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A SCANA COMPANY

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RC-14-0048

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555-0001

Dear Sir/Madam:

Subject: VIRGIL C. SUMMER NUCLEAR STATION (VCSNS) UNIT 1
DOCKET NO. 50-395
OPERATING LICENSE NO. NPF-12
SOUTH CAROLINA ELECTRIC & GAS (SCE&G) SEISMIC HAZARD AND SCREENING REPORT (CEUS SITES), RESPONSE TO NRC REQUEST FOR INFORMATION PURSUANT TO 10 CFR 50.54(f) REGARDING RECOMMENDATION 2.1 OF THE NEAR-TERM TASK FORCE REVIEW OF INSIGHTS FROM THE FUKUSHIMA DAI-ICHI ACCIDENT

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 [ML12053A340]
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.

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,

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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.

South Carolina Electric & Gas, acting for itself and as an agent for South Carolina Public Service Authority, provides the attached Seismic Hazard Evaluation and Screening Report for Virgil C. Summer Nuclear Station (VCSNS) Unit 1. This attachment 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.

Should you have any questions concerning the content of this letter, please contact Bruce L. Thompson at (803) 931-5042.

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

3-26-14
Executed on

Thomas D. Gatlin

BD/TDG/ts

Attachment:
I. Seismic Hazard Evaluation and Screening Report for VCSNS

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VIRGIL C. SUMMER NUCLEAR STATION (VCSNS) UNIT 1

Attachment I

Seismic Hazard Evaluation and Screening Report for VCSNS

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. 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 Virgil C. Summer Nuclear Station Unit 1 (VCSNS), located in Fairfield County near Jenkinsville, South Carolina. In providing this information, South Carolina Electric & Gas (SCE&G) 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, 2012). The Augmented Approach, *Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic* (EPRI 3002000704, 2013), 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 original geologic and seismic siting investigations for VCSNS were performed in accordance with Appendix A to 10 CFR Part 100 and meet General Design Criterion 2 in Appendix A to 10 CFR Part 50. The Safe Shutdown Earthquake Ground Motion (SSE) was developed in accordance with Appendix A to 10 CFR Part 100 and used for the design of seismic Category I systems, structures and components.

In response to the 50.54(f) letter and following the guidance provided in the SPID (EPRI 1025287, 2012), 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, VCSNS screens in for a Risk Evaluation, Spent Fuel Pool Evaluation, and a High Frequency Confirmation.

2.0 Seismic Hazard Reevaluation

Virgil C. Summer Nuclear Station Unit 1 (VCSNS) is located in Fairfield County, S.C., adjacent to the Monticello Reservoir and approximately 3 miles northwest of the town of Jenkinsville, and 1 mile east of the Broad River. VCSNS is located in the Carolina Zone of the Central Piedmont province. The VCSNS site lies within the Charlotte Terrane, the westernmost terrane of the Carolina Zone. The Charlotte Terrane is dominated by Neoproterozoic to Early Paleozoic plutonic rocks that intrude a suite of mainly metaigneous rocks. The surface is characterized by elevated, gently rolling hills which are separated on the northwest from the intensely folded and faulted Appalachian Mountains by the intervening hills of the Blue Ridge Province and bordered on the southeast by the Atlantic Coastal Plain. The principle plant structures are founded on competent bedrock. Bedrock at the site consists primarily of metamorphic rocks of the Charlotte Belt with Paleozoic igneous intrusive zones.

Earthquake activity in historic times within 200 miles of the plant site has been moderate. Within 200 miles of the VCSNS site, there are four principle areas of concentrated seismicity. Three of these (the Middleton-Place Summerville, Bowman, and Adams Run seismic zones) are located near Charleston, South Carolina. The fourth area of concentrated seismicity in the site region is the Eastern Tennessee Seismic Zone. Sources of major earthquakes in the central and eastern United States (CEUS) are distant, and have not had an appreciable effect at the site. The original investigation of historical seismic activity in the region indicated that a design intensity of VII (Modified Mercalli Scale) is adequately conservative for the site. SCE&G determined that Intensity VII corresponds to a peak ground acceleration of 0.13g in rock and 0.20g in soil, which was conservatively increased to 0.15g and 0.25g respectively for the SSE.

2.1 Regional and Local Geology

VCSNS is located in the Carolina Zone of the Central Piedmont province. The VCSNS site lies within the Charlotte Terrane, the westernmost terrane of the Carolina Zone. The Charlotte Terrane is dominated by Neoproterozoic to Early Paleozoic plutonic rocks that intrude a suite of mainly metaigneous rocks. The Piedmont is a seaward-sloping plateau varying in width from about 10 miles in southeastern New York to almost 125 miles in South Carolina and is the least rugged of the Appalachian provinces. Elevation of the inland boundary ranges from about 200 feet MSL in New Jersey to over 1,800 feet MSL in South Carolina.

Within the VCSNS site region, the area of the Piedmont physiographic province is also divided on the basis of its geologic history and lithology into different lithotectonic associations. These two lithotectonic elements, the Piedmont Zone and the Carolina Zone, are separated by a series of faults collectively called the Central Piedmont shear zone. West of the Central Piedmont shear zone, the Piedmont Zone contains the Inner Piedmont block, the Smith River Allochthon in Virginia and North Carolina, and the Sauratown Mountains anticlinorium of north central North Carolina. The province is a composite stack of thrust sheets containing a variety of gneisses, schists, amphibolites, sparse ultramafic bodies, and intrusive granitoids. The protoliths are immature quartzo-feldspathic sandstone, pelitic sediments, and mafic lavas.

VCSNS is located adjacent to the Monticello Reservoir and approximately 3 miles northwest of the town of Jenkinsville, South Carolina, and 1 mile east of the Broad River. The site is generally covered by a deep mantle of residual soils derived by the in place weathering of the underlying rock. The soil profile is typically characterized by an upper silty and clayey horizon overlying saprolite, which grades with depth to decomposed rock and unweathered rock. Soil strengths typically increase with depth. Residual soils overlie the parent bedrock; the soils range in thickness from about 40-85 feet in borings drilled in site area. The soil grades from usually clayey and silty soils near the ground surface, to dense sandy silty and silty sand saprolites at depth. Bedrock at the site consists primarily of metamorphic rocks of the Charlotte Belt with Paleozoic igneous intrusive zones. The potential for tectonic deformation at the site is negligible. Detailed geologic mapping and inspection of excavations during construction of Unit 1 revealed no evidence of geologically recent or active faulting. There are no Quaternary faults or capable tectonic sources within 25 miles of the site. There is negligible potential for non-tectonic surface deformation within the site area. There is no information suggesting the potential for non-tectonic surface deformation within the site area. Rocks within the site area are igneous and metamorphic crystalline rocks that are neither susceptible to karst-type dissolution collapse nor to subsidence due to fluid withdrawal.

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). A site-specific review of the CEUS-SSC earthquake catalog was also performed as described below, and these results are incorporated into the PSHA for the VCSNS site. 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 source zones out to a distance of 200 miles (320 km) around the site were included. For the large magnitude sources (Repeated Large Magnitude Earthquake or RLME) modeled for the CEUS-SSC, the Charlevoix and Charleston sources, as they lie within 1,000 km of the site, were included in the PSHA. For each of the CEUS-SSC sources, the mid-continent version of the updated CEUS EPRI GMM was used.

Site-Specific CEUS-SSC Catalog Review

A site-specific review (EPRI, 2014) of the CEUS-SSC earthquake catalog published in the CEUS-SSC was performed with regard to two issues: (1) identification of additional reservoir induced seismicity (RIS) earthquakes in the southeastern US and (2) locations of earthquakes in South Carolina near the time of the 1886 Charleston, S.C. earthquake sequence.

In developing the CEUS-SSC catalog, earthquakes identified as RIS were removed from the final earthquake listing. The source for this identification in the southeastern US was the set of available Southeast US Seismic Network (SEUSSN) Bulletins. The master list contained 120 earthquakes. Sixteen of these were large enough to be in the CEUS-SSC catalog. These earthquakes occurred primarily near Monticello Reservoir and Lake Keowee. These earthquakes were removed from the final (Version 7) CEUS-SSC catalog published in NUREG-2115.

Additional reviews were performed of available published information to identify potential additional RIS earthquakes that are in the CEUS-SSC catalog. The basis for each of the potential RIS records was reviewed, taking into consideration the magnitude of the earthquake and depth, proximity to a reservoir, timing of the earthquake versus the filling of the reservoir, and proximity to a nuclear plant.

Thirty additional RIS or potentially RIS earthquakes were identified in the CEUS-SSC catalog. Of these, thirteen were large enough ($E[M] \geq 2.9$) to potentially affect recurrence calculations. Some of these were identified as dependent events of other earthquakes in the catalog. After review, it was determined that all thirty RIS or potentially RIS earthquakes should be removed from the catalog. Table 2.2.1-1 lists the specific earthquake database records reviewed.

Seven additional earthquakes in the CEUS-SSC catalog from the time period 1799 to 1888 in South Carolina were also identified as being potentially mislocated (Table 2.2.1-2). The majority of these earthquakes have locations and times that come from the USGS earthquake catalog used for seismic hazard mapping. The primary source of the USGS catalog is the NCEER-91 catalog. The events in question have alternative locations in the SUSN catalog that place them at the location of the 1886 Charleston, S.C. main shock. A review was performed of the identification of these earthquakes and assignment of these locations in the development of the CEUS-SSC catalog in light of additional information in the paper by W.H. Bakun and M.G. Hopper (2004, "Magnitudes and Locations of the 1811-1812 New Madrid, Missouri, and the 1886 Charleston, South Carolina, Earthquakes," Bulletin of the Seismological Society of America, 94, 64-75) and recent information provided by Donald Stevenson and Dr. Pradeep Talwani.

The review identified another potential duplicate record. Bakun and Hopper (2004) also studied the Charleston aftershock on 1886/11/05 17:20 and found a location near Charleston, but slightly inland from other locations. Talwani and Sharma (1999) also concluded that this earthquake occurred at a slightly different location than other Charleston aftershocks. This earthquake appears in the CEUS-SSC catalog as TMP02071. There is also an event TMP02072 that is listed in the USGS catalog with time 12:25 with a location to the northwest of Charleston. Both events were identified as Charleston aftershocks in the declustering, but the timing suggests that they may be duplicates. The recommendation was to remove TMP02072 and use the magnitude and location given in Bakun and Hopper for TMP02071.

An additional review was performed of earthquake locations provided by Seeber and Armbruster (1987). These locations and size assessments were incorporated into the NCEER-91 catalog and then into the USGS catalog used as the primary source for the CEUS-SSC catalog. The original Seeber and Armbruster (1987) listing was also incorporated into the

CEUS-SSC catalog, along with their listed values of felt area. During the review, the classification of nine additional earthquakes at locations distance from Charleston significant to hazard (E[M]≥2.9) were changed from dependent to independent. Previously, these earthquakes had been classified as dependent earthquakes in clusters associated with the earthquakes identified above. The information for each of these earthquakes was reviewed, including additional information provided by Stevenson and Talwani.

Table 2.2.1-3 summarizes the assessment of the larger events in the CEUS-SSC catalog located at sufficient distance from Charleston to not be identified as aftershocks of the 1886/09/01 main shock.

Table 2.2.1-1
Summary of RIS Earthquake Review

TMPID	yr	mo	dy	hr	mn	sec	lat	lon	depth	E[M]	Comment / Disposition
TMP07012	1969	12	13	10	19	29.7	35.04	-82.85	6	3.46	Retain as non RIS
TMP07159	1971	7	13	11	42	26	34.8	-83	n/a	3.63	Possible RIS
TMP07565	1974	8	2	8	52	11.1	33.91	-82.53	4	3.91	Retain as non RIS
TMP08078	1975	11	25	15	17	34.8	34.93	-82.9	10*	3.21	RIS
TMP08787	1977	9	7	14	41	32.7	34.982	-82.927	n/a	2.77	RIS
TMP08971	1978	1	25	8	29	39	34.301	-81.234	5**	2.6	RIS
TMP09354	1978	8	27	10	23	8	34.313	-81.337	2	2.93	RIS
TMP08998	1978	2	10	20	23	38.7	34.343	-81.348	1	2.77	Possible RIS
TMP08999	1978	2	11	0	19	0.7	34.343	-81.35	3	2.77	Possible RIS
TMP09000	1978	2	11	5	19	0.2	34.346	-81.349	1	2.93	Possible RIS
TMP09006	1978	2	14	12	45	7.2	34.342	-81.346	2	2.77	Possible RIS
TMP09007	1978	2	14	13	9	59.5	34.351	-81.343	2	2.85	Possible RIS
TMP09013	1978	2	15	21	14	34.2	34.349	-81.346	0	2.77	Possible RIS
TMP09014	1978	2	16	2	14	33.4	34.332	-81.362	2	2.85	Possible RIS
TMP09023	1978	2	22	7	13	25.1	34.327	-81.35	1	2.85	Possible RIS
TMP09024	1978	2	22	12	13	24.3	34.339	-81.35	1	3.00	Possible RIS
TMP09025	1978	2	22	13	4	59.2	34.356	-81.352	0	2.77	Possible RIS
TMP09027	1978	2	24	7	34	10.5	34.334	-81.348	1	2.93	Possible RIS
TMP09029	1978	2	25	4	2	42.7	34.345	-81.351	1	2.77	Possible RIS
TMP09031	1978	2	26	6	52	35.4	34.315	-81.297	1	2.85	Possible RIS
TMP09032	1978	2	26	11	52	33	34.391	-81.361	1	3.00	Possible RIS
TMP09033	1978	2	26	18	17	48.8	34.321	-81.348	0	3.08	Possible RIS
TMP09343	1978	8	24	10	23	7.6	34.311	-81.341	2	2.85	Possible RIS
TMP09355	1978	8	27	10	23	8	34.313	-81.337	7	2.77	Possible RIS
TMP09460	1978	10	27	16	27	18.1	34.302	-81.326	2	3.08	RIS
TMP09518	1978	11	24	11	54	40.9	34.296	-81.347	1	2.85	Possible RIS
TMP10034	1979	8	26	1	31	45	34.916	-82.956	1	3.64	RIS
TMP39374	1979	10	8	8	54	19.4	34.31	-81.33	2	2.85	RIS
TMP10104	1979	10	8	23	20	11	34.306	-81.344	1	3.16	RIS
TMP10109	1979	10	14	8	24	57.6	34.306	-81.338	2	3.08	RIS
TMP10506	1980	7	29	1	10	22.7	34.351	-81.364	1	3.31	Possible RIS
TMP16282	1988	1	27	22	5	42.9	34.189	-82.75	6.1	2.32	RIS

* depth 17 km in RANDJ
** depth 1 km in Stover & Coffman

Table 2.2.1-2
Potential Charleston SC Area Aftershocks from CEUS-SSC Catalog

TMPID	yr	mo	dy	hr	mn	sec	lat	lon	E[M]	Source of Catalog Location
TMP00331	1799	4	11	8	20	0	33.95	-80.18	4.68	USGSnd_000145 Revised by Jeff Munsey of TVA based on Bakun and Hopper Method
TMP01089	1860	1	19	23	0	0	33.68	-80.57	4.21	USGSnd_000427
TMP01731	1886	9	1	6	0	0	33.91	-82.02	4.54	SeebArm87_000014
TMP01739	1886	9	1	9	45	0	34.3	-82.86	4.17	USGSnd_000771
TMP02019	1886	10	22	5	0	0	34.71	-81.66	4.13	USGSnd_000805
TMP02025	1886	10	22	14	45	0	33.87	-81.01	4.5	USGSnd_000807
TMP02360	1888	1	12	9	55	0	34.18	-80.17	4.33	USGSnd_000860

Table 2.2.1-3
Summary of Events Affected by the Charleston Aftershock Review

TMPID	yr	mo	dy	hr	mn	sec	lat	lon	Comment / Disposition
TMP00331	1799	4	11	8	20	0	33.95	-80.18	Retain as is
TMP01089	1860	1	19	23	0	0	33.68	-80.57	Move to Charleston and base E[M] on I0
TMP01731	1886	9	1	6	0	0	33.91	-82.02	Event removed from catalog as a duplicate of TMP01732. Location and magnitude of TMP01732 do not require modification
TMP01739	1886	9	1	14	45	0	34.04	-82.9	Event removed from catalog as a duplicate of TMP01738. Location and magnitude of TMP01738 do not require modification
TMP01942	1886	9	28	3	0	0	34.7	-81.62	Consider as a false event
TMP02002	1886	10	12	11	0	0	34.14	-81.33	Not use reported felt area, event becomes < E[M] 2.9
TMP02019	1886	10	22	5	0	0	34.71	-81.66	Event removed from catalog as a duplicate of TMP02023
TMP02023	1886	10	22	10	20		32.9	-80	Magnitude taken from Bakun and Hopper (2004)
TMP02024	1886	10	22	10*	25		33.69	-81	Event removed from catalog as a duplicate of TMP02023
TMP02025	1886	10	22	14	45	0	33.87	-81.01	Location moved to Charleston, magnitude taken from Bakun and Hopper (2004)
TMP02068	1886	11	5	5	0	0	33.38	-82.49	Not use reported felt area, event becomes < E[M] 2.9
TMP02071	1886	11	5	17	20	0	32.9	-80	Magnitude taken from Bakun and Hopper (2004)
TMP02072	1886	11	5	12	25		33.4	-80.42	Event removed from catalog as a duplicate of TMP02071.
TMP02134	1886	12	8	10	25	0	34.039	-80.886	Revise I0 from 4.5 to 4
TMP02136	1886	12	11	21	0	0	34.18	-82.06	Retain as is
TMP02173	1887	1	12	11	0	0	34.35	-82.42	Retain as less than E[M] 2.9, remove felt area
TMP02210	1887	3	4	10	0	0	33.74	-81.5	Not use reported felt area, event becomes < E[M] 2.9
TMP02360	1888	1	12	9	55	0	34.18	-80.17	Event removed from catalog as a duplicate of TMP39326.
TMP02393	1888	4	5	0	0	0	34.21	-81.534	Retain, reduce to I0 4, E[M] less than 2.9
TMP02423	1888	8	15	23	30	0	34.37	-81.08	Retain as is

Probabilistic Seismic Hazard Analysis

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

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

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

1. Charleston
2. Commerce
3. Eastern Rift Margin Fault northern segment (ERM-N)
4. Eastern Rift Margin Fault southern segment (ERM-S)
5. Marianna
6. New Madrid Fault System (NMFS)
7. 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

As indicated in the Section 2.3, the VCSNS nuclear plant reactor is founded on hard rock. To be consistent with the SPID (EPRI, 2013a), hard-rock seismic hazard curves are provided below.

2.3 Site Response Evaluation

Based on information describing the VCSNS site presented in Section 2.3.1, the geologic layers underlying the foundation of the nuclear reactor consist of hard rock (Vs ≥ 9280 fps). Therefore no site-specific evaluation of site amplification was performed for VCSNS.

2.3.1 Description of Subsurface Material

VCSNS is located in Fairfield County, S.C., approximately 3 miles northwest of the town of Jenkinsville and 1 mile east of the Broad River. VCSNS is located in the Carolina Zone of the Central Piedmont province. The VCSNS site lies within the Charlotte Terrane, the westernmost terrane of the Carolina Zone. The Charlotte Terrane is dominated by Neoproterozoic to Early Paleozoic plutonic rocks that intrude a suite of mainly metaigneous rocks. The surface of the Piedmont Physiographic Province is characterized by elevated, gently rolling hills which are separated on the northwest from the intensely folded and faulted Appalachian Mountains by the intervening hills of the Blue Ridge Province and bordered on the southeast by the Atlantic Coastal Plain. Plant grade is at elevation 435 feet.

The province in underlain by a sequence of at least 15,000 feet of late Precambrian to early Paleozoic age metamorphic rocks which mantle gneiss estimated to be 1,100 million years old. The general site area is underlain by a complex series of almandine amphibolite facies metamorphic rocks consisting of gneisses, amphibolites, schist, and migmatite formed by the intrusion of plutons of granite to grandiorite composition.

The site is generally covered by a deep mantle of residual soils derived by the in place weathering of the underlying rock. The soil profile is typically characterized by an upper silty and clayey horizon overlying saprolite, which grades with depth to decomposed rock and unweathered rock. Soil strengths typically increase with depth. Residual soils overlie the parent bedrock; the soils range in thickness from about 40-85 feet in borings drilled in site area. The soil grades from usually clayey and silty soils near the ground surface, to dense sandy silty and silty sand saprolites at depth. Bedrock at the site consists primarily of metamorphic rocks of the Charlotte Belt with Paleozoic igneous intrusive zones.

The Rock SSE Control Point is at the top of the site defined basement or competent rock layer. The basement/competent rock layer is composed of rock with measured (during original construction) compressional wave velocity of 8,000 feet per second or greater. The properties of underlying materials are summarized in Table 2.3.1-1, which is based upon information extracted from VCSNS Unit 1 FSAR Section 2.5 and the VCSNS Unit 2/3 COL FSAR Section 2.5.4. The Reactor, Control, and Auxiliary Building are founded on fill concrete upon competent rock. Table 2.3.1-1 provides a brief description of the subsurface material in terms of the geologic units and layer thicknesses.

Table 2.3.1-1
Geologic Profile and Estimated Layer Thickness for VCSNS

Depth Range (feet)	Soil/Rock Description		Density (pcf)	Shear Wave Velocity (fps)	Compressional Wave Velocity (fps)	Poisson's Ratio
0	SOIL SSE Control Point (at surface)					
0-25	Zone III Structural Fill		140	--- [b]	--- [b]	0.33
25-65	Saprolite		110-135	900 [a]	1000-3000	0.35
65-75	All highly weathered rock; and moderately weathered highly jointed rock.	Type 3	140-160	3000 [a]	12000-13000	0.3
75-85	Moderately weathered rock, slight jointing; and slightly weathered rock, moderately to very jointed.	Type 2	140-160	6000 [a]	12000-13000	0.3
85	ROCK SSE Control Point IPEEE HCLPF Control Point					
85+	Massive Fresh Rock - Late Precambrian to Early Paleozoic Igneous and Metamorphic Rock	Type 1	165	10000 [a]	15000	0.2

NOTES:

[a]Shear wave velocity measurements taken from VCSNS Unit 2/3 COL Application FSAR. The measurements were taken in near vicinity of VCSNS Unit 1 and rock is considered to be equivalent. Review of boring logs for each site validates this assumption. Shear wave velocity measurements were taken using current methods (geophysical down-hole tests using suspension P-S Velocity logging), and are considered to contain greater accuracy than dated methods used during Unit 1 construction.

[b]Compressional/Shear wave velocity measurements for the Zone III fill not available.

2.3.2 Development of Base Case Profiles and Nonlinear Material Properties

VCSNS is defined as a hard rock site and therefore Sections 2.3.2 through 2.3.6 are not applicable.

2.3.7 Control Point Seismic Hazard Curves

The procedure to develop probabilistic seismic hazard curves for hard rock follows standard techniques documented in the technical literature (e.g., McGuire, 2004). Separate seismic hazard calculations are conducted for the 7 spectral frequencies for which ground motion equations are available (100 Hz = peak ground acceleration or PGA, 25 Hz, 10 Hz, 5 Hz, 2.5 Hz, 1 Hz, and 0.5 Hz). As discussed in Section 2.2.1, ground motion equations from the updated EPRI Ground-Motion Model (GMM) for the CEUS (EPRI, 2013b) were used for the calculation of rock hazard. All spectra accelerations presented herein correspond to 5% of critical damping. Figure 2.3.7-1 shows the mean hard-rock seismic hazard curves for the 7 spectral frequencies. The digital values for the mean and fractile hazard curves are provided in Appendix A.

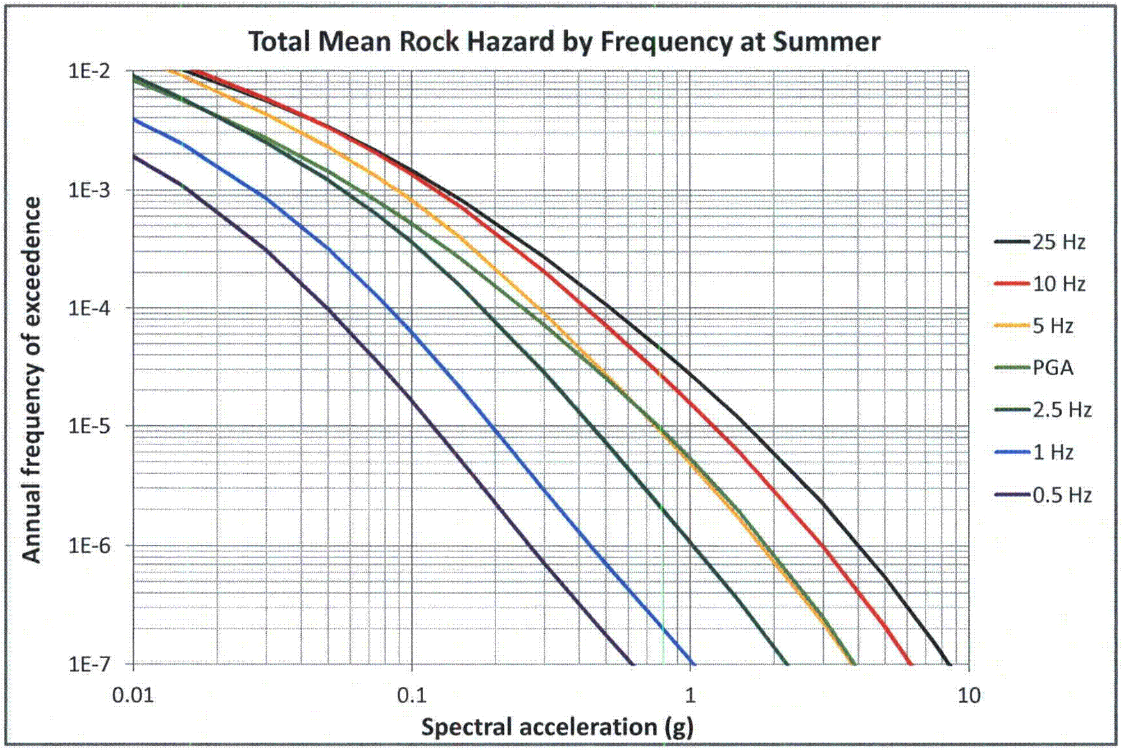

Figure 2.3.7-1. Control point mean rock hazard curves for spectral frequencies of 0.5, 1, 2.5, 5, 10, 25 and 100 Hz (PGA) at VCSNS.

2.4 Ground Motion Response Spectrum

The hard-rock hazard curves described in Section 2.3.7 were used to develop mean uniform hazard response spectra (UHRS) and the ground motion response spectrum (GMRS). The mean UHRS were calculated through log-log interpolation of mean seismic hazard curves for each of the 7 spectral frequencies for which ground motion equations were available (EPRI 2013b), for annual frequencies of exceedence of 1E-4 and1E-5. Table 2.4-1 shows the mean rock UHRS and GMRS for typical spectral frequencies, including the 7 spectral frequencies of interest.

Table 2.4-1 Mean Rock UHRS and GMRS for VCSNS

Freq. (Hz)	10^{-4} UHRS (g)	10^{-5} UHRS (g)	GMRS
100	2.52E-01	7.67E-01	3.68E-01
90	2.72E-01	8.29E-01	3.98E-01
80	3.08E-01	9.38E-01	4.50E-01
70	3.62E-01	1.10E+00	5.30E-01
60	4.30E-01	1.31E+00	6.29E-01
50	4.91E-01	1.50E+00	7.20E-01
45	5.13E-01	1.57E+00	7.53E-01
40	5.27E-01	1.61E+00	7.74E-01
35	5.33E-01	1.64E+00	7.84E-01
30	5.31E-01	1.63E+00	7.82E-01
25	5.20E-01	1.60E+00	7.67E-01
20	5.12E-01	1.55E+00	7.44E-01
15	4.86E-01	1.43E+00	6.92E-01
12.5	4.61E-01	1.34E+00	6.49E-01
10	4.25E-01	1.21E+00	5.90E-01
9	4.03E-01	1.14E+00	5.54E-01
8	3.78E-01	1.05E+00	5.15E-01
7	3.51E-01	9.61E-01	4.71E-01
6	3.21E-01	8.62E-01	4.24E-01
5	2.87E-01	7.54E-01	3.73E-01
4	2.50E-01	6.43E-01	3.19E-01
3	2.05E-01	5.17E-01	2.58E-01
2.5	1.79E-01	4.43E-01	2.22E-01
2	1.56E-01	3.81E-01	1.91E-01
1.5	1.25E-01	2.98E-01	1.50E-01
1.25	1.05E-01	2.48E-01	1.25E-01
1	8.26E-02	1.94E-01	9.81E-02
0.9	7.81E-02	1.84E-01	9.30E-02
0.8	7.26E-02	1.72E-01	8.67E-02
0.7	6.60E-02	1.57E-01	7.90E-02
0.6	5.84E-02	1.39E-01	7.01E-02
0.5	4.97E-02	1.19E-01	5.98E-02
0.4	3.98E-02	9.50E-02	4.79E-02
0.3	2.98E-02	7.12E-02	3.59E-02
0.2	1.99E-02	4.75E-02	2.39E-02
0.167	1.66E-02	3.96E-02	2.00E-02
0.125	1.24E-02	2.97E-02	1.50E-02
0.1	9.94E-03	2.37E-02	1.20E-02

The mean rock 1E-4 and1E-5 UHRS and GMRS are plotted in Figure 2.4-1.

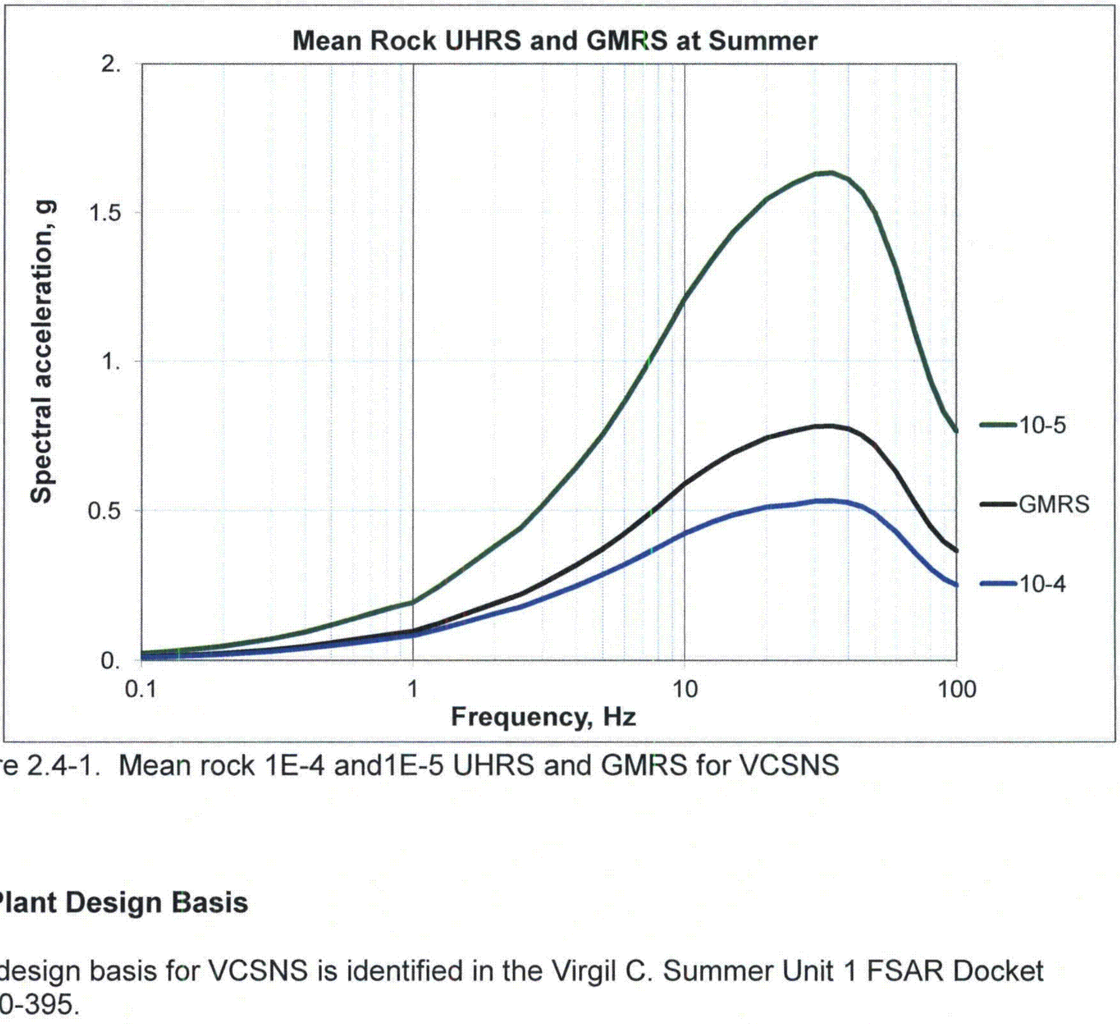

Figure 2.4-1. Mean rock 1E-4 and1E-5 UHRS and GMRS for VCSNS

3.0 Plant Design Basis

The design basis for VCSNS is identified in the Virgil C. Summer Unit 1 FSAR Docket No.50-395.

3.1 SSE Description of Spectral Shape

The SSE was developed in accordance with 10 CFR Part 100, Appendix A through an evaluation of the maximum earthquake potential for the region surrounding the site. The SSE is considered as a random occurrence of an Intensity VII earthquake near the site. The event would be similar to the 1913 Union County, S.C., earthquake which occurred some 35 miles northeast of the site. The maximum horizontal ground motion resulting from this shock at the site would conservatively be about 0.13g in rock and 0.20g in soil. However, more conservative factors of 0.15g and 0.25g were utilized for the Safe Shutdown Earthquake in rock and soil, respectively. Ground motion estimates at the site as a result of larger, more distant events (such as a recurrence of the 1886 Charleston, S.C. earthquake of Intensity X) would be 0.10g and 0.15g for rock and soil, respectively. The corresponding vertical accelerations used in design are 2/3 of the horizontal.

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 VCSNS (SCE&G, 2012)

Freq. (Hz)	0.5	1	2.5	5	9	10	25	100
SA (g)	0.08	0.2	0.4	0.4	0.29	0.26	0.15	0.15

3.2 Control Point Elevation

The Rock SSE Control Point is defined as top of competent rock at an approximate elevation of 350 feet (see Table 2.3.1-1), which is nominally 85 feet below plant grade elevation of 435 feet.

4.0 Screening Evaluation

In accordance with SPID Section 3, 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 GMRS exceeds the SSE. Therefore, VCSNS screens in for a risk evaluation.

4.2 High Frequency Screening (> 10 Hz)

For frequencies above 10 Hz, the GMRS exceeds the SSE. The high frequency exceedances can be addressed in the risk evaluation discussed in 4.1 above.

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

In the 1 to 10 Hz part of the response spectrum, the GMRS exceeds the SSE. Therefore, VCSNS screens in for a spent fuel pool evaluation.

5.0 Interim Actions

Based on the screening evaluation, the expedited seismic evaluation described in EPRI 3002000704 will be performed as proposed in a letter to NRC dated April 9, 2013 [ML131 01A379] and agreed to by NRC in a letter dated May 7, 2013 [ML13106A331].

Consistent with NRC letter dated February 20, 2014 [ML14030A046], the seismic hazard reevaluations presented herein are distinct from the current design and licensing bases of

VCSNS. Therefore, the results do not call into question the operability or functionality of SSCs and are not reportable pursuant to10 CFR 50.72, "Immediate notification requirements for operating nuclear power reactors," and10 CFR 50.73, "Licensee event report system".

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, 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:

> 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.

VCSNS is included in the March 12, 2014 risk estimates. Using the methodology described in the NEI letter, all plants were shown to be below 1E-4; thus, the above conclusions apply.

VCSNS also performed the Individual Plant Examination of External Event (IPEEE). VCSNS was classified as a Focused Scope plant and evaluations were performed in accordance with EPRI NP-6041. No vulnerabilities were identified in the VCSNS IPEEE. However, the VCSNS IPEEE Report identified three outlier concerns. The three outliers were reviewed as part of Recommendation 2.3 Seismic Walkdown Report which determined the three outliers had been sufficiently resolved. Description of each of the outliers and respective resolution is provided below.

1. Reactor Coolant Loop 'C' Hot Leg Sample Header Isolation Valve (Component ID XVX09365C) was identified as non-conforming in the IPEEE walkdowns which identified a missing U-bolt anchor. Subject U-bolt was replaced and actions addressing the non-conformance were completed on January 13, 1995. A subsequent re-design and support of the valve deleted the requirement for the U-bolt anchorage. The 2.3 walkdown verified the current plant configuration.

2. 17 Electrical panels were identified as having the potential to move out of phase and impact one another under seismic motions. Modifications for 16 of these panels were developed under a plant modification (MRF 22647). The panels were connected to adjacent panels (typically along the top of the panels) using combinations of flat bar stock plate material and/or angle clips and bolts/washers. Actions addressing MRF 22647 were completed on January 13, 1995. Actions addressing the remaining panel were completed on October 18, 1996. Panels XPN6001, XPN6020, XPN7001, XPN7010, and XSW0001 were selected for the 2.3 walkdown to confirm that the plant has maintained these modifications. No issues were identified with panel anchorage or other conditions for all items.

3. Neutral Grounding Resistor cabinets XCA0015A and XCA0015B were identified as having ceramic feet from which experience has shown to be susceptible to damage during earthquakes. A review of the seismic test report for the resistors and a HCLPF calculation resulted in a value of 0.42g which is above the 0.3g Review Level Earthquake. Neutral Grounding Resistor Cabinet XCA0015A was selected for the 2.3 walkdown to confirm that the plant has maintained the robust design of these cabinets. No issues were identified with cabinet anchorage or other conditions.

IPEEE HLCPF evaluations were performed for VCSNS and determined a plant HCLPF of 0.22g, which was controlled by the Service Water Pond Dams. All other SSCs evaluated as part of the IPEEE HCLPF process met or exceeded the 0.3g Review Level Earthquake.

On November 26, 2012, VCSNS completed seismic walkdowns as requested by Near-Term Task Force Recommendation 2.3. On January 30, 2014, the NRC issued the VCSNS staff assessment of the seismic walkdown report supporting implementation of Near-Term Task Force Recommendation 2.3 related to the Fukushima Dai-ichi Nuclear Power Plant Accident. The NRC staff concluded that the VCSNS implementation of the seismic walkdown methodology met the intent of the walkdown guidance. The staff also concluded that, through the implementation of the walkdown guidance activities and, in accordance with plant processes and procedures, the licensee verified the plant configuration with the current seismic licensing basis; addressed degraded, nonconforming, or unanalyzed seismic conditions; and verified the adequacy of monitoring and maintenance programs for protective features. Furthermore, the staff noted that no immediate safety concerns were identified.

6.0 Conclusions

In accordance with the 50.54(f) request for information, a seismic hazard and screening evaluation was performed for VCSNS. 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, VCSNS screens in for a Risk Evaluation, a Spent Fuel Pool Evaluation, and a High Frequency Confirmation.

7.0 References

CEUS-SSC (2012). *Central and Eastern United States Seismic Source Characterization for Nuclear Facilities*, U.S. Nuclear Regulatory Commission Report, NUREG-2115; EPRI Report 1021097, 6 Volumes; DOE Report# DOE/NE-0140.

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EPRI (2014). *Review of EPRI 1021097 Earthquake Catalog for RIS Earthquakes in the Southeastern U. S. and Earthquakes in South Carolina Near the Time of the 1886 Charleston Earthquake Sequence,* transmitted by letter from J. Richards to R. McGuire on March 5.

Lettis Consultants International, Inc (2014). Letter to SCE&G, "Summer Seismic Hazard and Screening Report", dated March 6.

McGuire, R.K. (2004). *Seismic Hazard and Risk Analysis*, Earthquake Engineering Research Institute, Monograph MNO-10.

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

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SCE&G (1998). Virgil C. Summer Nuclear Station Engineering Services Technical Report TR00310-001, "Individual Plant Examination for External Events," December.

SCE&G (2012). *Request for Information Response – EPRI Seismic Attenuation and GMRS Project,* South Carolina Electric & Gas Co., Letter CGSV-12-0010 from J. Graham to J. Hamel, with Appendices, July 2.

SCE&G (2012). "South Carolina Electric & Gas (SCE&G) Final Seismic Walkdown Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Seismic Aspects of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident", dated November 26, RC-12-0175.

SCE&G. V.C. Summer Unit 1 FSAR Docket No. 50-395.

SCE&G. V.C. Summer Units 2/3, COL Application, Part 2, FSAR Docket No. 52-027/028.

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

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.52E-02	2.96E-02	3.84E-02	4.56E-02	5.27E-02	5.66E-02
0.001	3.63E-02	2.13E-02	2.96E-02	3.68E-02	4.37E-02	4.83E-02
0.005	1.48E-02	7.45E-03	1.04E-02	1.42E-02	1.82E-02	2.57E-02
0.01	8.25E-03	3.95E-03	5.27E-03	7.66E-03	1.04E-02	1.72E-02
0.015	5.63E-03	2.46E-03	3.28E-03	5.05E-03	7.34E-03	1.27E-02
0.03	2.71E-03	8.23E-04	1.21E-03	2.22E-03	4.01E-03	6.93E-03
0.05	1.44E-03	3.09E-04	4.98E-04	1.04E-03	2.29E-03	4.25E-03
0.075	8.13E-04	1.34E-04	2.29E-04	5.20E-04	1.31E-03	2.72E-03
0.1	5.21E-04	7.34E-05	1.31E-04	3.14E-04	8.23E-04	1.87E-03
0.15	2.63E-04	3.09E-05	6.26E-05	1.53E-04	3.95E-04	1.01E-03
0.3	7.23E-05	6.83E-06	1.72E-05	4.37E-05	1.05E-04	2.60E-04
0.5	2.55E-05	2.25E-06	5.75E-06	1.64E-05	3.95E-05	8.12E-05
0.75	1.05E-05	8.23E-07	2.19E-06	6.83E-06	1.72E-05	3.19E-05
1.	5.38E-06	3.68E-07	1.01E-06	3.42E-06	8.98E-06	1.67E-05
1.5	1.93E-06	9.37E-08	2.92E-07	1.15E-06	3.23E-06	6.45E-06
3.	2.50E-07	5.66E-09	2.13E-08	1.20E-07	4.01E-07	1.01E-06
5.	4.10E-08	4.83E-10	1.95E-09	1.49E-08	6.09E-08	1.95E-07
7.5	7.90E-09	1.57E-10	3.09E-10	2.16E-09	1.08E-08	4.13E-08
10.	2.18E-09	1.10E-10	1.57E-10	5.42E-10	2.80E-09	1.21E-08

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

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.91E-02	3.57E-02	4.31E-02	4.98E-02	5.50E-02	5.91E-02
0.001	4.18E-02	2.84E-02	3.52E-02	4.19E-02	4.83E-02	5.27E-02
0.005	2.14E-02	1.20E-02	1.62E-02	2.10E-02	2.57E-02	3.33E-02
0.01	1.38E-02	7.34E-03	9.79E-03	1.32E-02	1.69E-02	2.39E-02
0.015	1.02E-02	5.27E-03	7.03E-03	9.65E-03	1.27E-02	1.90E-02
0.03	5.65E-03	2.64E-03	3.52E-03	5.20E-03	7.34E-03	1.15E-02
0.05	3.38E-03	1.32E-03	1.84E-03	2.96E-03	4.70E-03	7.34E-03
0.075	2.12E-03	6.73E-04	9.93E-04	1.77E-03	3.19E-03	4.98E-03
0.1	1.47E-03	4.01E-04	6.09E-04	1.16E-03	2.29E-03	3.73E-03
0.15	8.34E-04	1.84E-04	2.96E-04	6.17E-04	1.31E-03	2.35E-03
0.3	2.72E-04	4.50E-05	8.35E-05	1.92E-04	4.19E-04	8.35E-04
0.5	1.08E-04	1.55E-05	3.28E-05	7.66E-05	1.67E-04	3.14E-04
0.75	4.92E-05	6.26E-06	1.49E-05	3.63E-05	7.77E-05	1.36E-04
1.	2.76E-05	3.37E-06	8.00E-06	2.10E-05	4.50E-05	7.45E-05
1.5	1.17E-05	1.29E-06	3.19E-06	8.85E-06	1.92E-05	3.19E-05
3.	2.25E-06	1.84E-07	4.90E-07	1.60E-06	3.84E-06	6.83E-06
5.	5.49E-07	3.01E-08	8.98E-08	3.52E-07	9.51E-07	1.84E-06
7.5	1.54E-07	6.00E-09	1.87E-08	8.60E-08	2.60E-07	5.83E-07
10.	5.68E-08	1.64E-09	5.42E-09	2.88E-08	9.65E-08	2.25E-07

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

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	5.23E-02	4.25E-02	4.63E-02	5.27E-02	5.83E-02	6.17E-02
0.001	4.61E-02	3.47E-02	3.95E-02	4.63E-02	5.20E-02	5.58E-02
0.005	2.44E-02	1.49E-02	1.87E-02	2.42E-02	2.96E-02	3.42E-02
0.01	1.54E-02	8.72E-03	1.11E-02	1.51E-02	1.90E-02	2.35E-02
0.015	1.11E-02	6.09E-03	7.77E-03	1.08E-02	1.40E-02	1.79E-02
0.03	5.82E-03	2.92E-03	3.79E-03	5.50E-03	7.55E-03	1.02E-02
0.05	3.34E-03	1.42E-03	1.95E-03	3.05E-03	4.63E-03	6.36E-03
0.075	2.02E-03	7.13E-04	1.04E-03	1.79E-03	2.96E-03	4.25E-03
0.1	1.36E-03	4.13E-04	6.26E-04	1.15E-03	2.07E-03	3.09E-03
0.15	7.23E-04	1.77E-04	2.84E-04	5.75E-04	1.13E-03	1.84E-03
0.3	2.04E-04	3.63E-05	6.54E-05	1.51E-04	3.23E-04	5.75E-04
0.5	7.16E-05	1.04E-05	2.19E-05	5.20E-05	1.15E-04	2.01E-04
0.75	2.98E-05	3.79E-06	8.72E-06	2.22E-05	4.90E-05	8.23E-05
1.	1.57E-05	1.79E-06	4.25E-06	1.16E-05	2.60E-05	4.31E-05
1.5	6.07E-06	5.75E-07	1.49E-06	4.43E-06	1.04E-05	1.74E-05
3.	9.86E-07	6.54E-08	1.79E-07	6.45E-07	1.69E-06	3.19E-06
5.	2.08E-07	8.72E-09	2.68E-08	1.20E-07	3.52E-07	7.55E-07
7.5	5.14E-08	1.44E-09	4.77E-09	2.49E-08	8.60E-08	2.04E-07
10.	1.73E-08	4.31E-10	1.32E-09	7.23E-09	2.88E-08	7.45E-08

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

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	5.26E-02	4.25E-02	4.63E-02	5.27E-02	5.83E-02	6.26E-02
0.001	4.64E-02	3.42E-02	3.90E-02	4.63E-02	5.35E-02	5.75E-02
0.005	2.29E-02	1.32E-02	1.72E-02	2.25E-02	2.88E-02	3.23E-02
0.01	1.33E-02	7.13E-03	9.51E-03	1.31E-02	1.72E-02	2.01E-02
0.015	9.04E-03	4.77E-03	6.26E-03	8.72E-03	1.18E-02	1.42E-02
0.03	4.28E-03	2.01E-03	2.72E-03	4.07E-03	5.83E-03	7.34E-03
0.05	2.29E-03	8.85E-04	1.27E-03	2.13E-03	3.28E-03	4.37E-03
0.075	1.30E-03	4.07E-04	6.17E-04	1.15E-03	1.95E-03	2.76E-03
0.1	8.23E-04	2.19E-04	3.47E-04	6.93E-04	1.29E-03	1.92E-03
0.15	3.96E-04	8.60E-05	1.44E-04	3.05E-04	6.26E-04	1.04E-03
0.3	9.11E-05	1.49E-05	2.80E-05	6.45E-05	1.42E-04	2.60E-04
0.5	2.74E-05	3.63E-06	7.66E-06	1.95E-05	4.37E-05	7.77E-05
0.75	1.01E-05	1.13E-06	2.57E-06	7.23E-06	1.67E-05	2.88E-05
1.	4.91E-06	4.70E-07	1.13E-06	3.47E-06	8.23E-06	1.44E-05
1.5	1.69E-06	1.25E-07	3.28E-07	1.11E-06	2.88E-06	5.27E-06
3.	2.25E-07	8.47E-09	2.68E-08	1.21E-07	3.84E-07	8.12E-07
5.	4.06E-08	8.47E-10	3.01E-09	1.69E-08	6.83E-08	1.62E-07
7.5	8.86E-09	2.01E-10	4.90E-10	2.80E-09	1.40E-08	3.84E-08
10.	2.74E-09	1.42E-10	1.95E-10	7.66E-10	4.07E-09	1.23E-08

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

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	5.04E-02	3.95E-02	4.37E-02	5.05E-02	5.66E-02	6.09E-02
0.001	4.23E-02	2.96E-02	3.42E-02	4.25E-02	5.05E-02	5.42E-02
0.005	1.71E-02	9.65E-03	1.23E-02	1.67E-02	2.19E-02	2.53E-02
0.01	9.03E-03	4.70E-03	6.17E-03	8.72E-03	1.18E-02	1.44E-02
0.015	5.82E-03	2.80E-03	3.79E-03	5.50E-03	7.77E-03	9.79E-03
0.03	2.50E-03	9.37E-04	1.38E-03	2.32E-03	3.57E-03	4.70E-03
0.05	1.22E-03	3.42E-04	5.50E-04	1.07E-03	1.87E-03	2.64E-03
0.075	6.24E-04	1.38E-04	2.32E-04	4.90E-04	1.01E-03	1.57E-03
0.1	3.63E-04	6.73E-05	1.18E-04	2.64E-04	5.91E-04	1.02E-03
0.15	1.54E-04	2.22E-05	4.13E-05	9.79E-05	2.49E-04	4.77E-04
0.3	2.83E-05	2.76E-06	5.75E-06	1.57E-05	4.43E-05	9.11E-05
0.5	7.24E-06	5.12E-07	1.23E-06	3.95E-06	1.16E-05	2.29E-05
0.75	2.39E-06	1.21E-07	3.37E-07	1.31E-06	4.01E-06	8.00E-06
1.	1.08E-06	4.01E-08	1.27E-07	5.58E-07	1.84E-06	3.84E-06
1.5	3.40E-07	7.66E-09	2.84E-08	1.55E-07	6.00E-07	1.32E-06
3.	3.92E-08	3.84E-10	1.46E-09	1.15E-08	6.45E-08	1.69E-07
5.	6.33E-09	1.53E-10	2.19E-10	1.27E-09	9.37E-09	2.92E-08
7.5	1.25E-09	1.01E-10	1.49E-10	2.57E-10	1.60E-09	5.83E-09
10.	3.61E-10	9.11E-11	1.02E-10	1.55E-10	4.90E-10	1.67E-09

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

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.54E-02	2.07E-02	2.64E-02	3.57E-02	4.37E-02	4.83E-02
0.001	2.45E-02	1.31E-02	1.74E-02	2.46E-02	3.09E-02	3.57E-02
0.005	7.42E-03	3.28E-03	4.63E-03	7.03E-03	1.01E-02	1.27E-02
0.01	3.88E-03	1.31E-03	2.04E-03	3.52E-03	5.75E-03	7.55E-03
0.015	2.42E-03	6.54E-04	1.11E-03	2.13E-03	3.68E-03	5.12E-03
0.03	8.52E-04	1.46E-04	2.88E-04	6.73E-04	1.38E-03	2.16E-03
0.05	3.18E-04	3.84E-05	8.12E-05	2.16E-04	5.50E-04	9.37E-04
0.075	1.27E-04	1.18E-05	2.57E-05	7.45E-05	2.19E-04	4.13E-04
0.1	6.21E-05	4.83E-06	1.08E-05	3.28E-05	1.05E-04	2.13E-04
0.15	2.08E-05	1.29E-06	3.01E-06	9.79E-06	3.47E-05	7.55E-05
0.3	2.89E-06	1.04E-07	2.96E-07	1.18E-06	4.77E-06	1.11E-05
0.5	7.05E-07	1.29E-08	4.56E-08	2.42E-07	1.15E-06	3.05E-06
0.75	2.37E-07	2.04E-09	8.98E-09	6.36E-08	3.68E-07	1.10E-06
1.	1.08E-07	5.83E-10	2.68E-09	2.25E-08	1.57E-07	5.12E-07
1.5	3.39E-08	1.79E-10	5.05E-10	4.70E-09	4.19E-08	1.62E-07
3.	3.67E-09	1.01E-10	1.53E-10	3.19E-10	3.23E-09	1.69E-08
5.	5.63E-10	9.11E-11	1.01E-10	1.53E-10	4.56E-10	2.46E-09
7.5	1.08E-10	9.11E-11	1.01E-10	1.53E-10	1.69E-10	4.98E-10
10.	3.05E-11	9.11E-11	9.37E-11	1.53E-10	1.53E-10	2.16E-10

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

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	1.93E-02	1.13E-02	1.46E-02	1.87E-02	2.39E-02	2.84E-02
0.001	1.23E-02	6.64E-03	8.72E-03	1.18E-02	1.60E-02	1.95E-02
0.005	3.92E-03	1.13E-03	1.87E-03	3.57E-03	6.00E-03	7.89E-03
0.01	1.92E-03	3.33E-04	6.45E-04	1.55E-03	3.19E-03	4.70E-03
0.015	1.09E-03	1.32E-04	2.84E-04	8.00E-04	1.87E-03	3.05E-03
0.03	3.11E-04	2.04E-05	4.90E-05	1.74E-04	5.50E-04	1.10E-03
0.05	9.87E-05	4.25E-06	1.07E-05	4.07E-05	1.72E-04	3.84E-04
0.075	3.54E-05	1.11E-06	2.96E-06	1.11E-05	5.66E-05	1.49E-04
0.1	1.63E-05	4.07E-07	1.13E-06	4.43E-06	2.46E-05	7.03E-05
0.15	5.16E-06	9.24E-08	2.76E-07	1.18E-06	7.13E-06	2.32E-05
0.3	7.08E-07	4.77E-09	2.01E-08	1.23E-07	8.85E-07	3.63E-06
0.5	1.77E-07	4.98E-10	2.49E-09	2.10E-08	1.92E-07	9.51E-07
0.75	6.05E-08	1.62E-10	4.90E-10	4.70E-09	5.27E-08	3.23E-07
1.	2.80E-08	1.44E-10	2.10E-10	1.49E-09	1.98E-08	1.40E-07
1.5	8.96E-09	1.01E-10	1.53E-10	3.47E-10	4.50E-09	4.19E-08
3.	1.02E-09	9.11E-11	1.01E-10	1.53E-10	3.52E-10	3.90E-09
5.	1.62E-10	9.11E-11	1.01E-10	1.53E-10	1.53E-10	6.00E-10
7.5	3.22E-11	9.11E-11	9.11E-11	1.53E-10	1.53E-10	2.01E-10
10.	9.34E-12	9.11E-11	9.11E-11	1.53E-10	1.53E-10	1.53E-10