FPL

March 31, 2014

L-2014-089
10 CFR 50.54(f)

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

Subject: Florida Power & Light (FPL) Seismic Hazard and Screening Report (CEUS Sites), Response 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, ADAMS Accession No. ML 12073A348

2. NEI Letter, *Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations*, dated April 9, 2013, ADAMS Accession No. ML13101A379

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, ADAMS Accession No. ML13106A331

4. 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*, ADAMS Accession No. ML12333A170

5. NRC Letter, *Endorsement of EPRI Final Draft Report 1025287, "Seismic Evaluation Guidance,"* dated February 15, 2013, ADAMS Accession No. ML12319A074

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.

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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.

Reference 4 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 5.

The attached Seismic Hazard Evaluation and Screening Report for St. Lucie Nuclear Station provides the information described in Section 4 of Reference 4 in accordance with the schedule identified in Reference 2.

This letter contains no new regulatory commitments.

If you have any questions regarding this report, please contact Ken Frehafer at (772) 467-7748.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on March 31, 2014.

Joseph Jensen
Site Vice President
St. Lucie Plant

Attachment

Florida Power & Light (FPL), St. Lucie Nuclear station Units 1 & 2 Seismic Hazard and Screening Report (CEUS Sites), Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding Recommendation 2.1 of the Near-Term Task Force Review of Insights form the Fukushima Dai-ichi Accident.

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 Nuclear Regulatory Commission (NRC) 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. The 50.54(f) letter requests that licensees and holders of construction permits under 10 CFR Part 50 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 pertaining to NTTF Recommendation 2.1 for the Florida Power & Light St. Lucie (PSL) Nuclear Station, located on Hutchinson Island in St. Lucie County, Florida. In providing this information, St. Lucie Nuclear Station 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* (EPRI 1025287, 2013a). The Augmented Approach, Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic (EPRI 3002000704, 2013c), 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 St. Lucie Safe Shutdown Earthquake (SSE) seismic design is based on acceleration ground response spectrum curves that were derived from Regulatory Guide 1.60 spectra normalized to 0.10g. The Final Safety Analysis Report commitment for an SSE of 0.10g was determined at a time when probabilistic definition of seismic input had not been developed with any degree of consistency or confidence. Therefore the 0.10g Peak Ground Acceleration was conservatively estimated and set at the legal minimum specified by 10CFR 100 Appendix A. (FPL, 2012a)

In response to the 50.54(f) letter and following the guidance provided in the SPID (EPRI 1025287, 2013a), a seismic hazard reevaluation was performed. For screening purposes, a Ground Motion Response Spectrum (GMRS) was developed.

Based on the results of the screening evaluation, no further evaluations will be performed.

2.0 Seismic Hazard Reevaluation

St. Lucie Nuclear Station is located approximately 10 miles south of Fort Pierce, Florida, adjacent to the Atlantic Ocean. The Station is located on an offshore sandbar, Hutchinson Island, along the east coast of peninsular Florida. Hutchinson Island is separated from the mainland by the Indian River, a shallow (approximately 6 ft) body of water. Land surface on the island ranges from mean sea level to 19 feet above, but is generally less than 10 feet. Lake Okeechobee is located approximately 30 miles to the west-southwest of the site. Florida lies entirely within the Coastal Plain physiographic province and is the emergent part of a much larger feature called the Floridan Plateau. The St. Lucie station is situated on the southern portions of this Floridan Plateau, a stable carbonate platform on which thick sequences of Createaceous and Tertiary limestones, dolomites, evaporites and comparatively small amounts of clastic sediments have accumulated. (FPL, 2012b)

The entire state of Florida is by all accounts a low seismicity region of the United States having been a Zone 0 area by the Uniform Building Code which means no seismic design loads for "conventional" buildings. However, in order to comply with the minimum accepted acceleration as stipulated by 10 CFR 100, Appendix A, the St. Lucie nuclear plant is designed for a maximum horizontal ground surface acceleration of 0.10 g. This conservative surface design acceleration exceeds the maximum acceleration appropriate for the maximum earthquake which has occurred in the sites seismotectonic province during the past 200 years. The maximum vertical acceleration for the postulated SSE is the same as the peak horizontal acceleration. (FPL, 2012b)

2.1 Regional and Local Geology

The St. Lucie Nuclear Station is in the Coastal Plain physiographic province and is the emergent part of a much larger feature called the Floridan Plateau. The St. Lucie site is situated on the southern portions of this Floridan Plateau, a stable carbonate platform on which thick sequences of Createaceous and Tertiary limestones, dolomites, evaporites and comparatively small amounts of clastic sediments have accumulated. (FPL, 2012b)

Prior to construction the site was covered with a mangrove swamp, consisting of about one foot of standing salt water. Underlying this water covered surface is from four to six feet of peat and roots. This material is a dark brown or black residuum produced by the partial decomposition and disintegration of trees, mangrove roots and other vegetation. In the immediate site power block area, this material and the underlying formation have been excavated to elevation minus 60 ft. and replaced with an engineered fill. (FPL, 2012b)

2.2 Probabilistic Seismic Hazard Analysis

2.2.1 Probabilistic Seismic Hazard Analysis Results

In accordance with the 50.54(f) letter and following the guidance in the SPID (EPRI, 2013a), 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 (CEUS-SSC, 2012) together with the updated EPRI Ground-Motion Model (GMM) for the CEUS (EPRI, 2013b). For the PSHA, a lower-bound moment magnitude of 5.0 was used, as specified in the 50.54(f) letter.

For the PSHA, the CEUS-SSC background seismic sources out to a distance of 400 miles (640 km) around St. Lucie were included. This distance exceeds the 200 mile (320 km) recommendation contained in USNRC (USNRC, 2007) and was chosen for completeness. Background sources included in this site analysis are the following:

Atlantic Highly Extended Crust (AHEX)
Extended Continental Crust—Atlantic Margin (ECC_AM)
Extended Continental Crust—Gulf Coast (ECC_GC)
Gulf Highly Extended Crust (GHEX)
Mesozoic and younger extended prior – narrow (MESE-N)
Mesozoic and younger extended prior – wide (MESE-W)
Study region (STUDY_R)

For sources of large magnitude earthquakes, designated Repeated Large Magnitude Earthquake (RLME) sources in CEUS-SSC (CEUS-SSC, 2012), the following sources lie within 1,000 km of the site and were included in the analysis:

Charleston

For each of the above background sources, the Gulf versions of the updated CEUS EPRI GMMs are used to model the seismic wave travel path. For the Charleston RLME source, a combination of Gulf (66%) and mid-continent (34%) GMMs are created based on the relative fraction of the seismic wave travel path through these regions from the center of the Charleston Local zone to the site.

2.2.2 Base Rock Seismic Hazard Curves

Consistent with the SPID (EPRI, 2013a), 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 below in Section 3 at the Safe Shutdown Earthquake (SSE) control point elevation.

2.3 Site Response Evaluation

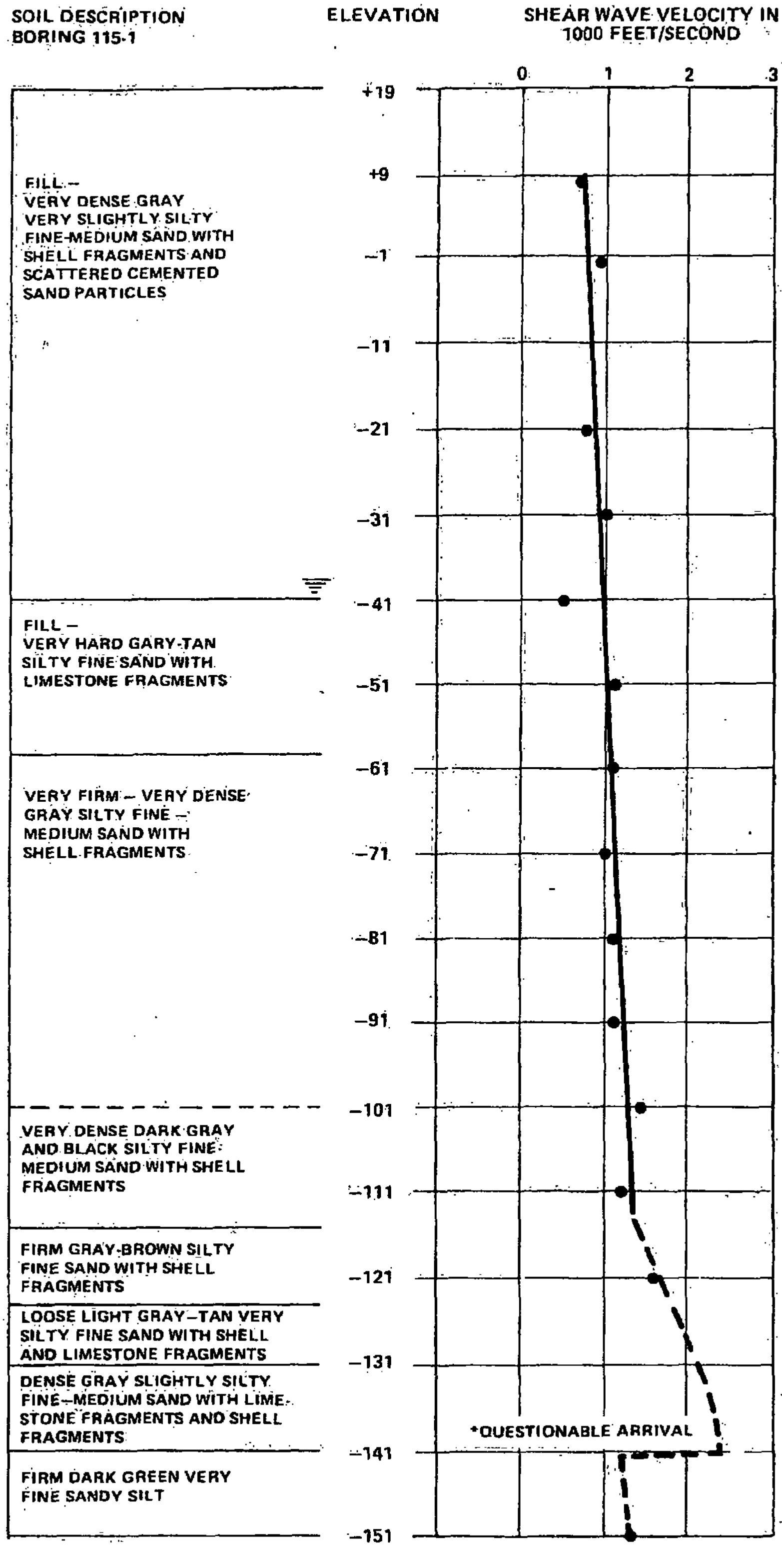
Following the guidance contained in Enclosure 1 of the 3/12/2012 50.54(f) Request for Information and in the SPID (EPRI, 2013a) for nuclear power plant sites that are not founded on hard rock (defined as 2.83 km/sec), a site response analysis was performed for St. Lucie.

2.3.1 Description of Subsurface Material

The St. Lucie Nuclear Power Station (NPS) site is located on an offshore sandbar, Hutchinson Island along the east coast of Florida. Hutchinson Island is separated from the mainland by the Indian River. The site is located within the Floridian Plateau of the Coastal Plain physiographic province. Lake Okeechobee is about 30 miles (48 km) west-southwest of the site. The ground surface is at an elevation of 18.5 ft (5.6 m).

The information used to create the site geologic profile at the St. Lucie NPS is shown in Table 2.3.1-1. This profile was developed using information documented in FPL (FPL, 2012a) and EPRI (EPRI, 2014). As indicated in EPRI (EPRI, 2014) the SSE Control Point is defined at the top of the ground surface at elevation of 18.5 ft. The profile consists of about 80 ft (24 m) of fill overlying about 700 ft (213 m) of soils. Underlying the soils is about 13,000 ft (3,960 m) of Jurassic through Tertiary Age carbonate rocks above Paleozoic crystalline basement.

Table 2.3.1-1 (Table 2)
Summary of Geotechnical Profile for St. Lucie NPS



Source: FPL (FPL, 2012b), Unit 2 UFSAR Figure 2.5-57

The following description of the general geology of the site is taken directly from FPL (FPL, 2012b):

"St. Lucie Nuclear Power Plant (Units 1 and 2) is located on an offshore sandbar, Hutchinson Island, along the east coast of peninsular Florida. Hutchinson Island is separated from the mainland by the Indian River, a shallow (approximately 6 ft) body of water. Land surface on the island ranges from mean sea level to 19 feet above, but is generally less than 10 feet. Lake Okeechobee is located approximately 30 miles to the west-southwest of the site.

Florida lies entirely within the Coastal Plain physiographic province and is the emergent part of a much larger feature called the Floridan Plateau. The St. Lucie site is situated on the southern portions of this Floridan Plateau, a stable carbonate platform on which thick sequences of Createaceous and Tertiary limestones, dolomites, evaporites and comparatively small amounts of clastic sediments have accumulated.

Prior to construction the site was covered with a mangrove swamp, consisting of about one foot of standing salt water. Underlying this water covered surface is from four to six feet of peat and roots. This material is a dark brown or black residuum produced by the partial decomposition and disintegration of trees, mangrove roots and other vegetation. In the immediate site power block area, this material and the underlying formation have been excavated to elevation minus 60 ft. and replaced with an engineered fill. Borings have identified two major formations underlying the plant site.

The Anastasia Formation (of Pleistocene age) underlies the original layer of peat. This gray slightly clayey silty, fine to medium sand with fragmented shells; and in places, fragmented shell beds wit slightly clayey and silty fine sands extend to about elevation minus 135 to minus 155 ft. There also discontinuous pockets of cemented sand with shells and sandy limestone. These discontinuous cemented pockets are generally found between elevation minus 35 and minus 60 ft. Discontinuous plastic clay lenses were also found in the upper portion of the formation.

The Hawthorn formation (of Miocene age) of partially cemented and sands clays and sandy limestone underlies the Anastasia formation and extends to about elevation minus 600 ft to minus 700ft in the site area. The upper 100 to 150 ft of the Hawthorne formation consists of green, slightly clayey and silty, very fine sand. The lower part becomes generally more clayey. The formation changes slightly to a gray white, phosphatic, sandy clay in the site area below elevation minus 450 ft. The clays of the Hawthorne are unusual in their content of the mineral atapugite. There is also a high fraction of calcite and dolomite, indicative of a marine environment.

Underlying the Hawthorne formation is about 13,000 ft of Jurassic through Tertiary Age carbonate rocks.

The geological structure is relatively simple with Anastasia and Hawthorne formations are nearly flat, dipping very slightly to the southeast at about 5 to 10 ft. per mile. The contact between the Anastasia formation and the underlying Hawthorne is undulating contact having minor irregularities. All of the formations overlie a Paleozoic crystalline basement."

2.3.2 Development of Base Case Profiles and Nonlinear Material Properties

Table 2.3.1-1 shows the recommended shear-wave velocities, depths, and soil description to elevation -151 ft. As indicated in EPRI (EPRI, 2014), the SSE Control Point is at the ground surface at elevation 18.5 ft. Based on Table 2.3.1-1, reflecting the only measured shear-wave velocities at Units 1 and 2, the linear gradient extends to elevation 9 ft with a shear-wave velocity of about 800 ft/s (244 m/s). To approximate the linear gradient extended to the surface, the 78.5 ft (24 m) of material above the Anastasia Formation was divided into two layers each of thickness 39.2 ft (12 m). Constant shear-wave velocities were taken as 1005 ft/s (306 m/s), the top-of-Anastasia Formation velocity, for the deeper layer and 800 ft/s (244 m/s) for the surficial layer. The linear gradient was continued to a depth of about 178 ft (54 m) where the 270 m/s profile template (EPRI, 2013a) was added for the soils of the underlying Hawthorne formation. At a depth of about 740 ft (226 m), shear-wave velocities were increased to 5,000 ft/s (1,524 m/s) to accommodate the underlying carbonate rocks.

To develop the mean or best-estimate base-case firm carbonate rock profile from a depth of 740 ft to 5,079 ft (226 m to 1,548 m), the shear-wave velocity of 5,000 ft/s (1,524 m/s) was assumed to reflect the top portion of the firm rock profile. Provided the materials to basement depth reflect similar sedimentary rocks and age, the shear-wave velocity gradient for sedimentary rock of 0.5 m/m/s (EPRI, 2013a) was assumed to be appropriate for the site. An assumed shear-wave velocity of 5,000 ft/s (1,548 m/s) was taken at a depth of about 740 ft (226 m) in the profile with the velocity gradient applied at that point, resulting in a base-case shear-wave velocity of about 7,400 ft/s (2,255 m/s) at a depth of 5,079 ft (1,548 m). The depth of 5,079 ft (1,548 m) to hard reference rock was considered adequate to reflect amplification over the lowest frequency of interest, about 0.5 Hz (EPRI, 2013a). Profile P3, the stiffest profile, encountered hard rock shear-wave velocities (9,285 ft/s, 2,890 m/s) at a depth below the SSE of about 2,323 ft (708 m). The mean or best estimate base-case profile is shown as profile P1 in Figure 2.3.2-1.

To accommodate epistemic uncertainty in shear-wave velocities a scale factor of 1.57 was chosen, reflecting the both the age and sparse shear-wave velocity measurements at the site. Profiles extended to a depth below the SSE of 5,079 ft (1,548 m), randomized ± 1,522 ft (± 464 m). The base-case profiles (P1, P2, and P3) are shown in Figure 2.3.2-1 and listed in Table 2.3.2-1. 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 scale factor of 1.57 reflect a σ_{ln} of about 0.35, based on the SPID (EPRI, 2013a) 10^{th} and 90^{th} fractiles which implies a 1.28 scale factor on σ_{μ}.

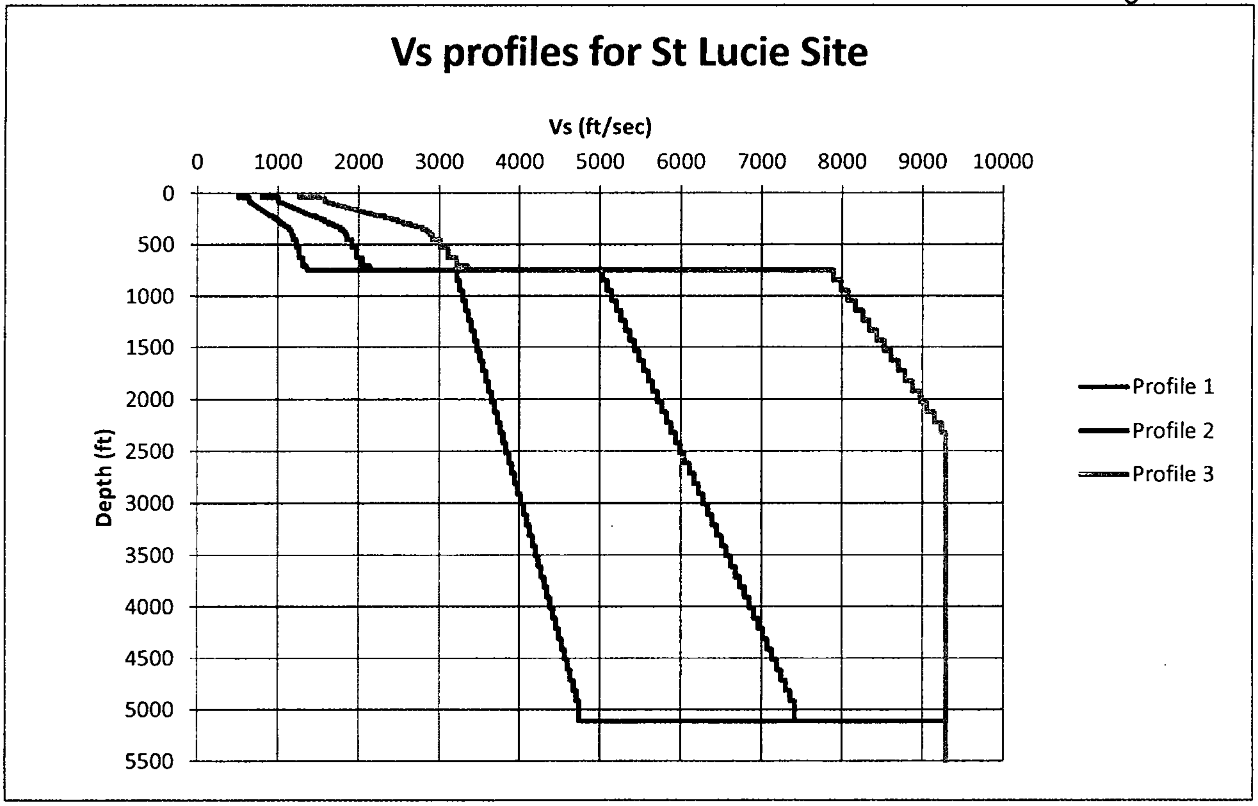


Figure 2.3.2-1. Shear-wave velocity profiles for the St. Lucie site. (EPRI, 2014)

Table 2.3.2-1 (EPRI, 2014)
Layer thicknesses, depths, and shear-wave velocities (Vs) for 3 profiles, the St. Lucie site

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	800		0	512		0	1256
3.9	3.9	800	3.9	3.9	512	3.9	3.9	1256
3.9	7.9	800	3.9	7.9	512	3.9	7.9	1256
3.9	11.8	800	3.9	11.8	512	3.9	11.8	1256
3.9	15.7	800	3.9	15.7	512	3.9	15.7	1256
3.9	19.7	800	3.9	19.7	512	3.9	19.7	1256
3.9	23.6	800	3.9	23.6	512	3.9	23.6	1256
3.9	27.6	800	3.9	27.6	512	3.9	27.6	1256
3.9	31.5	800	3.9	31.5	512	3.9	31.5	1256
3.9	35.4	800	3.9	35.4	512	3.9	35.4	1256
3.9	39.4	800	3.9	39.4	512	3.9	39.4	1256
3.9	43.3	1005	3.9	43.3	643	3.9	43.3	1578
3.9	47.2	1005	3.9	47.2	643	3.9	47.2	1578
3.9	51.2	1005	3.9	51.2	643	3.9	51.2	1578
3.9	55.1	1005	3.9	55.1	643	3.9	55.1	1578

3.9	59.1	1005	3.9	59.1	643	3.9	59.1	1578
3.9	63.0	1005	3.9	63.0	643	3.9	63.0	1578
3.9	66.9	1005	3.9	66.9	643	3.9	66.9	1578
3.9	70.9	1005	3.9	70.9	643	3.9	70.9	1578
3.9	74.8	1005	3.9	74.8	643	3.9	74.8	1578
3.9	78.7	1005	3.9	78.7	643	3.9	78.7	1578
3.3	82.0	1005	3.3	82.0	643	3.3	82.0	1578
3.3	85.3	1015	3.3	85.3	649	3.3	85.3	1593
3.3	88.6	1025	3.3	88.6	656	3.3	88.6	1609
3.3	91.9	1034	3.3	91.9	662	3.3	91.9	1624
3.3	95.1	1044	3.3	95.1	668	3.3	95.1	1640
3.3	98.4	1054	3.3	98.4	675	3.3	98.4	1655
3.3	101.7	1064	3.3	101.7	681	3.3	101.7	1670
3.3	105.0	1074	3.3	105.0	687	3.3	105.0	1686
3.3	108.3	1084	3.3	108.3	694	3.3	108.3	1701
3.3	111.5	1094	3.3	111.5	700	3.3	111.5	1717
3.3	114.8	1103	3.3	114.8	706	3.3	114.8	1732
3.3	118.1	1113	3.3	118.1	712	3.3	118.1	1748
3.3	121.4	1123	3.3	121.4	719	3.3	121.4	1763
3.3	124.7	1133	3.3	124.7	725	3.3	124.7	1779
3.3	128.0	1143	3.3	128.0	731	3.3	128.0	1794
3.3	131.2	1153	3.3	131.2	738	3.3	131.2	1810
3.3	134.5	1162	3.3	134.5	744	3.3	134.5	1825
3.3	137.8	1172	3.3	137.8	750	3.3	137.8	1840
3.3	141.1	1182	3.3	141.1	757	3.3	141.1	1856
3.3	144.4	1192	3.3	144.4	763	3.3	144.4	1871
3.3	147.6	1202	3.3	147.6	769	3.3	147.6	1887
3.3	150.9	1212	3.3	150.9	775	3.3	150.9	1902
3.3	154.2	1221	3.3	154.2	782	3.3	154.2	1918
3.3	157.5	1231	3.3	157.5	788	3.3	157.5	1933
3.3	160.8	1241	3.3	160.8	794	3.3	160.8	1949
3.3	164.0	1251	3.3	164.0	801	3.3	164.0	1964
3.3	167.3	1261	3.3	167.3	807	3.3	167.3	1979
3.3	170.6	1271	3.3	170.6	813	3.3	170.6	1995
3.3	173.9	1281	3.3	173.9	820	3.3	173.9	2010
3.3	177.2	1290	3.3	177.2	826	3.3	177.2	2026
3.3	180.4	1300	3.3	180.4	832	3.3	180.4	2041
3.3	183.7	1310	3.3	183.7	838	3.3	183.7	2057
3.3	187.0	1320	3.3	187.0	845	3.3	187.0	2072
3.3	190.3	1330	3.3	190.3	851	3.3	190.3	2088

3.3	193.6	1340	3.3	193.6	857	3.3	193.6	2103
3.3	196.8	1349	3.3	196.8	864	3.3	196.8	2119
3.3	200.1	1359	3.3	200.1	870	3.3	200.1	2134
3.3	203.4	1369	3.3	203.4	876	3.3	203.4	2149
3.3	206.7	1379	3.3	206.7	883	3.3	206.7	2165
3.3	210.0	1389	3.3	210.0	889	3.3	210.0	2180
3.3	213.3	1399	3.3	213.3	895	3.3	213.3	2196
3.3	216.5	1408	3.3	216.5	901	3.3	216.5	2211
3.3	219.8	1418	3.3	219.8	908	3.3	219.8	2227
3.3	223.1	1428	3.3	223.1	914	3.3	223.1	2242
8.6	231.7	1482	8.6	231.7	948	8.6	231.7	2327
8.6	240.3	1482	8.6	240.3	948	8.6	240.3	2327
9.4	249.6	1537	9.4	249.6	984	9.4	249.6	2413
9.4	259.0	1537	9.4	259.0	984	9.4	259.0	2413
9.4	268.4	1582	9.4	268.4	1012	9.4	268.4	2484
9.4	277.8	1582	9.4	277.8	1012	9.4	277.8	2484
9.4	287.1	1627	9.4	287.1	1041	9.4	287.1	2554
9.4	296.5	1627	9.4	296.5	1041	9.4	296.5	2554
10.0	306.5	1687	10.0	306.5	1080	10.0	306.5	2649
10.0	316.5	1687	10.0	316.5	1080	10.0	316.5	2649
10.0	326.5	1727	10.0	326.5	1105	10.0	326.5	2711
2.2	328.7	1727	2.2	328.7	1105	2.2	328.7	2711
17.8	346.5	1777	17.8	346.5	1137	17.8	346.5	2790
10.0	356.5	1777	10.0	356.5	1137	10.0	356.5	2790
10.6	367.1	1817	10.6	367.1	1163	10.6	367.1	2853
10.6	377.7	1817	10.6	377.7	1163	10.6	377.7	2853
11.5	389.2	1837	11.5	389.2	1176	11.5	389.2	2884
11.5	400.7	1837	11.5	400.7	1176	11.5	400.7	2884
17.7	418.4	1857	17.7	418.4	1188	17.7	418.4	2915
17.7	436.0	1857	17.7	436.0	1188	17.7	436.0	2915
17.7	453.7	1857	17.7	453.7	1188	17.7	453.7	2915
18.2	471.9	1917	18.2	471.9	1227	18.2	471.9	3010
28.0	500.0	1917	28.0	500.0	1227	28.0	500.0	3010
8.5	508.4	1917	8.5	508.4	1227	8.5	508.4	3010
18.2	526.7	1917	18.2	526.7	1227	18.2	526.7	3010
20.0	546.7	1977	20.0	546.7	1265	20.0	546.7	3104
20.0	566.7	1977	20.0	566.7	1265	20.0	566.7	3104
12.0	578.7	1977	12.0	578.7	1265	12.0	578.7	3104
28.0	606.7	1977	28.0	606.7	1265	28.0	606.7	3104
20.0	626.7	1977	20.0	626.7	1265	20.0	626.7	3104

20.0	646.7	2047	20.0	646.7	1310	20.0	646.7	3214
20.0	666.7	2047	20.0	666.7	1310	20.0	666.7	3214
20.0	686.7	2047	20.0	686.7	1310	20.0	686.7	3214
20.0	706.7	2047	20.0	706.7	1310	20.0	706.7	3214
19.3	726.0	2137	19.3	726.0	1368	19.3	726.0	3355
19.3	745.4	2137	19.3	745.4	1368	19.3	745.4	3355
98.6	843.9	5028	98.6	843.9	3218	98.6	843.9	7894
98.6	942.5	5085	98.6	942.5	3254	98.6	942.5	7983
98.6	1041.1	5142	98.6	1041.1	3291	98.6	1041.1	8073
98.6	1139.7	5199	98.6	1139.7	3327	98.6	1139.7	8162
98.6	1238.3	5256	98.6	1238.3	3364	98.6	1238.3	8251
98.6	1336.9	5312	98.6	1336.9	3400	98.6	1336.9	8341
98.6	1435.4	5369	98.6	1435.4	3436	98.6	1435.4	8430
98.6	1534.0	5426	98.6	1534.0	3473	98.6	1534.0	8519
98.6	1632.6	5483	98.6	1632.6	3509	98.6	1632.6	8608
98.6	1731.2	5540	98.6	1731.2	3546	98.6	1731.2	8698
98.6	1829.8	5597	98.6	1829.8	3582	98.6	1829.8	8787
98.6	1928.3	5654	98.6	1928.3	3618	98.6	1928.3	8876
98.6	2026.9	5711	98.6	2026.9	3655	98.6	2026.9	8966
98.6	2125.5	5767	98.6	2125.5	3691	98.6	2125.5	9055
98.6	2224.1	5824	98.6	2224.1	3728	98.6	2224.1	9144
98.6	2322.7	5881	98.6	2322.7	3764	98.6	2322.7	9233
98.6	2421.3	5938	98.6	2421.3	3800	98.6	2421.3	9285
98.6	2519.8	5995	98.6	2519.8	3837	98.6	2519.8	9285
98.6	2618.4	6052	98.6	2618.4	3873	98.6	2618.4	9285
98.6	2717.0	6109	98.6	2717.0	3910	98.6	2717.0	9285
98.6	2815.6	6166	98.6	2815.6	3946	98.6	2815.6	9285
98.6	2914.2	6222	98.6	2914.2	3982	98.6	2914.2	9285
98.6	3012.8	6279	98.6	3012.8	4019	98.6	3012.8	9285
98.6	3111.3	6336	98.6	3111.3	4055	98.6	3111.3	9285
98.6	3209.9	6393	98.6	3209.9	4092	98.6	3209.9	9285
98.6	3308.5	6450	98.6	3308.5	4128	98.6	3308.5	9285
98.6	3407.1	6507	98.6	3407.1	4164	98.6	3407.1	9285
98.6	3505.7	6564	98.6	3505.7	4201	98.6	3505.7	9285
98.6	3604.3	6620	98.6	3604.3	4237	98.6	3604.3	9285
98.6	3702.8	6677	98.6	3702.8	4273	98.6	3702.8	9285
98.6	3801.4	6734	98.6	3801.4	4310	98.6	3801.4	9285
98.6	3900.0	6791	98.6	3900.0	4346	98.6	3900.0	9285
98.6	3998.6	6848	98.6	3998.6	4383	98.6	3998.6	9285
98.6	4097.2	6905	98.6	4097.2	4419	98.6	4097.2	9285

98.6	4195.7	6962	98.6	4195.7	4455	98.6	4195.7	9285
98.6	4294.3	7019	98.6	4294.3	4492	98.6	4294.3	9285
98.6	4392.9	7075	98.6	4392.9	4528	98.6	4392.9	9285
98.6	4491.5	7132	98.6	4491.5	4565	98.6	4491.5	9285
98.6	4590.1	7189	98.6	4590.1	4601	98.6	4590.1	9285
98.6	4688.7	7246	98.6	4688.7	4637	98.6	4688.7	9285
98.6	4787.2	7303	98.6	4787.2	4674	98.6	4787.2	9285
98.6	4885.8	7360	98.6	4885.8	4710	98.6	4885.8	9285
192.8	5078.7	7417	192.8	5078.7	4747	192.8	5078.7	9285
3280.8	8359.5	9285	3280.8	8359.5	9285	3280.8	8359.5	9285

2.3.2.1 Shear Modulus and Damping Curves

Results of recent laboratory testing for nonlinear dynamic material properties were not available for the soils or firm rock materials for the St. Lucie NPS. To reflect epistemic uncertainty in nonlinear dynamic material properties, over the top 500 ft (152 m) a realistic range in soil nonlinearity was accommodated with two sets of modulus reduction and hysteretic damping curves. Consistent with the SPID (EPRI, 2013a), the EPRI soil curves (model M1) were considered to be appropriate to represent the upper range nonlinearity likely in the materials at the site and Peninsular Range (PR) curves (model M2) was assumed to represent an equally plausible less nonlinear alternative response across loading level. For the linear analyses, the low strain damping from the EPRI soil curves were used as the constant damping values in the upper 500 ft (152 m) of the profile.

2.3.2.2 Kappa

Base-case kappa estimates were determined using Section B-5.1.3.1 of the SPID (EPRI, 2013a) for a 740 ft (226 m) of soil over firm CEUS rock site. Kappa for a deep soil over firm rock site may be estimated from the contributions of the soil and firm rock in the top 500 ft (152 m), plus the contribution of the deeper firm rock assuming Qs equal to 40 and the contribution of the reference rock profile of 0.006s. The corresponding kappa estimates were 0.033s, 0.040s (maximum), and 0.017s for profiles P1, P2, and P3 respectively. The range of kappa from 0.017s to 0.040s reflects a reasonable assessment of epistemic uncertainty. The suite of kappa estimates and associated weights are listed in Table 2.3.2-2.

Table 2.3.2-2
Kappa Values and Weights Used for Site Response Analyses

Velocity Profile	Kappa(s)
P1	0.033
P2	0.040
P3	0.017
	Weights
P1	0.4
P2	0.3
P3	0.3
G/G_{max} and Hysteretic Damping Curves	
M1	0.5
M2	0.5

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 shear-wave velocity profiles has been incorporated in the site response calculations. For the St. Lucie NPS site, 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 (EPRI, 2013a), 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 (Toro, 1997) 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 ft and 0.15 below that depth. As specified in the SPID (EPRI, 2013a), 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 for the limits on random velocity fluctuations.

2.3.4 Input Spectra

Consistent with the guidance in Appendix B of the SPID (EPRI, 2013a), input Fourier amplitude spectra were defined for a single representative earthquake magnitude (**M** 6.5) using two different assumptions 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 0.01 to 1.5 g) were used in the site response analyses. The characteristics of the seismic source and upper crustal attenuation properties assumed for the analysis of the St. Lucie NPS site were the same as those identified in Tables B-4, B-5, B-6 and B-7 of the SPID (EPRI, 2013a) as appropriate for typical CEUS sites.

2.3.5 Methodology

To perform the site response analyses for the St. Lucie site, 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 (EPRI, 2013a). The guidance contained in Appendix B of the SPID (EPRI, 2013a) 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 the St. Lucie NPS site.

2.3.6 Amplification Functions

The results of the site response analysis consist of amplification factors (5% 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 oscillator frequency and input rock amplitude. Consistent with the SPID a minimum median amplification value of 0.5 was employed in the present analysis. Figure 2.3.5-1 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 EPRI soil G/G_{max} and hysteretic damping curves (EPRI, 2013a). 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 more linear response at the St. Lucie NPS site, Figure 2.3.5-2 shows the corresponding amplification factors developed with PR curves for soil (model M2). Between the linear and nonlinear (equivalent-linear) analyses, Figures 2.3.5-1 and Figure 2.3.5-2 respectively show only minor difference for 0.4g loading level and below. Above about the 0.4g loading level, the differences increase but only above about 1 Hz.

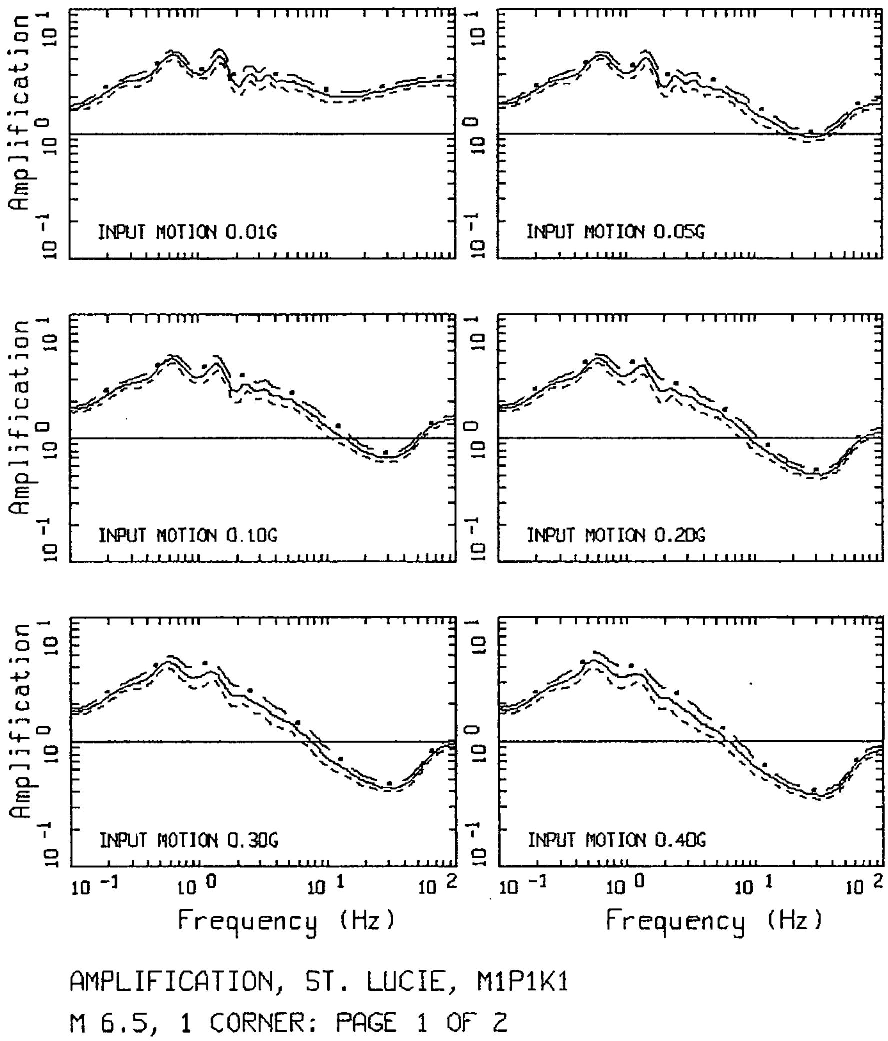
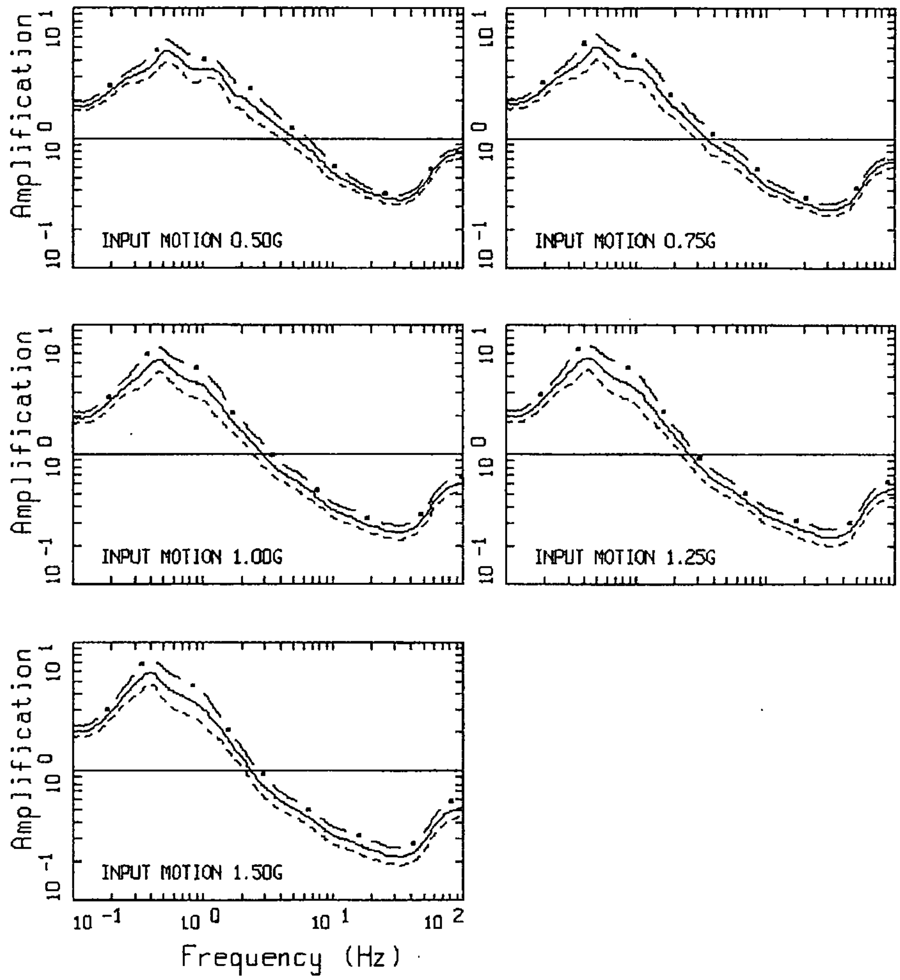


Figure 2.3.5-1. Example suite of amplification factors (5% damping pseudo absolute acceleration spectra) developed for the mean base-case profile (P1), EPRI soil and rock modulus reduction and hysteretic damping curves (model M1), and base-case kappa at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g. **M** 6.5 and single-corner source model (EPRI, 2013a).



AMPLIFICATION, ST. LUCIE, M1P1K1
M 6.5, 1 CORNER: PAGE 2 OF 2

Figure 2.3.5-1.(cont.)

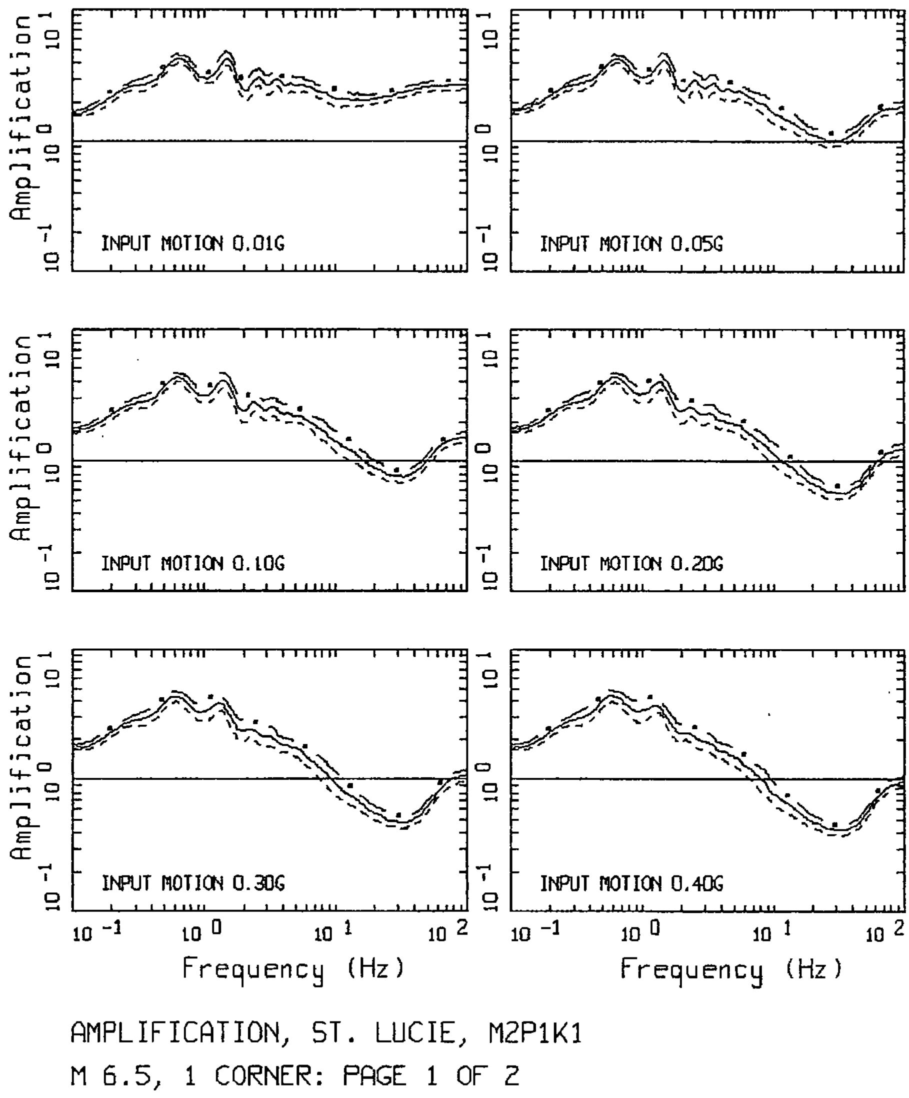
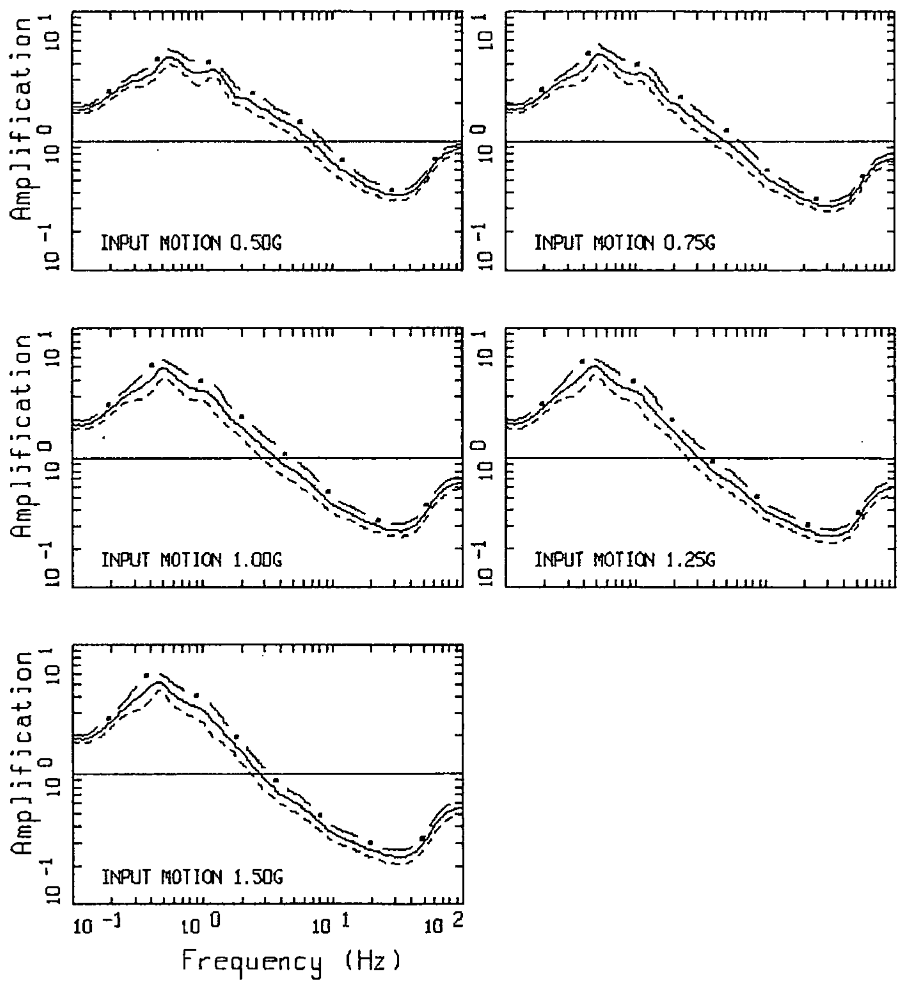


Figure 2.3.5-2. Example suite of amplification factors (5% damping pseudo absolute acceleration spectra) developed for the mean base-case profile (P1), Peninsular Range curves for soil and linear site response for firm rock (model M2), and base-case kappa at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g. **M** 6.5 and single-corner source model (EPRI, 2013a).



AMPLIFICATION, ST. LUCIE, M2P1K1
M 6.5, 1 CORNER: PAGE 2 OF 2

Figure 2.3.5-2.(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 (EPRI, 2013a). 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 St. Lucie 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.

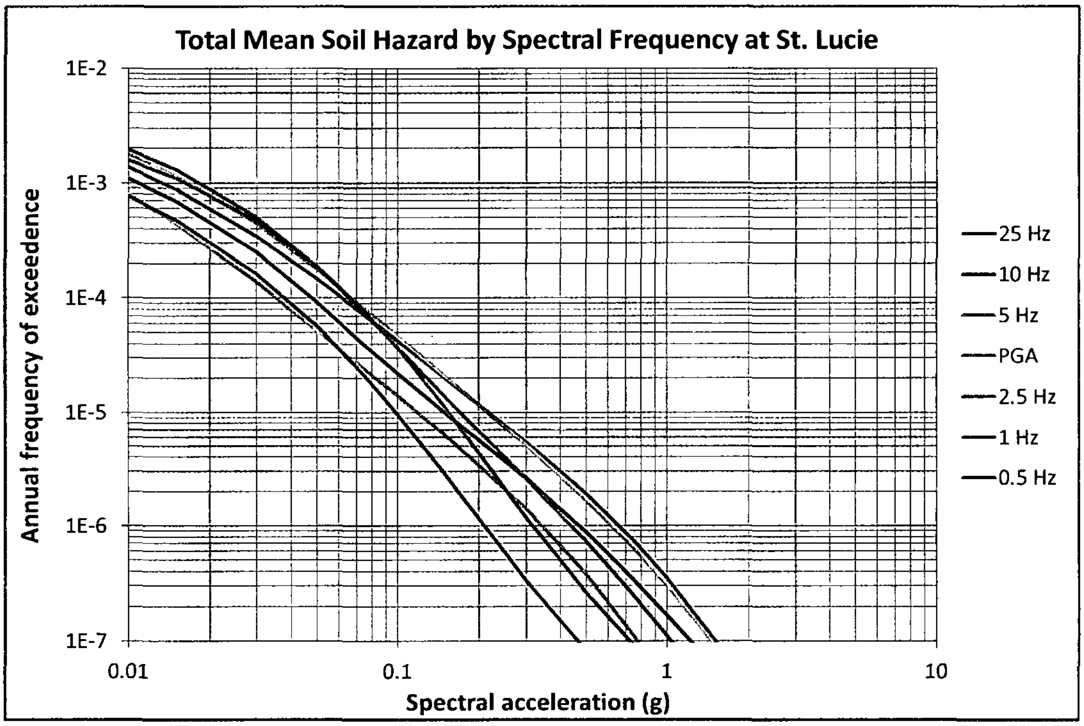


Figure 2.3.7-1. Control point mean hazard curves for spectral frequencies of 0.5, 1, 2.5, 5, 10, 25 and 100 Hz at St. Lucie.

2.4 Ground Motion Response Spectrum

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. Table 2.4-1 shows the UHRS and GMRS accelerations for a range of frequencies.

Table 2.4-1. UHRS and GMRS for St. Lucie.

Freq. (Hz)	10^{-4} UHRS (g)	10^{-5} UHRS (g)	GMRS (g)
100	3.56E-02	1.19E-01	5.60E-02
90	3.61E-02	1.19E-01	5.61E-02
80	3.68E-02	1.18E-01	5.63E-02
70	3.76E-02	1.19E-01	5.66E-02
60	3.86E-02	1.19E-01	5.72E-02
50	3.99E-02	1.22E-01	5.84E-02
40	4.18E-02	1.27E-01	6.11E-02
35	4.32E-02	1.32E-01	6.34E-02
30	4.51E-02	1.39E-01	6.64E-02
25	4.80E-02	1.50E-01	7.16E-02
20	4.92E-02	1.64E-01	7.72E-02
15	5.33E-02	1.85E-01	8.66E-02
12.5	5.70E-02	2.00E-01	9.34E-02
10	6.25E-02	2.17E-01	1.02E-01
9	6.44E-02	2.20E-01	1.03E-01
8	6.62E-02	2.23E-01	1.05E-01
7	6.80E-02	2.25E-01	1.06E-01
6	6.89E-02	2.20E-01	1.05E-01
5	6.79E-02	2.16E-01	1.03E-01
4	7.14E-02	2.07E-01	1.00E-01
3.5	6.98E-02	1.95E-01	9.52E-02
3	6.20E-02	1.68E-01	8.25E-02
2.5	6.61E-02	1.71E-01	8.48E-02
2	5.83E-02	1.55E-01	7.64E-02
1.5	7.09E-02	1.73E-01	8.67E-02
1.25	6.09E-02	1.59E-01	7.87E-02
1	6.69E-02	1.55E-01	7.87E-02
0.9	6.41E-02	1.55E-01	7.81E-02
0.8	5.81E-02	1.49E-01	7.42E-02
0.7	5.25E-02	1.37E-01	6.78E-02
0.6	4.57E-02	1.20E-01	5.93E-02
0.5	3.81E-02	9.87E-02	4.90E-02
0.4	3.05E-02	7.90E-02	3.92E-02
0.35	2.67E-02	6.91E-02	3.43E-02
0.3	2.28E-02	5.92E-02	2.94E-02
0.25	1.90E-02	4.94E-02	2.45E-02
0.2	1.52E-02	3.95E-02	1.96E-02
0.15	1.14E-02	2.96E-02	1.47E-02
0.125	9.52E-03	2.47E-02	1.22E-02
0.1	7.62E-03	1.97E-02	9.79E-03

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.

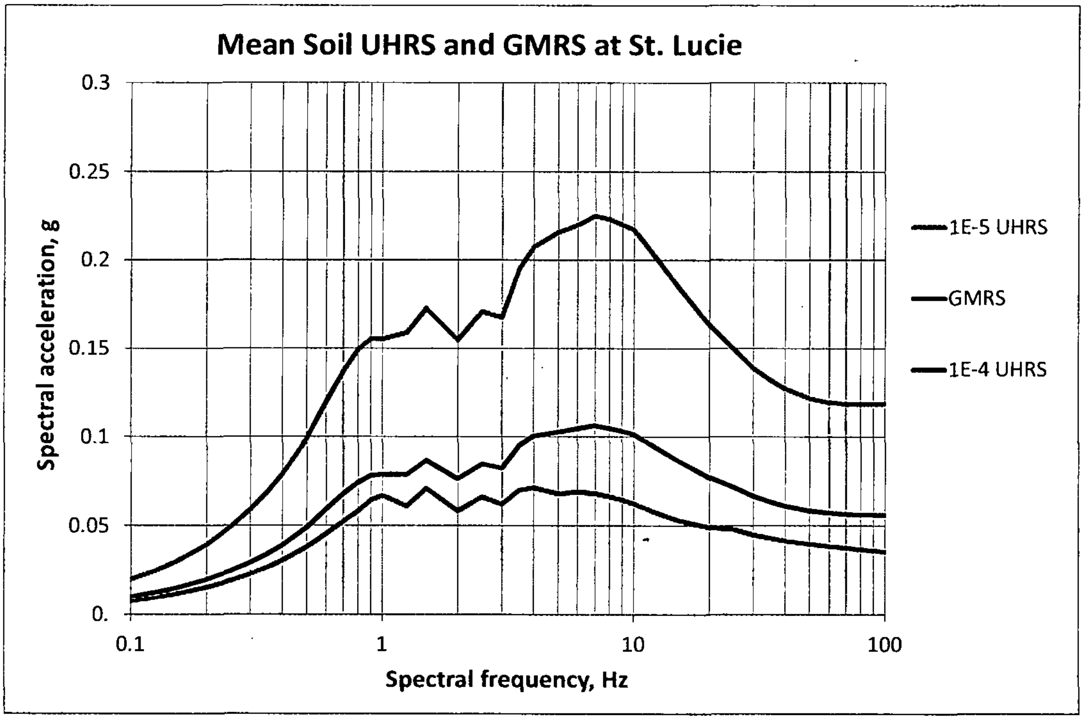


Figure 2.4-1. Plots of 1E-4 and 1E-5 uniform hazard spectra and GMRS at control point for St. Lucie (5%-damped response spectra).

3.0 Safe Shutdown Earthquake Ground Motion

The design basis for St. Lucie Nuclear Station is identified in the Updated Final Safely Evaluation Reports (UFSAR) Chapter 3, Figures 3.7-3 & 3.7-4. The curves were derived from Regulatory Guide 1.60 spectra normalized to 0.10g. The UFSAR commitment for an SSE of 0.10g was determined at a time when probabilistic definition of seismic input had not been developed with any degree of consistency or confidence. Therefore, the 0.10g Peak ground Acceleration (PGA) was conservatively estimated and set at the legal minimum specified by 10CFR 100 Appendix A. (FPL, 2012a)

3.1 SSE Description of Spectral Shape

In order to comply with the minimum accepted acceleration as stipulated by 10 CFR 100, Appendix A, the St. Lucie nuclear station is designed for a maximum horizontal ground surface acceleration of 0.10 g. This conservative surface design acceleration exceeds the maximum acceleration appropriate for the maximum earthquake which has occurred in the site's seismotectonic province during the past 200 years. The maximum vertical acceleration for the postulated SSE is the same as the peak horizontal acceleration. (FPL, 2012b)

The SSE is defined in terms of a PGA and a design response spectrum. Table 3.1-1 shows the spectral acceleration values as a function of frequency for the 5% damped horizontal SSE.

Table 3.1-1. SSE for St. Lucie (FPL, 2012a)

Freq. (Hz)	2.5	5	9	15	20	25	33
SA (g)	0.31	0.28	0.26	0.19	0.15	0.13	0.10

3.2 Control Point Elevation

The SSE control point elevation is defined at the top of the ground surface at elevation of 18.5 ft (EPRI, 2014).

3.3 IPEEE Description and Capacity Response Spectrum

St. Lucie 1 & 2 were classified as a reduced-scope in NUREG 1407 and were only required to conduct a walkdown to ensure compliance with the design basis. St. Lucie, Unit 1 was evaluated as a USI A-46 plant. As a reduced-scope plant, completion of the A-46 requirements satisfied the other requirements for the Individual Plant Examination of External Events (IPEEE) program for St. Lucie, Unit 1. Significant anchorage improvements were made to Unit 1. A reduced scope IPEEE walkdown inspection was conducted for St. Lucie, Unit 2. As an outcome of the walkdown inspections both units of St. Lucie were subjected to maintenance actions and implementation of a strict seismic housekeeping policy.

4.0 Screening Evaluation

In accordance with SPID Section 3 (EPRI, 2013a), a screening evaluation was performed as described below.

4.1 Risk Evaluation Screening (1 to 10 Hz)

In the 1 to 10 Hz part of the response spectrum, the SSE exceeds the GMRS. Therefore, a risk evaluation will not be performed.

4.2 High Frequency Screening (> 10 Hz)

Above 10 Hz, the SSE exceeds the GMRS. Therefore, the high frequency confirmation will not be performed.

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

In the 1 to 10 Hz part of the response spectrum, the SSE exceeds the GMRS. Therefore, a spent fuel pool evaluation will not be performed.

4.4 Screening Evaluation Outcome

Based on the comparison of the SSE and GMRS, as described above, a risk evaluation is not required for St. Lucie Station Units 1 & 2.

The GMRS is also less than the SSE above 10 Hz so the "High Frequency Confirmation" is not required.

A seismic assessment of the spent fuel pool seismic integrity is also not required.

In conclusion, St. Lucie is screened out based on comparison of the SSE and GMRS, and elects not to perform a seismic risk evaluation in response to NTTF 2.1.

5.0 Interim Actions

Based on the screening evaluation described above, there are no Interim Actions required to be performed at St. Lucie Nuclear Station.

6.0 Conclusions

In accordance with the 50.54(f) request for information, a seismic hazard and screening evaluation was performed for St. Lucie Nuclear Power Station. A GMRS was developed solely for purpose of screening for additional evaluations in accordance with the SPID.

Based on the results of the screening evaluation, no further evaluations will be performed.

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Appendix A (EPRI, 2014)

Table A-1a. Mean and Fractile Seismic Hazard Curves for PGA at St. Lucie

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	6.47E-03	3.01E-03	4.19E-03	6.26E-03	8.72E-03	1.07E-02
0.001	4.69E-03	1.87E-03	2.80E-03	4.50E-03	6.54E-03	8.23E-03
0.005	1.69E-03	3.23E-04	6.83E-04	1.51E-03	2.64E-03	3.68E-03
0.01	7.89E-04	1.20E-04	2.53E-04	6.17E-04	1.27E-03	2.10E-03
0.015	4.46E-04	6.26E-05	1.31E-04	3.23E-04	6.83E-04	1.32E-03
0.03	1.38E-04	1.67E-05	3.42E-05	9.24E-05	2.07E-04	4.13E-04
0.05	5.21E-05	4.77E-06	1.13E-05	3.37E-05	8.35E-05	1.57E-04
0.075	2.40E-05	1.40E-06	4.50E-06	1.46E-05	4.01E-05	7.66E-05
0.1	1.40E-05	5.58E-07	2.35E-06	8.12E-06	2.35E-05	4.56E-05
0.15	6.36E-06	1.29E-07	8.98E-07	3.47E-06	1.08E-05	2.16E-05
0.3	1.43E-06	7.13E-09	1.36E-07	6.83E-07	2.46E-06	5.27E-06
0.5	3.82E-07	7.13E-10	2.88E-08	1.67E-07	6.54E-07	1.49E-06
0.75	1.12E-07	1.10E-10	6.54E-09	4.37E-08	1.87E-07	4.50E-07
1.	4.32E-08	3.37E-11	1.87E-09	1.53E-08	7.23E-08	1.79E-07
1.5	1.03E-08	3.01E-11	2.72E-10	2.96E-09	1.67E-08	4.43E-08
3.	7.75E-10	3.01E-11	3.68E-11	1.46E-10	1.07E-09	3.68E-09
5.	9.49E-11	2.01E-11	3.01E-11	6.09E-11	1.34E-10	5.05E-10
7.5	1.50E-11	2.01E-11	3.01E-11	5.05E-11	6.09E-11	1.13E-10
10.	3.64E-12	2.01E-11	3.01E-11	5.05E-11	6.09E-11	6.09E-11

Table A-1b. Mean and Fractile Seismic Hazard Curves for 25 Hz at St. Lucie

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	6.86E-03	3.52E-03	4.70E-03	6.64E-03	8.98E-03	1.11E-02
0.001	5.08E-03	2.25E-03	3.19E-03	4.83E-03	6.93E-03	8.72E-03
0.005	2.02E-03	4.83E-04	8.98E-04	1.84E-03	3.09E-03	4.25E-03
0.01	1.10E-03	1.95E-04	3.90E-04	8.85E-04	1.77E-03	2.76E-03
0.015	6.95E-04	1.10E-04	2.22E-04	5.27E-04	1.10E-03	1.95E-03
0.03	2.51E-04	3.42E-05	6.83E-05	1.77E-04	3.79E-04	7.34E-04
0.05	9.24E-05	9.93E-06	2.19E-05	6.17E-05	1.49E-04	2.64E-04
0.075	3.93E-05	2.80E-06	7.66E-06	2.53E-05	6.83E-05	1.18E-04
0.1	2.19E-05	1.11E-06	3.84E-06	1.34E-05	3.84E-05	6.83E-05
0.15	9.96E-06	3.33E-07	1.64E-06	5.91E-06	1.77E-05	3.33E-05
0.3	2.62E-06	3.23E-08	4.19E-07	1.60E-06	4.56E-06	8.72E-06
0.5	8.89E-07	5.66E-09	1.42E-07	5.58E-07	1.57E-06	2.84E-06
0.75	3.43E-07	1.23E-09	5.50E-08	2.22E-07	6.26E-07	1.08E-06
1.	1.68E-07	4.07E-10	2.46E-08	1.07E-07	3.05E-07	5.35E-07
1.5	5.95E-08	8.12E-11	6.83E-09	3.47E-08	1.08E-07	2.04E-07
3.	8.80E-09	3.01E-11	5.50E-10	4.13E-09	1.60E-08	3.37E-08
5.	1.75E-09	3.01E-11	8.85E-11	6.73E-10	3.09E-09	7.34E-09
7.5	4.17E-10	3.01E-11	4.43E-11	1.55E-10	7.34E-10	1.90E-09
10.	1.38E-10	2.01E-11	3.01E-11	7.13E-11	2.57E-10	6.64E-10

Table A-1c. Mean and Fractile Seismic Hazard Curves for 10 Hz at St. Lucie

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	7.76E-03	4.37E-03	5.58E-03	7.45E-03	9.93E-03	1.21E-02
0.001	5.98E-03	2.96E-03	3.95E-03	5.75E-03	8.00E-03	9.79E-03
0.005	2.47E-03	7.66E-04	1.27E-03	2.29E-03	3.68E-03	4.77E-03
0.01	1.38E-03	3.23E-04	5.83E-04	1.20E-03	2.16E-03	3.05E-03
0.015	8.84E-04	1.77E-04	3.28E-04	7.23E-04	1.40E-03	2.16E-03
0.03	3.43E-04	5.58E-05	1.07E-04	2.60E-04	5.42E-04	9.24E-04
0.05	1.49E-04	2.13E-05	4.19E-05	1.10E-04	2.35E-04	4.01E-04
0.075	7.21E-05	8.60E-06	1.84E-05	5.20E-05	1.20E-04	1.98E-04
0.1	4.24E-05	3.95E-06	9.65E-06	2.88E-05	7.34E-05	1.21E-04
0.15	2.00E-05	1.11E-06	3.57E-06	1.25E-05	3.57E-05	6.17E-05
0.3	5.48E-06	1.13E-07	6.09E-07	2.88E-06	1.02E-05	1.95E-05
0.5	1.94E-06	2.13E-08	1.92E-07	9.37E-07	3.47E-06	7.23E-06
0.75	7.53E-07	4.77E-09	7.23E-08	3.42E-07	1.31E-06	3.01E-06
1.	3.51E-07	1.51E-09	3.14E-08	1.51E-07	6.00E-07	1.44E-06
1.5	1.03E-07	2.35E-10	6.83E-09	4.19E-08	1.84E-07	4.13E-07
3.	1.06E-08	3.01E-11	2.68E-10	3.52E-09	1.95E-08	4.43E-08
5.	2.70E-09	3.01E-11	5.66E-11	3.47E-10	4.43E-09	1.32E-08
7.5	1.02E-09	2.01E-11	3.01E-11	7.66E-11	1.53E-09	5.35E-09
10.	5.10E-10	2.01E-11	3.01E-11	6.09E-11	7.23E-10	2.76E-09

Table A-1d. Mean and Fractile Seismic Hazard Curves for 5 Hz at St. Lucie

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	8.62E-03	5.20E-03	6.36E-03	8.35E-03	1.08E-02	1.31E-02
0.001	7.05E-03	3.68E-03	4.83E-03	6.83E-03	9.24E-03	1.13E-02
0.005	3.08E-03	1.08E-03	1.72E-03	2.92E-03	4.43E-03	5.58E-03
0.01	1.79E-03	4.83E-04	8.35E-04	1.64E-03	2.72E-03	3.63E-03
0.015	1.17E-03	2.64E-04	4.90E-04	1.02E-03	1.84E-03	2.57E-03
0.03	4.43E-04	8.00E-05	1.55E-04	3.52E-04	7.03E-04	1.11E-03
0.05	1.80E-04	2.96E-05	5.75E-05	1.40E-04	2.84E-04	4.77E-04
0.075	8.25E-05	1.23E-05	2.46E-05	6.26E-05	1.32E-04	2.16E-04
0.1	4.67E-05	6.36E-06	1.31E-05	3.52E-05	7.66E-05	1.23E-04
0.15	2.09E-05	2.19E-06	5.27E-06	1.53E-05	3.57E-05	5.83E-05
0.3	5.12E-06	2.32E-07	9.11E-07	3.23E-06	9.24E-06	1.60E-05
0.5	1.69E-06	2.88E-08	1.69E-07	8.85E-07	3.19E-06	6.00E-06
0.75	6.47E-07	4.56E-09	3.84E-08	2.84E-07	1.23E-06	2.49E-06
1.	3.05E-07	1.18E-09	1.49E-08	1.18E-07	5.58E-07	1.29E-06
1.5	9.27E-08	1.90E-10	3.84E-09	2.80E-08	1.60E-07	4.19E-07
3.	8.36E-09	3.01E-11	1.98E-10	1.90E-09	1.40E-08	3.84E-08
5.	1.21E-09	3.01E-11	5.05E-11	2.60E-10	1.92E-09	5.50E-09
7.5	2.86E-10	2.01E-11	3.01E-11	6.93E-11	4.37E-10	1.38E-09
10.	1.11E-10	2.01E-11	3.01E-11	6.09E-11	1.74E-10	5.75E-10

Table A-1e. Mean and Fractile Seismic Hazard Curves for 2.5 Hz at St. Lucie

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	8.81E-03	5.42E-03	6.54E-03	8.47E-03	1.10E-02	1.32E-02
0.001	7.31E-03	3.95E-03	5.05E-03	7.03E-03	9.51E-03	1.16E-02
0.005	3.28E-03	1.21E-03	1.87E-03	3.14E-03	4.70E-03	5.83E-03
0.01	1.97E-03	5.35E-04	9.51E-04	1.82E-03	2.96E-03	3.90E-03
0.015	1.32E-03	2.92E-04	5.50E-04	1.16E-03	2.07E-03	2.84E-03
0.03	5.01E-04	8.23E-05	1.64E-04	3.95E-04	8.35E-04	1.29E-03
0.05	1.89E-04	2.76E-05	5.50E-05	1.36E-04	3.09E-04	5.35E-04
0.075	7.52E-05	1.04E-05	2.07E-05	5.35E-05	1.20E-04	2.19E-04
0.1	3.73E-05	4.90E-06	1.01E-05	2.68E-05	6.00E-05	1.08E-04
0.15	1.37E-05	1.57E-06	3.47E-06	9.65E-06	2.29E-05	3.95E-05
0.3	2.60E-06	1.62E-07	5.12E-07	1.72E-06	4.56E-06	8.00E-06
0.5	7.36E-07	1.98E-08	9.79E-08	4.07E-07	1.32E-06	2.53E-06
0.75	2.50E-07	2.68E-09	1.82E-08	1.10E-07	4.56E-07	9.51E-07
1.	1.11E-07	4.98E-10	4.19E-09	4.01E-08	2.01E-07	4.50E-07
1.5	3.26E-08	5.20E-11	4.01E-10	8.23E-09	5.75E-08	1.42E-07
3.	3.22E-09	3.01E-11	5.05E-11	3.84E-10	4.63E-09	1.55E-08
5.	5.06E-10	2.01E-11	3.01E-11	6.09E-11	5.66E-10	2.39E-09
7.5	1.09E-10	2.01E-11	3.01E-11	6.09E-11	1.16E-10	5.12E-10
10.	3.55E-11	2.01E-11	3.01E-11	5.42E-11	6.09E-11	1.74E-10

Table A-1f. Mean and Fractile Seismic Hazard Curves for 1 Hz at St. Lucie

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	7.64E-03	4.01E-03	5.27E-03	7.45E-03	9.93E-03	1.20E-02
0.001	5.96E-03	2.72E-03	3.79E-03	5.75E-03	8.12E-03	9.93E-03
0.005	2.57E-03	6.83E-04	1.25E-03	2.42E-03	3.90E-03	4.98E-03
0.01	1.59E-03	2.49E-04	5.42E-04	1.40E-03	2.60E-03	3.57E-03
0.015	1.10E-03	1.21E-04	2.84E-04	9.11E-04	1.92E-03	2.76E-03
0.03	4.66E-04	2.84E-05	7.23E-05	3.05E-04	8.72E-04	1.46E-03
0.05	1.90E-04	8.35E-06	2.22E-05	9.79E-05	3.52E-04	6.83E-04
0.075	7.76E-05	2.92E-06	7.77E-06	3.47E-05	1.40E-04	2.96E-04
0.1	3.68E-05	1.32E-06	3.52E-06	1.53E-05	6.26E-05	1.44E-04
0.15	1.12E-05	4.13E-07	1.11E-06	4.56E-06	1.82E-05	4.37E-05
0.3	1.19E-06	4.56E-08	1.36E-07	5.50E-07	1.98E-06	4.50E-06
0.5	2.63E-07	7.13E-09	2.68E-08	1.20E-07	4.37E-07	1.01E-06
0.75	9.30E-08	1.36E-09	6.83E-09	3.68E-08	1.51E-07	3.79E-07
1.	4.64E-08	3.73E-10	2.49E-09	1.60E-08	7.34E-08	1.95E-07
1.5	1.75E-08	7.03E-11	5.66E-10	4.63E-09	2.64E-08	7.66E-08
3.	3.05E-09	3.01E-11	6.09E-11	4.50E-10	4.01E-09	1.40E-08
5.	7.33E-10	2.57E-11	3.01E-11	8.98E-11	8.12E-10	3.33E-09
7.5	2.11E-10	2.01E-11	3.01E-11	6.09E-11	2.10E-10	9.24E-10
10.	8.15E-11	2.01E-11	3.01E-11	6.09E-11	9.37E-11	3.63E-10

Table A-1g. Mean and Fractile Seismic Hazard Curves for 0.5 Hz at St. Lucie

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.72E-03	2.04E-03	2.92E-03	4.56E-03	6.45E-03	8.00E-03
0.001	3.41E-03	1.20E-03	1.92E-03	3.28E-03	4.90E-03	6.09E-03
0.005	1.40E-03	1.49E-04	3.84E-04	1.21E-03	2.42E-03	3.33E-03
0.01	7.69E-04	3.84E-05	1.15E-04	5.50E-04	1.44E-03	2.25E-03
0.015	4.79E-04	1.51E-05	4.83E-05	2.84E-04	9.37E-04	1.62E-03
0.03	1.63E-04	2.53E-06	8.85E-06	6.09E-05	3.14E-04	6.54E-04
0.05	5.73E-05	5.83E-07	2.10E-06	1.53E-05	9.79E-05	2.53E-04
0.075	2.12E-05	1.74E-07	6.26E-07	4.63E-06	3.19E-05	9.65E-05
0.1	9.65E-06	7.03E-08	2.60E-07	1.87E-06	1.34E-05	4.37E-05
0.15	2.88E-06	1.92E-08	7.55E-08	5.27E-07	3.63E-06	1.23E-05
0.3	3.34E-07	1.79E-09	9.11E-09	6.64E-08	4.31E-07	1.44E-06
0.5	8.36E-08	2.53E-10	1.82E-09	1.57E-08	1.08E-07	3.79E-07
0.75	3.31E-08	6.83E-11	4.77E-10	5.20E-09	4.07E-08	1.53E-07
1.	1.79E-08	4.37E-11	1.90E-10	2.32E-09	2.01E-08	8.35E-08
1.5	7.45E-09	3.01E-11	6.73E-11	7.23E-10	7.45E-09	3.47E-08
3.	1.47E-09	3.01E-11	3.23E-11	1.02E-10	1.10E-09	6.36E-09
5.	3.83E-10	2.01E-11	3.01E-11	6.09E-11	2.35E-10	1.46E-09
7.5	1.19E-10	2.01E-11	3.01E-11	6.09E-11	8.23E-11	4.25E-10
10.	4.86E-11	2.01E-11	3.01E-11	5.05E-11	6.09E-11	1.77E-10

Table A-2. Amplification Functions for St. Lucie

PGA	Median AF	Sigma ln(AF)	25 Hz	Median AF	Sigma ln(AF)	10 Hz	Median AF	Sigma ln(AF)
1.00E-02	2.45E+00	9.00E-02	1.30E-02	1.98E+00	9.29E-02	1.90E-02	2.01E+00	1.31E-01
4.95E-02	1.65E+00	1.00E-01	1.02E-01	9.77E-01	1.28E-01	9.99E-02	1.56E+00	1.60E-01
9.64E-02	1.37E+00	1.01E-01	2.13E-01	7.68E-01	1.39E-01	1.85E-01	1.37E+00	1.65E-01
1.94E-01	1.11E+00	1.08E-01	4.43E-01	5.93E-01	1.47E-01	3.56E-01	1.13E+00	1.78E-01
2.92E-01	9.65E-01	1.09E-01	6.76E-01	5.00E-01	1.52E-01	5.23E-01	9.81E-01	1.91E-01
3.91E-01	8.66E-01	1.12E-01	9.09E-01	5.00E-01	1.56E-01	6.90E-01	8.72E-01	2.01E-01
4.93E-01	7.93E-01	1.17E-01	1.15E+00	5.00E-01	1.61E-01	8.61E-01	7.85E-01	2.15E-01
7.41E-01	6.71E-01	1.22E-01	1.73E+00	5.00E-01	1.63E-01	1.27E+00	6.32E-01	2.39E-01
1.01E+00	5.91E-01	1.32E-01	2.36E+00	5.00E-01	1.67E-01	1.72E+00	5.26E-01	2.58E-01
1.28E+00	5.34E-01	1.42E-01	3.01E+00	5.00E-01	1.69E-01	2.17E+00	5.00E-01	2.66E-01
1.55E+00	5.00E-01	1.50E-01	3.63E+00	5.00E-01	1.72E-01	2.61E+00	5.00E-01	2.74E-01
5 Hz	**Median AF**	**Sigma ln(AF)**	**2.5 Hz**	**Median AF**	**Sigma ln(AF)**	**1 Hz**	**Median AF**	**Sigma ln(AF)**
2.09E-02	2.49E+00	1.69E-01	2.18E-02	2.90E+00	1.50E-01	1.27E-02	3.83E+00	1.03E-01
8.24E-02	2.21E+00	1.83E-01	7.05E-02	2.70E+00	1.45E-01	3.43E-02	3.63E+00	1.23E-01
1.44E-01	2.03E+00	1.78E-01	1.18E-01	2.52E+00	1.46E-01	5.51E-02	3.52E+00	1.34E-01
2.65E-01	1.77E+00	1.74E-01	2.12E-01	2.25E+00	1.60E-01	9.63E-02	3.37E+00	1.43E-01
3.84E-01	1.59E+00	1.75E-01	3.04E-01	2.05E+00	1.72E-01	1.36E-01	3.30E+00	1.64E-01
5.02E-01	1.45E+00	1.81E-01	3.94E-01	1.89E+00	1.84E-01	1.75E-01	3.25E+00	1.74E-01
6.22E-01	1.34E+00	1.92E-01	4.86E-01	1.76E+00	1.92E-01	2.14E-01	3.19E+00	1.76E-01
9.13E-01	1.12E+00	2.12E-01	7.09E-01	1.51E+00	1.99E-01	3.10E-01	3.12E+00	1.84E-01
1.22E+00	9.55E-01	2.40E-01	9.47E-01	1.34E+00	2.19E-01	4.12E-01	3.06E+00	1.91E-01
1.54E+00	8.31E-01	2.65E-01	1.19E+00	1.23E+00	2.41E-01	5.18E-01	3.01E+00	1.98E-01
1.85E+00	7.49E-01	2.77E-01	1.43E+00	1.19E+00	2.48E-01	6.19E-01	2.96E+00	2.01E-01
0.5 Hz	**Median AF**	**Sigma ln(AF)**						
8.25E-03	3.20E+00	9.36E-02						
1.96E-02	3.20E+00	9.94E-02						
3.02E-02	3.21E+00	1.12E-01						
5.11E-02	3.27E+00	1.44E-01						
7.10E-02	3.35E+00	1.69E-01						
9.06E-02	3.43E+00	1.74E-01						
1.10E-01	3.48E+00	1.81E-01						
1.58E-01	3.57E+00	1.86E-01						
2.09E-01	3.59E+00	1.84E-01						
2.62E-01	3.56E+00	1.92E-01						
3.12E-01	3.52E+00	1.99E-01						

Table A2-b1. Median AFs and sigmas for Model 1, Profile 1, for 2 PGA levels.

M1P1K1	Rock PGA=0.01			M1P1K1	PGA=0.0964		
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
100.0	0.026	2.635	0.076	100.0	0.137	1.419	0.077
87.1	0.026	2.630	0.076	87.1	0.137	1.392	0.077
75.9	0.027	2.622	0.076	75.9	0.137	1.345	0.077
66.1	0.027	2.609	0.076	66.1	0.137	1.259	0.077
57.5	0.027	2.584	0.076	57.5	0.138	1.110	0.077
50.1	0.027	2.538	0.077	50.1	0.138	0.945	0.077
43.7	0.027	2.474	0.077	43.7	0.139	0.810	0.078
38.0	0.027	2.396	0.077	38.0	0.140	0.736	0.079
33.1	0.027	2.305	0.078	33.1	0.143	0.696	0.082
28.8	0.027	2.232	0.079	28.8	0.146	0.701	0.086
25.1	0.028	2.147	0.080	25.1	0.150	0.705	0.088
21.9	0.029	2.094	0.080	21.9	0.156	0.755	0.095
19.1	0.029	2.013	0.080	19.1	0.164	0.793	0.099
16.6	0.031	1.991	0.080	16.6	0.174	0.867	0.107
14.5	0.032	1.991	0.091	14.5	0.188	0.968	0.125
12.6	0.034	1.990	0.097	12.6	0.201	1.054	0.148
11.0	0.037	2.004	0.120	11.0	0.216	1.149	0.158
9.5	0.039	2.064	0.122	9.5	0.232	1.280	0.152
8.3	0.043	2.214	0.122	8.3	0.248	1.467	0.150
7.2	0.045	2.306	0.105	7.2	0.258	1.615	0.131
6.3	0.049	2.476	0.107	6.3	0.271	1.792	0.107
5.5	0.053	2.613	0.138	5.5	0.291	2.002	0.132
4.8	0.056	2.626	0.146	4.8	0.296	2.068	0.145
4.2	0.057	2.600	0.142	4.2	0.307	2.195	0.144
3.6	0.066	2.934	0.132	3.6	0.314	2.294	0.160
3.2	0.060	2.708	0.174	3.2	0.321	2.475	0.153
2.8	0.064	2.870	0.152	2.8	0.301	2.435	0.153
2.4	0.062	2.871	0.187	2.4	0.313	2.733	0.135
2.1	0.049	2.406	0.166	2.1	0.261	2.491	0.223
1.8	0.054	2.857	0.148	1.8	0.240	2.558	0.177
1.6	0.068	4.016	0.123	1.6	0.280	3.428	0.147
1.4	0.061	3.999	0.138	1.4	0.281	3.971	0.133
1.2	0.045	3.265	0.136	1.2	0.220	3.520	0.172
1.0	0.039	3.034	0.098	1.0	0.179	3.163	0.135
0.91	0.039	3.149	0.095	0.91	0.164	3.155	0.110
0.79	0.042	3.684	0.108	0.79	0.169	3.563	0.110
0.69	0.045	4.227	0.060	0.69	0.175	4.129	0.084
0.60	0.041	4.214	0.084	0.60	0.159	4.266	0.078
0.52	0.032	3.755	0.086	0.52	0.125	3.931	0.088
0.46	0.024	3.183	0.081	0.46	0.090	3.367	0.079
0.10	0.001	1.621	.045	0.10	0.002	1.740	0.044

Table A2-b2. Median AFs and sigmas for Model 2, Profile 1, for 2 PGA levels.

M2P1K1	PGA=0.01			M2P1K1	PGA=0.0964		
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
100.0	0.027	2.694	0.081	100.0	0.147	1.521	0.096
87.1	0.027	2.689	0.081	87.1	0.147	1.492	0.096
75.9	0.027	2.681	0.081	75.9	0.147	1.443	0.096
66.1	0.027	2.668	0.081	66.1	0.147	1.351	0.096
57.5	0.027	2.643	0.081	57.5	0.148	1.193	0.097
50.1	0.027	2.597	0.081	50.1	0.149	1.018	0.098
43.7	0.027	2.532	0.082	43.7	0.150	0.876	0.100
38.0	0.028	2.455	0.083	38.0	0.153	0.801	0.103
33.1	0.028	2.365	0.084	33.1	0.157	0.764	0.108
28.8	0.028	2.294	0.085	28.8	0.162	0.776	0.114
25.1	0.029	2.209	0.087	25.1	0.167	0.785	0.118
21.9	0.029	2.160	0.088	21.9	0.175	0.851	0.129
19.1	0.031	2.082	0.088	19.1	0.187	0.906	0.128
16.6	0.032	2.068	0.091	16.6	0.202	1.004	0.139
14.5	0.034	2.074	0.104	14.5	0.217	1.117	0.161
12.6	0.036	2.075	0.109	12.6	0.233	1.220	0.180
11.0	0.038	2.093	0.138	11.0	0.250	1.326	0.188
9.5	0.041	2.163	0.146	9.5	0.264	1.456	0.175
8.3	0.045	2.315	0.130	8.3	0.283	1.673	0.176
7.2	0.047	2.406	0.112	7.2	0.291	1.821	0.159
6.3	0.051	2.578	0.113	6.3	0.302	1.995	0.124
5.5	0.055	2.696	0.137	5.5	0.319	2.195	0.120
4.8	0.057	2.701	0.144	4.8	0.319	2.228	0.150
4.2	0.058	2.652	0.149	4.2	0.322	2.302	0.153
3.6	0.068	3.009	0.142	3.6	0.334	2.440	0.167
3.2	0.061	2.726	0.179	3.2	0.327	2.521	0.174
2.8	0.065	2.917	0.163	2.8	0.309	2.498	0.165
2.4	0.062	2.885	0.184	2.4	0.317	2.765	0.154
2.1	0.049	2.427	0.162	2.1	0.258	2.465	0.215
1.8	0.055	2.915	0.144	1.8	0.248	2.640	0.168
1.6	0.070	4.112	0.118	1.6	0.297	3.635	0.135
1.4	0.061	4.040	0.141	1.4	0.289	4.088	0.137
1.2	0.045	3.269	0.133	1.2	0.220	3.517	0.172
1.0	0.039	3.040	0.098	1.0	0.180	3.171	0.134
0.91	0.039	3.161	0.098	0.91	0.166	3.190	0.115
0.79	0.043	3.704	0.108	0.79	0.172	3.633	0.113
0.69	0.045	4.241	0.059	0.69	0.177	4.166	0.079
0.60	0.041	4.219	0.086	0.60	0.158	4.244	0.084
0.52	0.032	3.752	0.086	0.52	0.123	3.867	0.087
0.46	0.024	3.178	0.081	0.46	0.089	3.305	0.082
0.10	0.001	1.622	0.045	0.10	0.002	1.736	0.041