1SX011 AND 1SX136	SX	The replacement valves, manufactured by Crane, are more restrictive to flow (lower Cv) than the existing Jamesbury valves they replace. However, it has been demonstrated (EC364470, Design Summary) that the additional resistance of the new valves will have a negligible impact on the ability of the 1A and B SX pumps to provide adequate flow to these affected essential loads. These do not degrade or impact the conclusion of the IPEEE evaluation. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.
362168	AF CROSSTIE	AF	This mod cross ties the U-1 and U-2 MD AF pumps to improve reliability. This will improve reliability. Components would have been on original SPEL. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.
392306/394715	INSTALL DRAIN LINE ON BONNEBT VENT OF 2CV8119	CV	Installs new equipment to correct a design deficiency around an item from the SPEL. Modification process ensures that SSCs were installed with adequate seismic capacity, train separation and free of any seismic interactions.

4.0 Adequacy Demonstration

In accordance with the guidance of the SPID, each of the nine Adequacy Demonstration items is addressed. Each Adequacy Demonstration item evaluates (1) the methodology used, (2) whether the analysis was conducted in accordance with NUREG-1407 and EPRI NP-6041-SL, and (3) a statement as to whether the results are adequate for screening purposes.

4.1 Structural Models and Structural Response Analysis

Subsection 3.1.3.2 and subsection 3.4.1 of the BNGS IPEEE submittal (Reference 1) document that the following Seismic Category I structures are considered for IPEEE adequacy review. The deep wells were screened out for IPEEE review level earthquake (RLE of 0.3g).

1. Containment Structure (Outer Shell) and Internal Structure
2. Auxiliary-Fuel Handling Building Complex
3. Essential Service Water Cooling Tower
4. Main Steam Isolation Valve Buildings and Tunnels

A plant layout of the Containment Building, Auxiliary Building, Fuel Handling Building, Turbine Building and Radwaste Building for Byron Units 1 and 2 is shown in Figure 3.7-57 of the UFSAR (Reference 12). The Essential Service Water Cooling Tower is a small separate structure consisting of two four-cell concrete structures erected over one common reinforced concrete cold water basin. The Main Steam Isolation Valve Building and Tunnels are at and below grade and founded on rock.

The following describe the specifics of the various structure models as they apply to their dynamic characteristics.

<u>Containment Structure (outer shell) and Internal Structure (inner structure)</u>

The two Byron units have identical and separate Containment Buildings. The description of the seismic model is provided in Section 3.7.2 of the Byron/Braidwood UFSAR (Reference 12).

<u>Containment Structure (outer shell)</u>

The outer shell is a cylindrical prestressed concrete structure with a dome. The outer shell and the internal structure have common circular basemat. The basemat of the outer shell and internal structure is structurally not connected to Auxiliary building or any other building. The configuration of the outer shell of the building is shown in Figure 3.8.1 of the UFSAR (Reference 12). Two lumped mass beam seismic models of outer shell are used, one for the horizontal seismic analysis and one for the vertical seismic analysis. Since, the horizontal and vertical seismic responses of the axisymmetric structure are decoupled, the use of two separate seismic models are justified. The seismic model of outer shell is shown in Figure 3.7-53 of the UFSAR (Reference 12). As stated in the UFSAR Section 3.7.2.3.3 (Reference 12), the lumped mass beam model has enough lumped masses and degrees of freedom to capture predominant modes with frequencies less than 33 Hz.

<u>Containment Internal Structure (inner structure)</u>

A lumped mass beam seismic model is used for the internal structure. Two lumped mass beam seismic models of the internal structure are used, one for the horizontal direction and one for the vertical direction. The two models are shown in S&L Report SL-BYR-96-009 (Reference 14) Figure 5. As stated in the UFSAR (Reference 12) Section 3.7.2.3.3, the lumped mass beam model has enough lumped masses and degrees of freedom to capture modes with frequencies less than 33 Hz. In S&L Report SL-BYR-96-009 (Reference 14) Figure 5 (b) (Vertical Dynamic Model), Nodes 9 and Nodes 18 through 29 represent the out-of-plane vertical frequencies of the floor slabs.

Auxiliary-Fuel Handling Building Complex

The Auxiliary-Fuel Handling building complex is a shear structure system, i.e. the lateral seismic force is resisted by shear walls and steel framing system. The details of the seismic model and building complex are provided in the UFSAR (Reference 12) Section 3.7.2.3.3, Section 3.8.4.1.1 and 3.8.4.1.2. The Auxiliary-Fuel Handling building complex is also connected to the non-Category Turbine Building (Reference 12 Section 3.7.2.11) and the Radwaste Building. Hence the seismic model of the Auxiliary-Fuel Handling building complex also includes the Turbine Building and the Radwaste Building. Since the building complex is predominantly a shear structure system and analyzed using a fixed base system, there is insignificant response in the vertical direction due to the horizontal direction excitation; and insignificant response in the horizontal direction due to the vertical direction response. Two decoupled models are developed for the Auxiliary-Fuel building complex: one for the horizontal response and one for the vertical response.

Figure 3.7-51 of the UFSAR (Reference 12) shows the horizontal model. The model consists of horizontal slabs at the elevation of all major floors. Three degrees of freedom have been considered at each slab: two along the horizontal axes and a rotation about the vertical axis. The mass properties of slabs are based on the floor masses and tributary wall masses connected to the slabs; and mass moment of inertia about the vertical axis. The masses include dead weights, seismic live weights and equipment weight on the slabs. The total mass on the slabs are lumped at the center of gravity of all contributing masses. The stiffness properties from the shear walls and the steel framing systems are located at the corresponding shear walls and the framing systems locations. Thus, the model accounts for resulting torsion due to the eccentricity between the center of the mass and the center of rigidity.

The dynamic behavior of the building complex in the vertical direction is a function of the wall and column axial stiffness, the floor system flexural stiffness and mass distribution. The predominant deformations in the building complex are the axial (vertical) deformations of the walls and the frames; and transverse deformation of the slabs (simulated by a mass and equivalent stiffness to represent the slab transverse deformation modes). Therefore, only the vertical degree-of freedom was considered in the model. A plane frame model was used to simulate the above dynamic behavior of the building for the vertical excitation. The vertical model is shown in Figure 8 of Reference 14.

Essential Service Water Cooling Tower (ESWCT)

The descriptions of the Essential Service Water Cooling Towers are provided in Byron UFSAR (Reference 12) Sections 3.8.4.1.6 and 3.8.5.1.3, and the IPEEE Submittal Section 3.1.3.2 (Reference 1). The ESWCT consists of two four-cell concrete structures erected over one common reinforced concrete cold water basin. The common mat foundation is supported on grouted rock strata. Because of symmetry, only one tower is modeled. The models are planar (no torsion because of symmetry); with 8 nodes in total to represent the outer walls, fan deck support tower and water basin including weight of water fill. There is one horizontal model and one vertical model. The horizontal model was excited for each horizontal direction separately; and the vertical model was excited in the vertical direction.

Main Steam Isolation Valve Buildings and Tunnels

The main steam isolation valve buildings and tunnels are described in IPEEE Submittal Section 3.1.3.2 (Reference 1). These buildings/tunnels are at and below grade and founded on rock. The seismic input to these structures is same foundation-rock motion used for the other power block buildings.

Adequacy of Structural Models

The adequacy of the structural models is assessed considering the recommendations provided for existing structural models in EPRI NP-6041-SL (Reference 2 page 4-19). The adequacies of various models are evaluated for important dynamic characteristics of the structure.

Assessment for overall responses due to horizontal and vertical excitations

Containment Structure (outer shell):
Since the outer shell of the Containment Structure is an axisymmetric structure, the horizontal and vertical seismic responses are decoupled and two separate models, one for horizontal direction excitation and one for the vertical direction excitation are justified. The lumped mass beam models (horizontal and vertical) have enough lumped masses and degrees of freedom to capture the predominant modes (frequencies less than 33 Hz) and the overall structural responses.

Containment Internal Structure (inner structure):
Two lumped mass beam models of the internal structure are used: one for the horizontal seismic analysis and one for the vertical seismic analysis. The lumped mass beam models (horizontal and vertical) have enough lumped masses and degrees of freedom to capture the predominant modes (frequencies less than 33 Hz) and the overall structural responses.

Auxiliary-Fuel Handling Building Complex:
Since the building complex is predominantly a shear structure system and analyzed as fixed base system (basemats in rock), there is insignificant response in the vertical direction due to the horizontal direction excitation, and insignificant response in the horizontal direction due to the vertical direction excitation. Two decoupled seismic models are used: one for the horizontal direction and one for the vertical direction. The horizontal model accounts for the torsional response, resulting due to the eccentricity between the center of mass and center of rigidity of the building complex. The models are capable of capturing the overall structural responses for the horizontal and vertical components of ground motion respectively.

Essential Service Water Cooling Tower (ESWCT):
The ESWCT consists of two four-cell concrete structure erected over one common basemat supported on rock strata. Because of symmetry only one tower is analyzed. There are separate models: one for the horizontal excitation and one for the vertical excitation. The models are capable of capturing the overall structural responses for the horizontal and vertical components of ground motion respectively.

Main Steam Isolation Valve Buildings and Tunnels:
These buildings/tunnels are at and below grade and founded on rock. The seismic motion is same as foundation-rock motion of other power block buildings.

Assessment for coupling between horizontal and vertical responses

Based on the above descriptions of the seismic models for Containment Structure (outer shell and inner structure); Auxiliary-Fuel Handling Complex and the Essential Service Water Cooling Tower, there is insignificant coupling between the horizontal and the vertical responses. Therefore, use of two separate models: one for the vertical excitation and one for the vertical excitation is justified.

Assessment for appropriate mass and stiffness distribution

As described above, the horizontal and vertical seismic models represent the dynamic characteristic for horizontal and vertical direction excitations. The models have appropriate mass and stiffness distribution based on the structural physical and mechanical properties. The horizontal model of the Auxiliary-Fuel Handling Building Complex considers the resulting torsion due to the eccentricity between the center of mass and the center of rigidity. The models have sufficient lumped mass locations and dynamic degrees of freedom to represent all significant structural modes with frequencies less than 33 Hz.

Assessment for floor diaphragm in-plane and out-of-plane flexibility

The in-plane floor diaphragm flexibility issue does not apply to containment outer shell model. In the containment internal structure model, the slab configuration and thickness justifies slab in-plane rigidity. The out-of-plane flexibility of the slab is considered by adding nodes to represent predominant out-of-plane vertical frequencies of the slab.

In the Auxiliary-Fuel Handling Building Complex model, the walls and support beams provide stiffness to justify in-plane rigidity of the floor slabs. The out-of-plane flexibilities of the slabs are considered by adding nodes to represent predominant out-of-plane vertical frequencies of the corresponding slabs.

Assessment for Soil-Structure Interaction (SSI)

Since Byron site is a rock site, fixed base seismic analysis was performed for the design of all buildings. Reference 2 (page 4-5) recommends that the effects of SSI be taken into account for major structures at all sites with a median soil stiffness at the foundation base slab interface corresponding to a shear wave velocity, V_s, of 3500 fps or lower. Per Table 2 in Attachment 2 of Reference 16, the shear wave velocity for average soil profile (profile 1) is 3197 fps from the ground surface to a depth of 97 ft.

Since, the shear wave velocity at the Byron site is lower than 3500 fps, an assessment is performed for the effect of the lower 3197 fps shear wave velocity on the fixed base analysis results. It is estimated that the SSI frequency for the Byron site will be 91% of the frequency for soil profile with 3500 fps [(3197 / 3500) x 100]. This 9% shift in the frequency is covered by the lower frequency side of the $\pm$15% widening of the response spectra at all frequencies. For combined effect of SSI and cracking, see "Impact of SSI and Cracked Concrete Section Considerations on the SMA" below.

Assessment for Cracked Concrete Sections

All seismic models discussed above are using un-cracked concrete section properties and the design is based on the results from these models. Due to robust design of BNGS reinforced concrete shear walls for SSE loading, the degree of cracking under SSE loads will not be that pronounced and using un-cracked concrete section properties is reasonable. However, as recommended in Reference 2 (page 4-19) the effect of cracked concrete because of higher seismic motion for IPEEE evaluation should be examined.

Referring to report, "Stiffness of Low Rise Concrete Shear Walls" (Reference 19), the ASCE working group recommends considering a $\pm$25% variation in shear stiffness of nuclear power plant shear walls to account for both increase in stiffness due to higher concrete strength resulting from aging of concrete as well as reduction in stiffness due to cracking of shear walls. A $\pm$25% variation in stiffness of shear walls will shift the frequencies by a maximum of 13% which is bounded by the $\pm$15% widening of the response spectra at all frequencies. For combined effect of SSI and cracking, see "Impact of SSI and Cracked Concrete Section Considerations on the SMA" below.

Impact of SSI and Cracked Concrete Section Considerations on the SMA

When considering the combined effect of SSI and cracked concrete section properties the maximum shift in the frequencies will be about -22% and +4%. By engineering judgment, existing models using fixed base analysis and un-cracked concrete section properties are adequate for the following reasons:

- Actual concrete cylinder compressive strength tests of BNGS show that the average (mean) actual concrete strengths are about 26% and 50% higher than the minimum specified design concrete compressive strength for 5500 psi and 3500 psi concrete respectively (Table Q130.6-6, Reference 12). The increase in frequencies due to this effect in combination with the ±15% widening of the response spectra at all frequencies will adequately account for maximum -22% and +4% shift in frequencies.

- In generation of SMA specific ISRS, conservatively no credit is taken for seismic motion incoherency. For structures with base dimensions in excess of 150 feet such a consideration will yield lower responses. For example, for the Auxiliary–Fuel handling Building Complex with the least base dimension of about 300 ft (in the E-W direction), referring to Section 4 (page 4-6) of EPRI NP-6041-SL, reduction factors of 1.0, 0.80, and 0.60 may be used to reduce response spectra at 5 HZ, 10 HZ, and 25 HZ, respectively.

<u>Structural Model and Structural Response Analysis Review Conclusion</u>

Based on the material presented above, the existing seismic models and Structural Response Analysis used for IPEEE evaluations meet the requirements of EPRI NP-6041-SL and NUREG-1407 and are adequate for screening purposes.

4.2 In-Structure Demands and ISRS

Specific In-Structure Response Spectra (ISRS) were generated for Seismic Margin Assessments (SMA) of Byron Units 1 and 2. The details of the generation of ISRS for SMA are provided in S&L Report SL-BYR-96-009 (Reference 14). The following describes the design basis seismic input motion for Byron Units 1 and 2 and the assessment of the ISRS for IPEEE evaluation.

Section 2.5.2.6 of the Byron UFSAR (Reference 12) states that Byron Units 1 and 2 are designed for a Safe Shutdown Earthquake (SSE) of 0.2g at the bedrock-soil interface. This value was applied at the foundation level. Using the subsurface properties, the corresponding ground surface acceleration was found to be 0.21g. Seismic design of Byron Units 1 and 2 are based upon a ground surface acceleration of 0.21g and Regulatory Guide 1.60 response spectra shape for SSE (Reference 12). The following description is provided in Section 3.7.1.1 of the UFSAR (Reference 12) for the design response spectra for the design basis of Byron Units 1&2:

"During the review of the FSAR for an Operating License, the Byron/Braidwood seismic design was reevaluated using the Regulatory Guide 1.60 spectra without the application of a deconvolution analysis. Attachment 3.7A contains the specific NRC questions / responses on seismic design. These questions and responses document the historical evolution of certain aspects of the Byron/Braidwood seismic design. Attachment 3.7A also provides the details and results of this reevaluation. It is concluded that the present seismic design of Byron / Braidwood is conservative. Based on the reevaluation described in Attachment 3.7A, the Byron / Braidwood seismic design basis is acceptable and will therefore be used for all future seismic evaluations."

Based on the previous summary description of Byron Units 1&2 seismic design, the following is concluded:

- The seismic design is based on ground surface acceleration of 0.21g and Regulatory Guide 1.60 response spectra shape.

- The seismic design also satisfies 0.20g and Regulatory Guide 1.60 response spectra shape at the bedrock-soil interface. Per Subsection 3.7.1.2 of Reference 12, the bedrock-soil interface is on an average 16 feet below the grade elevation.

The SMA specific ISRS are generated for the following buildings:

1. Containment Structure (Outer Shell) and Internal Structure (inner structure)
2. Auxiliary-Fuel Handling Building Complex

The seismic models used for generating the ISRS for the respective buildings are as described in Section 4.1. The ISRS were generated by direct generation using random vibration technique (an alternate ISRS generation technique acceptable per Chapter 4 of Reference 2). The details of the technique are summarized in Section 5 of Reference 14.

Per Table 3.1 of NUREG-1407 (Reference 3), Byron site is binned for 0.3g focused scope review level earthquake evaluation. Considering the rock site conclusion of design, the input motion spectrum for horizontal motion used in IPEEE evaluation was NUREG/CR-0098 (Reference 15) median rock spectrum anchored at 0.3g peak ground acceleration. The resulting horizontal foundation motion spectra are tabulated in Table 7 and plotted in Figure 9 of Reference 14. Based on Reference 2, for the vertical models input foundation spectra are 2/3 times the horizontal foundation spectra.

Per page 4-6 of EPRI NP-6041-SL (Reference 2), the horizontal foundation motion spectra may be modified using frequency dependent reduction factors to account for basement size and horizontal spatial variation in ground motion (shear waves incoherence effect). The generated ISRS for specific buildings are provided in Appendix A and B of Reference 14. These spectra were not modified to account for the basement size and shear waves incoherence effect.

In-Structure Demand and ISRS Review Conclusion

Based on the above, In-structures demands and generation of SMA specific ISRS meet the requirements of NUREG-1407 and EPRI NP-6041-SL and are adequate for screening purposes.

4.3 Selection of SSEL

Consistent with the SMA methodology in the EPRI SMA methodology, EPRI NP-6041-SL (Reference 2), Exelon developed a success path equipment list (SPEL) for Byron station. The SPEL identifies the plant components required to survive the Seismic Margin Earthquake (SME) presented in the BNGS IPEEE Submittal (Reference 1). The SPEL was identified by choosing two independent methods, or success paths, for achieving the safe shutdown condition. The SME's effect, such as loss of offsite power and the subsequent unavailability of the instrument air (IA) system were considered for path selection. Development of the equipment list involved identification of 1) the frontline systems that perform the four safety functions identified in Generic Letter 88-20, Supplement 4 (Reference 5), 2) determination of the frontline system dependency on the various plant support systems, and 3) the identification of the components that are necessary for function of both the frontline and support systems.

This methodology meets the guidance and requirements of Reference 2 and the enhancements specified in Reference 3. Section 3.2.5.1 of Reference 3 requires a complete set of potential success paths be identified and the narrowing/elimination of paths to be documented in detail. Section 3.2.2 (Reference 1) documents in detail the system analysis and the elimination of success paths.

Reference 3, Section 3.2.5.1 also requires that to the maximum extent possible, the alternate path involve operational sequences, systems, piping runs and components different from those used in the preferred path. A plant-specific Success Path Logic Diagram (SPLD) is presented in the IPEEE submittal (Figures 3.1A and 3.1B, Reference 1) showing the frontline systems that can be used for safety functions required to maintain a long-term safe shutdown condition for both a preferred path and alternate path. For both paths, the reactivity control would be accomplished by the control rod insertion due to a high seismic ruggedness. The alternate method of reactivity control, emergency boration, is not considered or recommended due to the high involvement of operators. The BNPS IPEEE submittal discussed the systems used for each function required for both the preferred and the alternate (small loss-of-coolant accident [LOCA]) success paths. For both reactivity control and pressure control, the same systems are used for the preferred and alternate success paths. In accordance with the NUREG-1407 guidance, separate systems are used for inventory control and decay heat removal.

A specific review for single train and multi train systems was not documented. The Fundamental and Support systems used for the Byron IPEEE all utilize a dual train system, with the exception of the RWST and Control Rod Drive control system The Control Rod Drive control system, credited as the Reactivity control system, is specifically identified and discussed as a single path system. The RWST is credited in the Inventory Control descriptions of the report; however, there is no discussion on the impact of a failure of the RWST in the IPEEE report. While the RWST was evaluated and shown to be qualified for the required seismic conditions, NUREG-1407 section 3.2.5.8 states that the redundancies of a success path should be described, and if only a single train is credited it should be identified.

Selection of SSEL Review Conclusion

The methodology used in the Byron IPEEE SPEL development meets the guidance and requirements of EPRI NP-6041-SL and the enhancements specified in NUREG-1407. Therefore, the SSEL selection is adequate for screening purposes.

4.4 Screening of Components

The methodology for screening of components was based on EPRI NP-6041-SL. Table 2-3 (for structures) and Table 2-4 (for equipment) of EPRI NP-6041-SL were used as the screening criteria, with judgments made by the SRT in accordance with EPRI NP-6041-SL. The supplemental screening guidance of Appendix A of EPRI NP-6041-SL was also used. The required walkdowns of all SPEL equipment were performed to confirm the prescreening and to review seismic interaction concerns per Appendix F of EPRI NP-6041-SL. Information regarding each type of screening performed and summary of the screening is provided below. The following adequacy reviews of the component screening are based on the IPEEE submittal (Reference 1) and additional screening documentation in Reference 18.

Civil Structure Screening (Section 3.4.1, Reference 1)

Seismic Class 1 structures which contain SPEL components include the Containment Building and Internals, Auxiliary Building, Essential Service Water Cooling Tower, and Main Steam Isolation Valve Buildings and Tunnels. The river screen house was excluded from the SMA per Section 3.1.3.1 of the submittal. All buildings were dynamically analyzed for the SSE level, which is greater than 0.1g. The screening criteria of Table 2-3 of EPRI NP-6041-SL state that if structures are dynamically analyzed for an SSE greater than 0.1g, the structures screen out at the RLE level of 0.3 PGA.

Therefore, the method of screening for civil structures using Table 2-3 of EPRI NP-6041-SL was applied appropriately.

Masonry Block Wall Screening (Section 3.4.3, Reference 1)

Masonry block walls at BNGS consist of types of hollow, solid, high density, reinforced and unreinforced block wall construction. During the construction of BNGS, block walls were reassessed per the Inspection & Enforcement Bulletin (IEB) 80-11 program (Reference 30). Modifications were installed as required by the reanalysis efforts including the addition of columns to reduce horizontal spans of the walls.

Removable block walls were removed from the screening review based on the fact that these walls were confined within structural members or grillages. A representative and worst-case or bounding approach was used to determine the overall adequacy of the masonry walls relative to RLE to address other masonry block walls which pose interaction concerns in the vicinity of SPEL equipment. This representative and worst-case or bounding review entailed determining the largest span walls for each wall type based on drawing reviews.

The screening criteria for masonry block walls was to screen out walls which had been reinforced externally or internally with structural steel columns which were installed to increase the seismic capacity of the walls. These reinforced walls were assigned a capacity of the 0.3 PGA RLE. This screening criteria is based on Appendix A of EPRI 6041-SL, which states "Walls which were externally reinforced to withstand a SSE of at least 0.1g using rolled steel sections anchored to floor and ceiling, with through wall bolts to plates, do not require reinvestigation for earthquakes less than 0.3g."

The method of screening block walls with steel column reinforcements installed to the RLE of 0.3g PGA was applied appropriately in accordance with EPRI NP-6041-SL. Note that block walls which did not pass screening criteria were evaluated to determine their HCLPF capacity (see Section 4.6).

Equipment Screening (Sections 3.4.4.2 and 3.4.4.5, Reference 1)

Screening of electrical and mechanical equipment on the SPEL was conducted per Table 2-4 and Appendix F of EPRI NP-6041-SL. The screenings were documented on Screening Evaluation Worksheets (SEWS) in the GIPPER software package electronic database. The SEWS were not provided in the IPEEE submittal. Summary level Screening Margin Data Sheets (SMDS) were created to document the results of the screening evaluations for each item and were signed (certified) by the seismic capability engineers. These SMDS are attached to the BNGS IPEEE submittal (Reference 1) in Appendix B.

The original SEWS used for documenting the equipment screenings are not retrievable. The seismic IPEEE consultant maintained the SEWS in an electronic database called GIPPER. BNGS was able to retrieve copies of SEWS from the consultant's database (Reference 18). A review of a sample subset of the SEWS copies shows that the screening and walkdown sheets follow the SQUG GIP (Reference 11) criteria, which is similar to the screening criteria of Appendix F of EPRI NP-6041-SL. The SEWS screening caveats are not always filled out for each piece of equipment. Where the screening caveats are not filled out, generally notes are provided that justify the screenings, or notes are provided to reference a similar piece of equipment that had been screened. In some cases, the screenings rely on the Braidwood IPEEE. This appears to be a reasonable approach because Byron and Braidwood are sister plants with identical equipment in many cases, the seismic analysis for the two plants is based on one bounding analysis, and the plants share a common UFSAR (Reference 12).

Most equipment on the SPEL was screened out using Table 2-4 and assigned a seismic capacity of 0.3g PGA. There were one hundred sixteen (116) items which were considered outliers. Resolution of outliers is documented in Table 3.3 of the IPEEE submittal (Reference 1). Atmospheric storage tanks and equipment on vibration isolators can not be screened generically per EPRI NP-6041-SL. The SPEL did not contain any equipment on vibration isolators.

The only atmospheric storage tank on the SPEL was the Refueling Water Storage Tanks (RWST). These tanks were screened out based on a drawing review. Details of this review are not provided in the submittal and justification is not provided as to why the RWST tanks are acceptable. Therefore, the screening of the RWSTs can not be verified, however all members of the SRT agreed that the RWST was acceptable to 0.3g PGA as documented in the SMDS in Appendix B of the submittal.

The equipment screening per Table 2-4 and Appendix F of EPRI NP-6041-SL is appropriate for the SMA. The SEWS copies (Reference 18) that document the screenings show that the appropriate screening caveats were considered. The seismic capability engineers documented acceptability of the screenings by signing (certifying) the SMDS. Although not all screenings are explicitly documented, based on available documentation, it is reasonable to consider that the seismic capability engineers were using the appropriate screening criteria. Therefore, it is concluded that the screenings were performed with the appropriate criteria for an EPRI SMA and are acceptable for seismic hazard screening purposes in accordance with the SPID (Reference 7).

Other Equipment (Section 3.4.5, Reference 1)

Nuclear Steam Supply System (NSSS) supports and the control rod drive housing and mechanisms were assigned a seismic capacity of 0.3g PGA based on Table 2-4 of EPRI NP-6041-SL. The screening criteria for these elements were applied appropriately based on the discussions provided in the IPEEE submittal (Reference 1).

Relays were reviewed per the requirements of NUREG-1407 for a focused scope plant. This effort consisted of a search for "bad actor" relays. Bad actor relays were identified and addressed as required per Section 3.4.5.4 of the submittal. No low ruggedness relays were identified which could affect items on the BNGS success path.

Distribution Systems (Section 3.4.6, Reference 1)

Category 1 piping was assigned a seismic capacity of 0.5g PGA based on Table 2-4 and Appendix A of EPRI NP-6041-SL. Appendix A allows for the use of selecting a representative sample of piping to review by a detailed walkdown to confirm the 0.5g PGA capacity. The essential service water system was selected for review by the SRT and walkdowns were performed on this system to address issues which may affect the piping capacity. No issues were identified in the walkdowns. Since all piping distribution systems in the SMA were seismically qualified, they were assigned a 0.5g PGA HCLPF.

HVAC ducts, dampers, cable trays, and electrical conduits were also reviewed by representative sample walkdowns and assigned a 0.3g PGA. This was based on reviews of the overall construction and detailing of these systems based on walkdowns and the fact that these items are seismically analyzed for BNGS.

The screening of distribution systems using Table 2-4 of EPRI NP-6041-SL was applied appropriately based on the above discussion.

Screening of Components Review Conclusion

Seismic screenings were applied to structures and components on the SPEL using the methodology of EPRI NP-6041-SL. This methodology is in compliance with NUREG-1407. The original screening documentation including the SEWS was not retrievable, but copies of the SEWS were obtained which document that the screenings considered the applicable EPRI NP-6041-SL criteria. Based on a review of the reported methods in the IPEEE submittal and a sampling of the regenerated SEWS, the screening methodology was applied appropriately. Therefore, the screening of components performed for BNGS are adequate for screening purposes.

4.5 Walkdowns

The IPEEE submittal report documents that SMA walkdowns were conducted for all equipment on the SPEL. Additional walkdowns were performed to investigate structures, distribution systems, interactions due to seismically induced fire and flooding, and containment integrity. These walkdowns were performed by seismic capability engineers from ComEd (now Exelon) and their contracted vendors Mr. Walter Djordjevic of Stevenson & Associates (S&A), and Dr. Robert Kennedy of RPK Structural Mechanics. Section 6 of the IPEEE submittal report states that all walkdown engineers had Seismic Qualification Utility Group (SQUG) training and also had EPRI IPEEE add-on training. The resumes of all walkdown team members are documented in Appendix A of the IPEEE submittal report (Reference 1).

The IPEEE submittal discusses the walkdown results, including seismic capacity, screening caveats, adequacy of anchorage, spatial interactions, seismic-induced fires and flooding, and the relay evaluation. Results of the seismic capability walkdown and screening for each component are summarized in the Screening Margin Data Sheets (SMDSs) in Appendix B of the IPEEE submittal (Reference 1). The SMDS are signed and certified by the seismic capability engineers that performed the walkdowns. Tables 2-3 and 2-4 of EPRI NP-6041-SL (Reference 2) were used as screening criteria to prescreen structures and components that do not require further evaluations following walkdowns.

Section 3.4.4.2 of the IPEEE submittal (Reference 1) discussed the use of SEWS to document screening of equipment. These SEWS also documented the walkdowns in some cases. As discussed in Section 4.4, copies of the SEWS were retrieved from the consultants that performed the work (Reference 18). The sample of SEWS reviewed contain notes and photographs which document some of the walkdowns, although not all items on the SPEL have complete walkdown notes. The SEWS were not signed as part of the process. Instead, the SMDS in Attachment B of the IPEEE submittal were signed by the seismic capability engineers, and were used to certify the results of the walkdowns, screenings, and capacity evaluations. These SMDS constitute the approval of the SMA results by the seismic capability engineers.

<u>Walkdowns Review Conclusion</u>

Based on the information summarized in the regenerated SEWS, SMDS, and discussed in the IPEEE submittal, the walkdowns were performed by qualified seismic capability engineers using methodology in accordance with EPRI NP-6041-SL. Therefore, the walkdown methodology used is in compliance with NUREG-1407 (Reference 3), and the results are adequate for screening purposes.

4.6 Fragility Evaluations

The term "fragility evaluations", as it relates to a SMA, are the HCLPF calculations performed for SPEL components. Considering the screening of all buildings that house SPEL components described in Section 4.4, the HCLPF of buildings is 0.3g or greater. HCLPFs were calculated for equipment, equipment anchorage, and block walls adjacent to SPEL components as required based on the initial screening results.

The methodology used to calculate HCLPF values is described in the submittal as the Conservative Deterministic Failure Margin (CDFM) approach in accordance with EPRI NP-6041-SL. The SMDS in Appendix B of the submittal (Reference 1) report the HCLPF capacities of each SPEL component. Where calculations were performed to determine the HCLPF (i.e. components were not screened), a footnote in the SMDS provides the calculation reference. Some of these calculations are provided in the SEWS obtained from the consultant (Reference 18), but other calculations are not retrievable. Therefore, the methodology review performed in this report is based on information presented in the IPEEE submittal report (Reference 1), and on a review of a sample of the available calculations.

<u>Masonry Walls (Section 3.4.3, Reference 1)</u>

Block walls which did not screen out had a HCLPF capacity calculated by scaling the design basis seismic evaluations. The first scale factor was to ratio the 4% damped SSE floor spectra and the 6% damped SME floor spectra at the fundamental frequency of the wall. The 6% damping ratio was based on Appendix R of EPRI NP-6041-SL. The second scale factor was the ratio between allowable stress and the actual calculated stress based on the governing loading condition. As noted previously in Section 6.4, a representative and worst-case or bounding approach was used to select the critical (longest) wall spans to review. All walls either screened out or had a HCLPF calculated in excess of the RLE with the limiting wall having a HCLPF of 0.39g (Table 3.1, Reference 1). The HCLPF calculation methodology for masonry block walls is consistent with the CDFM approach in EPRI NP-6041-SL. The scaling calculations for the block walls are not retrievable, but the stated approach for scaling block wall capacities is acceptable and in general the results seem reasonable given that Byron block walls were reviewed and reinforced during construction due to the IEB 80-11 program and generally have high HCLPF capacities.

<u>Equipment Anchorage (Section 3.4.4.3, Reference 1)</u>

Equipment anchorage was evaluated based on "representative and worst-case or bounding" calculations. For instance, all Motor Control Centers (MCC's) were evaluated using the seismic demand at the highest elevation (greatest seismic demand) and the weakest anchorage pattern (least amount of bolts or welds). This type of evaluation was typically done for each equipment class. All anchorage capacities were at least at the RLE level of 0.3g PGA.

The methodology used to evaluate anchorage was per the GIP (Reference 11) procedures, specifically Section II.4.4 and Appendix C. The SMA floor response spectra generated for the

IPEEE project were used instead of the SSE spectra. GIP reduction factors for anchorage were applied, except for the essential relay reduction factor which is not required for an SMA. Also, bolt tightness was not checked. Typically bolt tightness was not considered as part of the IPEEE program as it was considered a QA issue and should have been addressed during construction of the plant.

The application of GIP procedures to compute anchorage HCLPF capacities is appropriate for the SMA evaluation. A review was performed of a representative anchorage calculation to determine if the stated methodologies from the IPEEE submittal are consistent with the calculations performed to determine anchorage HCLPF capacities. Based on a review of the SMDS in Appendix B of the submittal (Reference 1), the anchorage evaluation for MCC 1AP32E was selected for review due to the fact that the reported anchorage HCLPF is 0.3g, which is equal to the RLE. The HCLPF calculation is attached to the SEWS for 1AP32E (Reference 18).

Review of HCLPF Determination for MCC 1AP32E

This section provides the summary and evaluation of the HCLPF calculations for the anchorages of 480V Motor Control Center (MCC) 132X5, Equipment I.D. 1AP32E given in Reference 18.

The highest location for this equipment is at El. 426'-0" of the Auxiliary Building which is the mezzanine floor (see Drawing M-7 (Reference 29)).

According to the design basis calculation (Reference 20), the dead weight of this equipment is estimated as 0.5 kips.

The minimum design concrete compressive strength for Byron is specified as 3500 psi, with actual average strength of more than 4300 psi (see section 5.2 of Reference 25). The In-Structure Response Spectra (ISRS) used to obtain the demands for the HCLPF evaluation are obtained from calculation BYR96-009 (Reference 21) which provides median NUREG/CR-0098 based spectra at different elevations for several structures including the Auxiliary Building. These spectra were generated for the purpose of SMA.

The Vendor Drawing No. 2660C42 (Reference 22) provides following information for this equipment:

- It is manufactured by Westinghouse Electric Corporation
- Width = 20", Depth = 21", Height = 90"
- It is welded to embedded channels in concrete: 1/8" fillet welds 1.5" long every 9". (see note 1)
- 2"-0.50"-13 SEA Grade 5 mechanical bolts secure the equipment cubicles to the base channel. The mechanical bolt spacing in each cubicle is specified as 16" in Reference 22. (see note 2)

Note 1: Based on the SEWS notes provided in Reference 18, the channels welds are given as 2" long at every 12". Although this weld sizing is different from the specifications in Reference 22, it provides identical strength.

Note 2: Based on the SEWS notes provided in Reference 18, the cabinet structure is anchored to base channel by 2 bolts (1 front and 1 back). This is different from what is specified on the vendor drawing (Reference 22) which specifies two bolts at each side of each MCC cubicle (4 bolts total). Since HCLPF capacities are obtained based on the SEWS notes and they are considered conservative (one bolt on each side, versus two), this difference is considered acceptable.

Pages 3 and 4 of the SEWS for 1AP32E (Reference 18) calculate the HCLPF capacity of the anchors. It is noted in the SEWS that "most embedded edge angle or steel is secured [to floor slabs] by Nelson studs. However, some plates that were located after construction are secured by 5/8" concrete expansion anchors @ 18" centers, so this detail was used." The statement above can be verified based on detail C given in DWG No. S-736 (Reference 23).

The SME acceleration demands given on page 3 of the SEWS for 1AP32E (Reference 18) are verified per information provided in Reference 21.

The 100-40 rule is used to combine the pullout demands in E-W horizontal and vertical directions. Due to the long length of 480V MCC assembly in N-S direction (13'-4"), the N-S excitation does not induce significant tension in the bolts. Therefore, not considering the N-S excitation for the calculation of the bolt tension is acceptable.

The shear demands due to the bi-directional horizontal (E-W and N-S) excitations are combined using the SRSS of the maximum shear demands in each direction. This approach is considered conservative as only 40% of the maximum demand in one direction should be considered simultaneous with the maximum demand in the other direction. Since this approach yields conservative results, it is considered acceptable.

It is stated on page 4 of the SEWS for 1AP32E (Reference 18) that the weak links are the embedded 5/8" CEA or the two ½" mechanical bolts. It is shown that the capacity of the expansion anchor will be controlling the capacity of the MCC support system.

The statement above can be justified provided that the weld capacity of the channels to the embedded angles does not control, and that the operability of the 480V MCC is not challenged at the level of seismic input being considered. The operability of the 480V MCC is not a consideration as it was screened out during the walkdowns based on the screening caveats of EPRI NP-6041-SL (Reference 2). The capacity of the weld is discussed below.

Using 30.6 ksi for weld strength from Section C.6.1 of the GIP (Reference 11), the 1/8" fillet weld 2" long every 12" will have a capacity over the anchor spacing of 20" of:

WELD_CAP= 0.707 x 1/8 x 30.6 x 2 x 20/12 = 9.01 kip

This weld capacity far exceeds the assumed capacity of 3.17 kips for the anchor bolt in the SEWS for 1AP32E (Reference 18) and is therefore not controlling. The capacity of the expansion anchors is verified next.

The mechanical bolts are made of SEA Grade 5 steel, which has a yield strength of 92 ksi. However, yield strength of 36 ksi is used for the capacity evaluation of the mechanical bolts. Even with this lower strength, it is shown that the capacity of the mechanical bolts is not controlling over the capacity of the concrete expansion anchors.

It is noted that the capacity of 5/8" expansion anchor bolts are based on Table C.2-1 of the GIP (Reference 11). The GIP generic capacities are generally lower than the generic allowable capacities that are given in EPRI NP-5228-SL (Reference 24), which are the basis for the HCLPF evaluation procedures in Appendix O of NP-6041-SL (Reference 2). However, per page 28 of Byron/Braidwood Concrete Expansion Anchors Design Criteria (Reference 25), the design basis ultimate tensile capacity of the 5/8" Hilti Kwik bolts are 12 kips for 3,500 psi reinforced concrete. Using a safety factor of 3.0 (per Table O-2 of NP-6041-SL (Reference 2)) will result in a CDFM bolt tensile capacity of 4.0 kips. Therefore, the estimated anchor capacity of 3.17 kip is considered conservative.

The shear-tension interaction is not used in the HCLPF capacity evaluation of expansion anchors. However, by inspection, the shear demand to capacity ratio is less than 0.3. Per section C.2.11 of the GIP (Reference 11), interactions between tension and shear do not need to be considered for shear demand to capacity of less than 0.3. Therefore, this is acceptable.

The tension demand to capacity of the 5/8" concrete expansion anchors is obtained as 1.0. Accordingly, the HCLPF capacity reported on page 4 of the SEWS for 1AP32E (Reference 18) is 1.0 x 0.3g = 0.30g.
From the above descriptions, the HCLPF capacity determined on the basis of capacity of anchor bolts is properly done, and this HCLPF capacity is considered reasonable, if not conservative.

Based on the HCLPF anchorage calculation review for 1AP32E, it has been determined that the methods used are consistent with the CDFM methods of EPRI NP-6041-SL. Therefore, based on this sample calculation review, the methodologies for HCLPF anchorage calculations have been properly implemented.

<u>Equipment (Section 3.4.4.2, Reference 1)</u>

Equipment was screened using Table 2-4 of EPRI NP-6041-SL. Outliers are discussed in Section 3.4.4.5 of the IPEEE submittal, which states that the "SME capacity of all outliers is discussed in Table 3.3". Table 3.3 discusses only one HCLPF value for the Recycle Monitor tanks (0.67g), but no reference is provided to the calculation. Per Appendix B of the submittal, page 17, the Recycle Monitor tank HCLPF is 0.3g, and a reference to Calculation C-003 (Reference 26) is provided in the footnote. A review of Calculation C-003 was performed (see the following summary) to confirm that the method used to evaluate the tank was per Appendix H of EPRI NP-6041-SL (Reference 2) and the HCLPF is 0.3g. The calculation review summary confirms these items. Therefore, it is considered that the HCLPF reported in Table 3.3 for the Recycle Monitor tanks is erroneous and the certified HCLPF (by the SMDS) is 0.3g.

A review was conducted of the SMDS in Appendix B of the submittal to determine if any equipment HCLPFs were calculated. In general, the majority of equipment was screened to 0.3g PGA. For a limited number of equipment, either the design basis calculation was reviewed to determine the capacity, or a calculation was generated to determine the HCLPF. The calculations generated for new HCLPFs were generally not retrievable.

<u>*Review of HCLPF Determination for the Recycle Monitor Tanks*</u>

A review of the calculation for the HCLPF capacity of the Recycle Monitor Tank, "C-003" (Reference 26) was performed as documented below in order to determine if the methods were done per the criteria in Appendix H of EPRI NP-6041-SL (Reference 2).

The Recycle Monitor Tank is a vertical flat bottom fluid storage tank. Per Drawing No. 62581-Sheet 1 (Reference 27), the tank is 11.5 feet tall and 19 feet in diameter and has a capacity of 20,000 gallons. Based on these dimensions, Reference 26 has properly estimated the maximum water level to be 9.42 feet. The tank material is also specified as A240 Type 304 steel in Reference 27. This tank is unanchored and relies on its bottom friction resistance to overcome the movements due to horizontal seismic excitations. Appendix H of NP-6041-SL (Reference 2) provides guidelines for the HCLPF evaluation of this type of tank, and the calculation has been prepared accordingly.

A median damping of 5% is assumed for the evaluation of seismic impulsive response of the tank, which is consistent with the recommended damping ratio of 5% in Appendix H of NP-6041-SL. Additionally, a damping ratio of 0.5% is assumed for the evaluation of seismic response of the tank in convective (sloshing) mode, which is also consistent with the recommended damping in Appendix H.

The tank is located at Auxiliary Building, El. 364 feet. The In-Structure Response Spectra (ISRS) used to obtain the demands for the HCLPF capacity evaluation are obtained from Reference 21 which provides median NUREG/CR-0098 based spectra at different elevations for several structures including the Auxiliary Building. These spectra were generated for the purpose of SMA. The calculation in Reference 26 has used the maximum response at the calculated frequency $\pm$10% shifts to consider the uncertainty in the frequency estimation. On top of that, it has used the widened ISRS for the evaluation of horizontal responses. Since the widened ISRS already take care of the uncertainty in frequency shifting, the additional consideration of $\pm$10% frequency shift is not necessary. However, this is conservative and therefore accepted. For the evaluation of the vertical response, the calculation in Reference 26 has used the ISRS at the location of the wall rather than the slab. This is justified in the response to comment 4 of the original reviewer's comment (Reference 26), "because a portion of each tank is already within 2 slab thickness of the outer wall (slab is 36" in depth) and for each tank another edge rests near or on a deep concrete beam (42' and 48' deep). Other slabs on this elevation are 24", 18" and 15" in depth and it stands to reason that A-12 [slab] spectral amplitudes are governed by thinner slabs. Since the HCLPF CDFM is striving for median demand values it is much more reasonable to use A-11 [wall] spectral amplitudes vs. those of A-12 [slab] given their proximity to the walls and 3 ft thickness of the slabs." The justification provided is reasonable.

According to NP-6041 (Reference 2), the seismic evaluation of these tanks consists of two parts: a seismic response evaluation, and a seismic capacity assessment.

For the seismic response evaluation, NP-6041 (Reference 2) states that the seismic response evaluation should provide estimates of each of the following:

1- *The overturning moment in the tank shell immediately above the base plate of the tank. This moment is then compared with base moment capacity which is governed by a combination of shell buckling or anchor bolt failure and generally governs the SME capacity of the tank. The combined response for base moment can be obtained by SRSS combination of the corresponding horizontal impulsive and convective responses.*

   Assessment for item 1 for the seismic evaluation of the response:
   The HCLPF calculation (Reference 26) has properly evaluated the overturning moment demand by combining the impulsive and convective (sloshing) moments and combining them through SRSS. The demands are evaluated using proper ISRS and according to the formula given in Appendix H. Therefore, the overturning moment response (demand) has been calculated properly and according to the NP-6041 (Reference 2) guidelines.

2- *The overturning moment applied to the tank foundation through a combination of the tank shell and the base plate. This moment is only needed for tanks founded on soil sites where a foundation failure mode should be investigated and is generally obtained as part of the SSI evaluation. It seldom governs the SME capacity.*

   Assessment for item 2 for the seismic evaluation of the response:
   The Recycle Monitor Tank is located at elevation 364' of the Auxiliary Building. Therefore, the soil failure modes are not relevant to these tanks.

3- *The base shear beneath the tank base plate. This base shear is compared to the horizontal sliding capacity of the tank.*

   Assessment for item 3 for the seismic evaluation of the response:
   The HCLPF calculation (Reference 26) has properly evaluated the base shear demand by combining the impulsive and convective (sloshing) shears and combining them through SRSS. The demands are evaluated using proper ISRS and according to the

formula given in Appendix H. Therefore, the base shear demand has been calculated properly and according to the NP-6041 (Reference 2) guidelines.

4- *The combination of the hydrostatic plus hydrodynamic pressures on the tankside wall. It is common design practice to compare these combined pressures with membrane hoop capacity of the tank side walls at on-foot above the base and each wall thickness change. These combined pressures essentially never govern the SME capacity of a properly designed tank.*

   Assessment for item 4 for the seismic evaluation of the response:
   The HCLPF calculation (Reference 26) does not show the calculation of the hydrostatic plus hydrodynamic induced hoop stresses. However, as stated on page H-6 of the NP-6041 (Reference 2), "These combined pressures essentially never govern the SME capacity of a properly designed tank." The Recycle Monitor tank is judged to be properly designed. Therefore, the evaluation of hoop stresses and the hoop capacity of these tanks for SMA are not necessary.

5- *The average hydrostatic minus hydrodynamic pressure on the base plate of the tank. This pressure is used when evaluating the sliding capacity of the tank.*

   Assessment for item 5 for the seismic evaluation of the response:
   The hydrodynamic vertical fluid pressure is properly evaluated in the HCLPF calculation and is subtracted from hydrostatic pressure for the evaluation of the sliding capacity of the tank.

6- *The fluid slosh height. This slosh height is compared with the freeboard above the fluid to estimate whether roof damage is likely.*

   Assessment for item 6 for the seismic evaluation of the response:
   The slosh height is checked in section 4.6 of the HCLPF calculation (Reference 26). It is shown that the maximum slosh height is 2' which is less than the freeboard clearance of 2.1'.

For the seismic capacity evaluation, NP-6041 (Reference 2) states that the seismic capacity should be evaluated for the following items:

1- *The overturning moment capacity at the tank base. This moment capacity depends upon the axial compressive buckling capacity of the tank shell, the tensile hold-down capacity of the anchor bolts including their anchorage and attachment to the tank, and the hold-down capacity of the fluid pressure acting on the tank base plate. Thus, each of these capacities must be estimated prior to estimating the overturning moment capacity.*

   Assessment for item 1 for the seismic evaluation of the capacity:
   The Recycle Monitor Tank in unanchored. Therefore, the requirements for the bolt hold-down capacity do not apply.

   For the evaluation of the shell buckling capacity, the elephant foot buckling and diamond buckling stress capacities are evaluated. Additionally, the moment that causes 0.2 in. uplift in the tank is evaluated. It is shown that the moment that causes 0.2 in. uplift is less than the moment causing the shell buckling. Therefore, the 0.2 in. uplift is considered the governing failure mode. The justification for the 0.2 in. uplift limit is given in response to the comment 3 of the original reviewer's comments (Reference 26). It is stated that "the judgment was made by the walkdown engineers at the time and given a small uplift of 0.2 inches is not a great challenge to the attached piping as assumed in section 3 of the subject calculation." This justification is judged to be reasonable.

   The calculation of the moment causing the 0.2 in. uplift is given on page A-10 of Reference 26. Comparing the equation (H-46) of the Appendix H of NP-6041 (Reference 2) to the equation shown on page A-10 reveals that the term $\Delta T_e C_3$ is not considered in the equation shown on page A-10.

   A study was made to find the effect of the missing term. The results of this study indicate that, omitting the $\Delta T_e C_3$ term is conservative. Had this term been included in the calculation of the uplift moment, the capacity would have increased from 227 kip-ft to 305 kip-ft, which translates into a HCLPF capacity of 0.4g.

   Based on the assessment above, the tank overturning capacity is conservatively evaluated.

2- *The sliding shear capacity at the tank base, compared to the seismic base shear response.*

   Assessment for item 2 for the seismic evaluation of the capacity:
   The sliding shear capacity is calculated using Equation (H-51) of the Appendix H of the NP-6041 (Reference 2). The coefficient of friction (COF) used in this equation is 0.7 which is a reasonable assumption. Moreover, the vertical hydrodynamic pressure is properly subtracted from the static pressure, when calculating the total vertical pressure at the bottom of the tank by using Equation (H-24) of Appendix H of the NP-6041 (Reference 2). Therefore, it is concluded that the sliding shear capacity calculation of the tank is performed properly.

3- *The membrane hoop stress capacity, compared to the seismic induced membrane hoop stresses due to combined hydrostatic plus hydrodynamic fluid pressures*

Assessment for item 3 for the seismic evaluation of the capacity:
The HCLPF calculation (Reference 26) does not show the hoop stress capacity of the tank. However, as stated on page H-6 of the NP-6041 (Reference 2), "These combined pressures essentially never govern the SME capacity of a properly designed tank." The Recycle Monitor Tank is judged to be properly designed. Therefore, the evaluation of hoop stresses and the hoop capacity of this tank for SMA are judged unnecessary.

4- *The fluid sloshing capacity against the tank roof.*

Assessment for item 4 for the seismic evaluation of the capacity:
The slosh height is checked in Section 4.6 of the HCLPF calculation (Reference 26). It is shown that the maximum slosh height is 2' which is less than the freeboard clearance of 2.1'.

5- *For soil sites, foundation failure modes should also be checked.*

Assessment for item 5 for the seismic evaluation of the capacity:
The Recycle Monitor Tank is located at elevation 364' of the Auxiliary Building. Therefore, the soil failure modes are not relevant to these tanks.

6- *Possibility of failure of piping or their attachment to the tank should be assessed.*

Assessment for item 6 for the seismic evaluation of the capacity:
This item is justified in response to the comment 3 of the original reviewer's comments given in Reference 26. It is stated that "the judgment was made by the walkdown engineers at the time and given a small uplift of 0.2 inches is not a great challenge to the attached piping as assumed in section 3 of the subject calculation."
The justification given above is considered reasonable.

In summary, from the above descriptions, the HCLPF capacity evaluation of the Recycle Monitor Tank is properly done. The HCLPF capacity of 0.3g is considered reasonable and conservative.

Fragility Evaluations Review Conclusion

Based on the material presented above, HCLPF capacities were calculated using the methodology of EPRI NP-6041-SL which meets the guidelines of NUREG-1407 and are adequate for screening purposes.

4.7 System Modeling

The methodology followed for the development of the Foundation and Support system lists, and the subsequent development of the SPEL was per the methodologies and requirements described in NUREG-1407, EPRI NP-6041-SL and GL 88-20.

The EPRI method, as identified in NUREG-1407, was used to describe the success paths for reaching and maintaining safe shutdown. In developing the primary systems to accomplish safe shutdown for both RCS intact and a small break LOCA conditions two paths were identified. From these two paths, one was selected as the primary path and the other as an alternate path. The two paths were then further reviewed to develop a list of support systems required to perform their described functions.

The systems identified through the above process will allow the unit to be brought to safe shutdown, in the time frames described in the UFSAR for both the RCS boundary intact and with a small break LOCA condition. These systems provide for Reactivity Control, Pressure Control of the RCS, Inventory Control of the RCS and Core Heat Removal.

The success paths identified and the support systems identified as required to meet the Primary and Alternate success paths were used to generate the list of Front Line and Support systems (Table 3.5 and Table 3.6 BYR IPEEE submittal). These systems were then used to develop the Success Path Equipment List for SMA Evaluation (SPEL).

Using these systems, the SPEL was developed for the systems by utilizing the UFSAR and Technical Specifications, input from the Byron IPE, as well as documentation of the current plant design using the current Piping and Instrument Drawings, Electrical Distribution Book, Electrical Design Drawings, and discussions with the Operations Staff. From these reviews the required components for the success paths were identified for review.

A specific review for single train and multi train systems was not documented. The Fundamental and Support systems used for the Byron IPEEE all utilize a dual train system, with the exception of the RWST and Control Rod Drive control system The Control Rod Drive control system, credited as the Reactivity control system, is specifically identified and discussed as a single path system. The RWST is credited in the Inventory Control descriptions of the report; however, there is no discussion on the impact of a failure of the RWST in the IPEEE report. While the RWST was evaluated and shown to be qualified for the required seismic conditions, NUREG-1407 section 3.2.5.8 states that the redundancies of a success path should be described, and if only a single train is credited it should be identified.

The issued Byron IPEEE submittal (Reference 1) did not discuss common cause failures related to human errors. However this topic was reviewed in the RAI response to the IPEEE submittal (Reference 1) dated January 29, 1998 (Reference 28). The RAI discussed the results from the Byron IPE, and noted that the success paths and operator actions consistent with current plant operating procedures were evaluated in that document. In addition, the operator actions required to support bringing the plant to cold shutdown were reviewed in the RAI and these were dispositioned as having no significant impact due to: 1) The operators are trained regularly on the accident mitigation procedures, and 2) shift supervisory personnel oversee the actions of the operators during the performance of emergency operations.

The methodology used in the Byron IPEEE SPEL development meets the guidance and requirements of EPRI NP-6041-SL and the enhancements specified in NUREG-1407, with the exception of the description of single and dual trains. Section 3.2.5.1 of NUREG-1407 requires a complete set of potential success paths be identified and the narrowing/elimination of the paths to be documented in detail. Section 3.2.1 of the Byron IPEEE documents the system analysis and description for selecting the primary and alternate paths which meets the requirements from NUREG-1407.

System Modeling Review Conclusion

Based on the above, the methodology used is in compliance with NUREG-1407 and IPEEE system modeling results are adequate for screening purposes.

4.8 Containment Performance

Per Section 3.2.6 of NUREG-1407 (Reference 3), the purpose of the containment performance evaluation for a seismic event is to identify vulnerabilities that involve early failure of containment functions. These potential seismic vulnerabilities include containment integrity, containment isolation, prevention of bypass functions, and support systems. Active seals of isolation hatches and cooling functions of penetrations are to be reviewed if these are required features.

Containment performance was evaluated with respect to seismic vulnerabilities in Sections 3.2.5, 3.4 and 3.5 of Reference 1. Containment structural integrity, isolation functions for containment penetrations, and containment cooling systems were evaluated.

Section 3.2.5 of the IPEEE submittal notes that the equipment and personnel equipment hatches at Byron are not equipped with active seals and are not seismically vulnerable. The Byron Individual Plant Examination (IPE) documentation (Reference 31) was used to identify penetrations that support containment isolation in order to perform walkdowns of these penetrations. The Reactor Containment Fan Cooler (RCFC) units are identified as providing prevention of over pressurization during a small break LOCA.

Section 3.4 of the IPEEE submittal concludes that the containment structure screens out at the RLE of 0.3 PGA based on the screening criteria of EPRI NP-6041-SL. This screening is based on the Table 2-3 of EPRI NP-6041-SL since the containment and internal structures were dynamically analyzed for a SSE greater than 0.1 g.

Walkdowns were performed to evaluate seismic vulnerabilities of the containment, containment isolation valves, mechanical and electrical penetrations, bypass systems, and igniters. The walkdowns did not identify any containment seismic vulnerabilities related to early containment failures.

<u>Containment Performance Review Conclusions</u>

The containment performance evaluation for seismic events is consistent with the intent of Supplement 4 to Generic Letter 88-20. The methodology used is in compliance with NUREG-1407 (Reference 3) and the IPEEE containment performance results are adequate for screening purposes.

4.9 Peer Review

In Supplement 4 to Generic Letter 88-20 (Reference 5), the staff requests that each licensee conduct a peer review by individuals who are not associated with the initial evaluation. The criteria for conducting a peer review are defined only in broad terms in NUREG-1407 (Reference 3) and GL 88-20, Supplement 4. NUREG-1407, Section 7 discusses the requirements for peer reviews of the IPEEE. It is stated that the IPEEE submittal should include description of the review performed, the results of the review, and a list of review team members. In addition, it is recommended that the peer review team should include licensee personnel. The staff recommendation is for the peer review team to have combined experience in the areas of systems engineering and the specific external event being analyzed.

An independent evaluation and peer review of the seismic IPEEE SMA process was performed by Harry Johnson of Programmatic Solutions as documented in Section 6 and Appendix C of Reference 1. The peer reviewer was not part of the BNGS IPEEE team and was an independent reviewer. The peer review was conducted by reviewing the IPEEE submittal report, performing a walkthrough of the plant, and reviewing a sampling of documentation. The peer review evaluated the methods used, implementation of the IPEEE program, reasonableness of the results, and recommended actions.

The peer review concluded that the IPEEE program for BNGS was implemented in accordance with the requirements of NUREG-1407 (Reference 3) for a focused scope EPRI SMA plant. The plant walkthrough documents that the plant was generally well designed for earthquake loads and good construction practices were used. Additionally, plant housekeeping appeared to be well managed. No peer review findings of significance were reported.

The IPEEE submittal does not state if the SMA peer review team consisted of more than Harry Johnson of Programmatic Solutions, and it does not discuss the qualifications of the peer reviewer. The peer review generally appears to evaluate the overall IPEEE submittal mainly based on a review of the plant seismic design basis, plant walkthrough, a review of sample documentation from plant walkdowns and screenings, and a review of the reasonableness of the IPEEE results. The review does not appear to include selection of the success paths and SPEL components.

The peer review is lacking a review of the success path systems selection, which is a weakness of the overall peer review. Sections 4.3 and 4.7 of this IPEEE Adequacy review report document that the SPEL selection and systems modeling were performed using methodologies consistent with NUREG-1407 (Reference 3). Given that the IPEEE Adequacy reviews determined that the SPEL selection and systems modeling were performed using acceptable methodologies, the lack of peer review of the success path system selection during the IPEEE SMA development does not constitute a significant weakness in the overall peer review.

There is also no discussion of any peer reviews conducted by licensee personnel in the IPEEE submittal (Reference 1), which was suggested in NUREG-1407 (Reference 3). Section 3.2 of the IPEEE submittal (Reference 1) states that the system selection process was performed by the licensee (ComEd), and therefore licensee involvement was inherent in the system selection process. Also, two ComEd personnel were part of the SRT. Therefore, although licensee personnel were not part of the peer review team, they were involved throughout the IPEEE SMA process. NUREG-1407 (Reference 3) states that the purpose of having licensee personnel involved in the peer review is to have "...utility personnel cognizant of the IPEEE". By having licensee personnel involved in the development of the IPEEE SMA, BNGS has met the intended requirement of NUREG-1407 of having licensee involvement in the IPEEE process.

Peer Review Conclusions

The methodology used for peer review has minor weaknesses relative to the criteria of NUREG-1407 (Reference 3), but these weaknesses are considered insignificant. The weaknesses are mitigated by the fact that the IPEEE Adequacy review documented in this report also constitutes a type of peer review of the IPEEE. Therefore, IPEEE peer review is considered adequate for screening purposes.

5.0 Conclusions

The NRC 50.54(f) letter (Reference 8) has requested all nuclear power plant licensees to conduct seismic hazard reevaluations using updated seismic hazard information and present-day methods. Byron Nuclear Generating Station is performing the seismic hazard and screening per the EPRI SPID (Reference 7) guidance. A new GMRS has been developed for BNGS using the SPID methodology. The GMRS can be compared to the IHS to screen out of further seismic risk assessments using the SPID guidelines. In order to perform the GMRS to IHS screening, the BNGS IPEEE has been subjected to an adequacy review to ensure that the IPEEE is of sufficient quality. This report documents the adequacy review performed following the guidance provided in Section 3.3.1 of the SPID (Reference 7).

The SPID defines four categories which must be addressed in order to use the IHS for seismic hazard screening. The four categories are:

- General Considerations
- Prerequisites
- Adequacy Demonstration
- Documentation

BNGS is a focused scope plant binned to 0.3g PGA NUREG/CR-0098 median rock spectrum. The IPEEE seismic assessment was performed using a SMA per the EPRI NP-6041-SL methodology. The SPID IPEEE adequacy "General Considerations" requires that focused scope plants perform full scope evaluations of soil failure modes and relay chatter. NEI Letter "Relay Chatter Reviews for Seismic Hazard Screening" dated October 3, 2013 (Reference 10) states that full scope relay chatter reviews will be performed later on a schedule consistent with high frequency evaluations. Therefore, relay chatter is not addressed in this report and will be evaluated later.

This report documents the IPEEE Adequacy review for BNGS which was performed following the guidelines of the SPID, Section 3.3.1.

The available documentation from the Byron seismic IPEEE was used to perform the Adequacy review. Some of the original documentation from the IPEEE is not available, but sufficient information was available for each review category to make determinations of the adequacy for each item.

Soil failure modes were evaluated in Section 2.2. The results of this evaluation conclude that liquefaction, slope stability, and settlement are not a concern for structures which contain SPEL components.

The four IPEEE adequacy Prerequisites were reviewed. Prerequisites 1 to 3 were found to be met. Prerequisite 4 required reviews of major plant modifications which could degrade / impact the conclusions reached in the seismic IPEEE. A review of the major modifications indicates that a number of modifications have been performed to IPEEE SPEL systems and individual components, but they do not have an adverse impact on the IPEEE conclusions.

The nine Adequacy Demonstration items defined in the SPID were reviewed based on available information from the IPEEE submittal (Reference 1) and additional available backup reference information (not all documentation is retrievable). The Adequacy Demonstration items, In-Structure Demands and ISRS (Section 4.2), Selection of SSEL (Section 4.3), Screening of Components (Section 4.4), Walkdowns (Section 4.5), Fragility Evaluations (Section 4.6), System Modeling (Section 4.7), and Containment Performance (Section 4.8) were found to have methods in compliance with NUREG-1407 and were determined to be adequate for seismic hazard screening purposes.

The Adequacy Demonstration item Structural Models and Structural Response Analysis (Section 4.1) was reviewed using EPRI NP-6041-SL criteria. The structural models did not consider SSI or cracking of concrete sections associated with higher IPEEE input motions. Upon further review, based on higher actual concrete compressive strength, $\pm$15% widening of the response spectra at all frequencies, and generation of SMA specific response spectra without accounting for effect of incoherent seismic motion, the impact of SSI and cracking of concrete sections associated with higher IPEEE input motions on SMA was found to be negligible. Thus, the results of the seismic models are considered adequate for seismic hazard screening purposes.

The Adequacy Demonstration item Peer Review (Section 4.9) had minor weaknesses in that it did not report peer reviews of the systems selection and peer reviews by the licensee personnel. These weaknesses are mitigated by the fact that the IPEEE Adequacy review in this report investigated the systems selection and the licensee participated in the SMA process.

Therefore, the overall Byron IPEEE SMA was determined to be adequate for seismic hazard screening and the risk insights from the IPEEE are still valid under current plant configurations. Therefore, the IHS can be used for screening of the new GMRS in accordance with the SPID (Reference 7).

6.0 References

1. ComEd (now Exelon) Letter BY: 96-0323, "Byron Nuclear Generating Station Units 1 and 2 Individual Plant Examination of External Events for Severe Accident Vulnerabilities Submittal Report", December, 1996
2. EPRI NP-6041-SL, Revision 1, "A Methodology for Assessment of Nuclear Power Plant Seismic Margin," August 1991
3. NRC NUREG-1407, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities," June 1991
4. NRC Correspondence RS-12-161, "Byron Generating Station Unit 1 & 2 Seismic Walkdown Reports", November, 2012
5. NRC Generic Letter 88-20, Supplement 4, "Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities – 10CFR 50.54"
6. Staff Evaluation by The Office of Nuclear Reactor Regulation Related to Generic Letter 88-20, Supplement 4, Individual Plant Examination of External Events, Exelon Generation Company, LLC, Byron Station, Units 1 and 2, May, 2001
7. EPRI, "Seismic Evaluation Guidance: Screening, Prioritization, and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic", February, 2013
8. NRC Letter (E. J. Leeds) to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status, "Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident", March 2012
9. Title 10 Code of Federal Regulations Part 50
10. NEI Letter to the NRC, "Relay Chatter Reviews for Seismic Hazard Screening", dated October 3, 2012
11. SQUG "Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment", Revision 2A, March 1993
12. Byron/Braidwood Nuclear Stations Updated Final Safety Analysis Report (UFSAR), Revision 14
13. USNRC Regulatory Guide 1.198, "Procedure and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plants Sites", November 2003
14. S&L Report No. SL-BYR-96-009, Revision 0, "Seismic Margin Earthquake (SME) In-Structure Spectra for Byron Station", October 1996
15. NUREG/CR-0098, "Development of Criteria for Seismic Review of Selected Nuclear Power Plant", May 1978

16. Letter from Glen T. Kaegi of Exelon Generating Company, LLC to U.S. Nuclear Regulatory Commission, dated September 12, 2013, transmitting the subsurface materials and properties and base case velocity profiles for each of the Exelon Generation Company (NTTF 2.1 Seismic Response for CEUS Sites)
17. SL-4492, Revision 1, "Seismic Qualification of the Byron Deep Wells", Report Prepared for Commonwealth Edison Company, November, 1988
18. Email from Jeff Clark (Exelon) to Ryan Foley (Sargent & Lundy), "FW: latest version of Byron SMDS-SEWS", dated January 27, 2014. Transmittal of Screening Evaluation Worksheets (SEWS) generated by Stevenson and Associates
19. Working Group on the Stiffness of Concrete Shear Wall Structures, Structural Division, ASCE, "Stiffness of Low Rise Concrete Shear Walls", 1994
20. Calculation No. 7.16.10.2, "Calculations for 480 Volt M.C.C," Sargent & Lundy Engineers Chicago, February 1985 (part of Calculation 7.16.10)
21. Calculation No. BYR96-009, Revision 0, "In-Structure Response Spectra for SMA" Prepared by Sargent and Lundy for Commonwealth Edison Company
22. Drawing No. 2660C42, "21 inches Deep Five Star Motor Control Center-Outline and Floor Plan," Westinghouse Electric Corporation, December 2, 1977
23. Byron Station Drawing No. S-736, Revision AF, "Auxiliary Building Foundation Sections & Details"
24. EPRI NP-5228-SL, Revision 1, "Seismic Verification of Nuclear Plant Equipment Anchorage," Electric Power Research Institute: Palo Alto, California, June 1991
25. Calculation No. 24.1.2, Revision 1, "Concrete Expansion Anchors Design Control Summary for Plant Modification and Station Support Work"
26. Calculation No. C-003 of Job No. 93C2806.01 & 05, "HCLPF Evaluation of Recycle Monitor Tank," Stevenson and Associates, November 27, 1996
27. Drawing No. 62581-Sheet 1, "General Plan for 19'-0Fx11'- 6" High C. R. Tank," Chicago Bridge and Iron Company
28. ComEd (now Exelon) Letter, "Response to Request for Additional Information Regarding Individual Plant Examination of External Events", Attachment B: Response to Request for Additional Information Regarding Byron Station Individual Plant Examination of External Events (IPEEE), dated January 29, 1998 (note the date should be January 29, 1999)
29. Byron Station Drawing No. M-7, Revision V, "General Arrangement Mezzanine Floor at EL 426-0"
30. NRC Bulletin 80-11: Masonry Wall Design, May 8, 1980
31. Byron Nuclear Generating Station Units 1 and 2 Individual Plant Examination Report, Volume 1, Commonwealth Edison Company, April, 1994

Enclosure 2

SUMMARY OF REGULATORY COMMITMENTS

The following table identifies commitments made in this document. (Any other actions discussed in the submittal represent intended or planned actions. They are described to the NRC for the NRC's information and are not regulatory commitments.)

COMMITMENT	COMMITTED DATE OR "OUTAGE"	COMMITMENT TYPE	
		ONE-TIME ACTION (Yes/No)	PROGRAMMATIC (Yes/No)
1. Byron Station, Units 1 and 2, will perform a High Frequency Confirmation evaluation in accordance with EPRI Report 1025287, Section 3.4.	As determined by NRC prioritization following submittal of all nuclear power plant Seismic Hazard Re-evaluations, but no later than December 31, 2019.	Yes	No
2. Byron Station, Units 1 and 2, will perform a Spent Fuel Pool evaluation in accordance with EPRI Report 1025287, Section 7.	As determined by NRC prioritization following submittal of all nuclear power plant Seismic Hazard Re-evaluations, but no later than December 31, 2019.	Yes	No
3. Byron station, Units 1 and 2, will perform a full scope detailed review of Relay Chatter to complete IPEEE Adequacy requirements of SPID (EPRI Report 1025287), Section 3.3.1.	As determined by NRC prioritization following submittal of all nuclear power plant Seismic Hazard Re-evaluations, but no later than December 31, 2019.	Yes	No
4. Byron Station, Units 1 and 2 will provide an Expedited Seismic Evaluation Process (ESEP) Report in accordance with EPRI Report 3002000704.	December 31, 2014	Yes	No