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April 17, 2009

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

Subject: Duke Energy Carolinas, LLC.
William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019
AP1000 Combined License Application for the
William States Lee III Nuclear Station Units 1 and 2
Response to Request for Additional Information
(RAI No. 1487 Revision 1)
Ltr# WLG2009.04-03

Reference: Letter from Brian Hughes (NRC) to Peter Hastings (Duke Energy), Request for Additional Information Letter No. 063 Related to SRP 02.05.02 for the William States Lee III Units 1 and 2 Combined License Application, dated January 14, 2009

This letter provides the Duke Energy response to the Nuclear Regulatory Commission's requests for additional information (RAIs) included in the referenced letter.

Responses to the NRC information requests described in the referenced letter are addressed in separate enclosures, which also identify associated changes, when appropriate, that will be made in a future revision of the Final Safety Analysis Report for the Lee Nuclear Station.

If you have any questions or need any additional information, please contact Peter S. Hastings, Nuclear Plant Development Licensing Manager, at 980-373-7820.

Bryan J. Dolan
Vice President
Nuclear Plant Development

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NRO

Enclosures:

1) Duke Energy Response to Request for Additional Information Letter 063, RAI 02.05.02-035
2) Duke Energy Response to Request for Additional Information Letter 063, RAI 02.05.02-036
3) Duke Energy Response to Request for Additional Information Letter 063, RAI 02.05.02-037
4) Duke Energy Response to Request for Additional Information Letter 063, RAI 02.05.02-038
5) Duke Energy Response to Request for Additional Information Letter 063, RAI 02.05.02-041
6) Duke Energy Response to Request for Additional Information Letter 063, RAI 02.05.02-043
7) Duke Energy Response to Request for Additional Information Letter 063, RAI 02.05.02-044
8) Duke Energy Response to Request for Additional Information Letter 063, RAI 02.05.02-045
9) Duke Energy Response to Request for Additional Information Letter 063, RAI 02.05.02-046
10) Duke Energy Response to Request for Additional Information Letter 063, RAI 02.05.02-047

AFFIDAVIT OF BRYAN J. DOLAN

Bryan J. Dolan, being duly sworn, states that he is Vice President, Nuclear Plant Development, Duke Energy Carolinas, LLC, that he is authorized on the part of said Company to sign and file with the U. S. Nuclear Regulatory Commission this supplement to the combined license application for the William States Lee III Nuclear Station and that all the matter and facts set forth herein are true and correct to the best of his knowledge.

Bryan J. Dolan

Subscribed and sworn to me on April 17, 2009

Notary Public

My commission expires: April 19, 2010

SEAL

KIM N. SLAVS
NOTARY PUBLIC
NEW HANOVER COUNTY, N.C.

xc (w/o enclosures):

Loren Plisco, Deputy Regional Administrator, Region II
Stephanie Coffin, Branch Chief, DNRL

xc (w/ enclosures):

Brian Hughes, Senior Project Manager, DNRL

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 063

NRC Technical Review Branch: **Geosciences and Geotechnical Engineering Branch 2 (RGS2)**

Reference NRC RAI Number(s): **RAI 02.05.02-035**

NRC RAI:

FSAR Section 2.5.2.1 (pg 2.5-83 through 2.5-85) describes how the seismicity catalog was updated for the post-EPRI/SOG time period from 1985 to 2005.

(a) Please explain why the rectangular region for the seismicity catalog update, shown in Figure 2.5.2-201, is not symmetrical about the Lee site, but, rather, extends farther southward into areas of lower seismicity.

(b) FSAR Section 2.5.2.1.1 (pg 2.5-83) describes the goal of creating a homogeneous catalog of CEUS earthquakes with consistent estimates of body-wave magnitude (mb). Currently the most commonly cataloged magnitude for moderate-size earthquakes in the CEUS is a short-period surface-wave magnitude like mbLg. Please explain the relationship between these two magnitude measures.

(c) FSAR Section 2.5.2.1.2 (pgs 2.5-84 and 2.5-85) describes how values of duration magnitude and local magnitude are converted to E[mb] and mb* using equation 4-2 from EPRI/SOG (Reference 204). The USGS/NEIC on-line PDE catalog (http://neic.usgs.gov/neis/epic/epic_rect.html) for the update region for 1985-2005 lists mbLg magnitudes for most of the earthquakes (~75%) with magnitude equal to or greater than 2.5. Reference 204 seems to recommend equation 4-3, not equation 4-2, for determining mb* when E[mb] is determined directly from instrumental data. Please clarify the method used to create an updated catalog with uniform magnitudes, and explain why mbLg and equation 4-3 are not used directly.

(d) FSAR Section 2.5.2.1.2 (pg 2.5-85) shows how magnitude uncertainty, σmb, is used to compute uniform, un-biased magnitudes, but does not describe how it is estimated. Please explain how σmb is estimated for post-EPRI/SOG earthquakes.

(e) The last sentence in FSAR Section 2.5.2.1.2 (pg 2.5-85) states that, for the purpose of recurrence analysis, the 89 earthquakes that occurred within the rectangular region are considered independent events. This statement suggests that the updated catalog is not declustered. Please explain why the updated catalog is not declustered for the purpose of recurrence analysis.

Duke Energy Response:

The Duke Energy responses to RAI items a, b, c, d, and e are provided below.

(a) The rectangular region for the seismicity catalog update is not symmetrical about the Lee site because the update area (1) includes the Lee site region (200-mi), (2) captures the full extent of seismicity in Alabama associated with the Eastern Tennessee seismic zone, and (3) uses

30 degrees N latitude as the southern boundary, which is the same southern boundary used in seismicity updates of other applications, specifically the nearby Vogtle and VC Summer sites.

(b) In EPRI (1988) (FSAR Reference 2.5.2-204, p. 4-4) the two magnitude measures, mb and mbLg, are considered equivalent. The calculation of mb magnitude uses the amplitude of compressional (P-wave) body waves for local events. The calculation of mbLg magnitude uses the amplitude of Lg waves, which are surface waves in continental crust (Richter (1958) (Reference 1)).

(c) The method used to create the updated earthquake catalog included the following steps:

1. Define the region to update as a geographic window that encompasses the site region (200-mi).
2. Download the preferred catalogs for the update (Southeastern United States Seismic Network (SEUSSN) and Advanced National Seismic System (ANSS)).
3. Filter the preferred catalogs to obtain events within the geographic window.
4. Compare catalogs, establish a composite update catalog of all events, and convert all magnitudes to best estimates of body wave magnitude (Emb).
5. Filter the composite updated catalog for independent events of Emb magnitude 3 and greater.
6. Determine EPRI Rmb (also expressed as mb*) magnitude using estimates of the variance of different magnitude types (σmb also expressed as sigma(mb)).

Equation 4-3 was not directly used in the earthquake catalog update because the EPRI catalog did not use this equation. Even though EPRI (1988) (FSAR Reference 2.5.2-204) prescribes equation 4-3 for use to obtain mb* when Emb is determined directly from instrumental data, an examination of the 1988 EPRI catalog reveals that equation 4-2 was used in all cases. The magnitude scale mbLg was not used directly, since it is considered equivalent to mb (EPRI (1988) (FSAR Reference 2.5.2-204, p. 4-4). These conventions were maintained for the Lee site updated catalog.

(d) Equation (4-2) of FSAR Reference 2.5.2-204 indicates the equation from which mb* (or Rmb) is estimated from the best estimate of magnitude E[mb] (also expressed as Emb) and the uncertainty in mb, σmb, when mb is determined through conversion from other size measures:

$$mb^* = E[mb] + (1/2) \times \ln(10) \times b \times \sigma mb^2$$

where the variance, σmb^2, and a single value of b = 1.0 have been used to calculate mb.

FSAR Reference 2.5.2-204 does not explicitly describe how σmb was determined. However, an examination of the EPRI catalog, particularly σmb values listed and the various size measures from which they were determined, shows that this value can be estimated from the different earthquake size estimates available for a given event. By inspection of the Reference 2.5.2-204 catalog, the following is a correlation of σmb and the available earthquake size estimates:

Size measure	σmb
body wave magnitude [Mb, MB, mb, MN, Mn, Lg]	0.10
coda (or duration) magnitude [MD, Md, md, mc] + intensity + felt area	0.22
coda (or duration) magnitude [MD, Md, md, mc] and local magnitude [ML, mL]	0.23
coda (or duration) magnitude [MD, Md, md, mc] + intensity	0.27
coda (or duration) magnitude only [MD, Md, md, Mc, mc]	0.30
local magnitude [ML, mL] + intensity	0.33
local magnitude [ML, mL] only	0.41
Surface wave magnitude [MS, Ms]	0.41
intensity only	0.56

These values of σmb were used to update the EPRI (1988) (FSAR Reference 2.5.2-204) earthquake catalog in analogy with the original catalog.

(e) The 1985-2005 update of the original EPRI catalog was not declustered for the purpose of recurrence analysis. There are only a small number of events that would be considered dependent earthquakes in the updated catalog (original EPRI catalog and 1985-2005 seismicity) performed as part of the WLS evaluation; and these events would not significantly impact the recurrence analysis. In addition, the recurrence analysis is performed as a check against the original 1989 EPRI (FSAR Reference 2.5.2-203) seismicity rates, which have been demonstrated to be slightly higher than seismicity rates determined from updated earthquake catalogs for this site and other recent ESP and COL applications.

In order to further justify this approach, the 89 events in the catalog update (1985-2005) presented in FSAR Table 2.5.2-201 were examined visually for dependent events. The identification of dependent events was based on temporal and spatial proximity and eight were identified as being dependent. In the table below, five groups are identified, showing the "mainshock" and the associated dependent events. Main events are labeled M1 through M5; the dependent events 1 through 8. The last column shows the time duration of each group. With the exception of the M1 group, all time spans are less than five days. Although event 3 follows M1 by 34 days, its near spatial coincidence with M1, and occurrence 20 days after event 3, justifies its inclusion in the M1 group.

Event Number	Year	Month	Day	Hour	Lat	Lon	Rmb Mag	Time Span (Days)
1	1986	12	3	9	37.580	-77.458	3.37	43
M1	**1986**	**12**	**10**	**11**	**37.585**	**-77.468**	**3.51**	
2	1986	12	24	17	37.583	-77.458	3.37	
3	1987	1	13	14	37.584	-77.465	3.37	
M2	**1987**	**7**	**11**	**0**	**36.105**	**-83.816**	**3.80**	0
4	1987	7	11	2	36.103	-83.819	3.44	
M3	**1995**	**3**	**11**	**8**	**36.959**	**-83.133**	**3.81**	0
5	1995	3	11	9	36.990	-83.180	3.31	
6	2002	11	8	13	32.422	-79.950	3.69	4
M4	**2002**	**11**	**11**	**23**	**32.404**	**-79.936**	**4.42**	
M5	**2003**	**4**	**29**	**8**	**34.445**	**-85.620**	**4.71**	4
7	2003	4	29	9	34.440	-85.640	3.20	
8	2003	5	2	2	34.490	-85.610	3.37	

To show the effect of the updated seismicity on earthquake recurrence in zones relevant to the site, FSAR Subsection 2.5.2.4.1 describes new recurrence curves computed using the updated catalog (original EPRI catalog and the1985-2005 seismicity) for three test sources, and compared to curves using only the original EPRI catalog (FSAR Reference 2.5.2-204). As shown in FSAR Figure 2.5.2-212, the test sources are Central South Carolina, Charleston, and Southern Appalachians. Recurrence curves for these test sources show that the updated rates (using the original EPRI catalog and the 1985-2005 seismicity) are slightly lower than the original EPRI rates (FSAR Figures 2.5.2-213 through 215). Of the eight earthquakes in the above table, four are located within the Southern Appalachians zone (events 4, 5, 7, 8), and none of the dependent events are located within the other two zones. In other words, the rates of the Central South Carolina and Charleston zones are unaffected by the dependent events. The deletion of four magnitude ~3 dependent events from the Southern Appalachians zone will not change the conclusion demonstrated in FSAR Figure 2.5.2-215 that the updated rate in this zone does not exceed the original EPRI rate.

Reference:

1. Richter, C.F., Elementary Seismology, W.H. Freeman and Co., 768 pp., 1958.

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

None

Attachments:

None

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 063

NRC Technical Review Branch:	**Geosciences and Geotechnical Engineering Branch 2 (RGS2)**
Reference NRC RAI Number(s):	**RAI 02.05.02-036**

NRC RAI:

FSAR Table 2.5.2-201 does not include sources for the earthquake parameters which are presented. Please indicate sources for the earthquake parameters (hypocenter, magnitude, etc) presented in Table 2.5.2-201.

Duke Energy Response:

The source catalog (CAT) for each listed earthquake will be added to FSAR Table 2.5.2-201. The attached mark-up will be incorporated into a future revision of the Final Safety Analysis Report.

References:

None

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

FSAR Table 2.5.2-201

Attachments:

1) Mark-up of FSAR Table 2.5.2-201

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 1 to RAI 02.05.02-036

Mark-up of FSAR Table 2.5.2-201

COLA Part 2, FSAR, Chapter 2, FSAR Table 2.5.2-201, is revised as follows:

Table 2.5.2-201 (Sheet 1 of 5)
1985–2005 UPDATE TO THE EARTHQUAKE CATALOG FOR EVENTS ≥ EMB 3.0

VLS COL 2.5-2

Year	Mon	Day	Hr	Min	Sec	Latitude	Longitude	Z (km)	MMI	Emb	Smb	Rmb	CAT
1985	6	10	12	22	38.30	37.2480	-80.4850	11.10	4	3.30	0.10	3.31	SEUSSN
1985	12	22	0	56	5.00	35.7010	-83.7200	13.40		3.25	0.30	3.35	SEUSSN
1986	1	7	1	26	43.30	35.6100	-84.7610	23.10		3.06	0.30	3.17	SEUSSN
1986	2	13	11	35	45.55	34.7550	-82.9430	5.00		3.50	0.10	3.51	ANSS
1986	3	13	2	29	31.40	33.2290	-83.2260	5.00	4	3.30	0.25	3.37	SEUSSN
1986	3	26	16	36	23.90	37.2450	-80.4940	11.90	4	3.30	0.25	3.37	SEUSSN
1986	7	11	14	26	14.80	34.9370	-84.9870	13.00	6	3.80	0.10	3.81	SEUSSN
1986	9	17	9	33	49.50	32.9310	-80.1590	6.70	4	3.30	0.25	3.37	SEUSSN
1986	12	3	9	44	21.20	37.5800	-77.4580	1.60	4	3.30	0.25	3.37	SEUSSN
1986	12	10	11	30	6.10	37.5850	-77.4680	1.20	5	3.50	0.10	3.51	SEUSSN
1986	12	24	17	58	38.30	37.5830	-77.4580	1.00	4	3.30	0.25	3.37	SEUSSN
1987	1	13	14	50	40.90	37.5840	-77.4650	2.50	4	3.30	0.25	3.37	SEUSSN
1987	3	16	13	9	26.80	34.5600	-80.9480	3.00		3.06	0.30	3.17	SEUSSN
1987	3	27	7	29	30.50	35.5650	-84.2300	18.50	6	4.20	0.10	4.21	SEUSSN
1987	6	4	17	19	23.40	37.9390	-85.8000	7.60		3.06	0.30	3.17	SEUSSN
1987	7	11	0	4	29.50	36.1050	-83.8160	25.10	5	3.79	0.10	3.80	SEUSSN
1987	7	11	2	48	5.90	36.1030	-83.8190	23.80	4	3.43	0.10	3.44	SEUSSN
1987	9	1	23	2	49.40	35.5150	-84.3960	21.10		3.06	0.30	3.17	SEUSSN
1987	9	22	17	23	50.10	35.6230	-84.3120	19.40	5	3.50	0.10	3.51	SEUSSN

Table 2.5.2-201 (Sheet 2 of 5)
1985–2005 UPDATE TO THE EARTHQUAKE CATALOG FOR EVENTS ≥ EMB 3.0

Year	Mon	Day	Hr	Min	Sec	Latitude	Longitude	Z (km)	MMI	Emb	Smb	Rmb	CAT
1987	11	27	18	58	29.30	36.8520	-83.1100	26.80	5	3.50	0.10	3.51	SEUSSN
1987	12	12	3	53	28.79	34.2440	-82.6280	5.00		3.00	0.10	3.01	ANSS
1988	1	9	1	7	40.60	35.2790	-84.1990	12.20	4	3.30	0.25	3.37	SEUSSN
1988	1	23	1	57	16.40	32.9350	-80.1570	7.40	5	3.50	0.25	3.57	SEUSSN
1988	2	16	15	26	54.80	36.5950	-82.2740	4.00	4	3.30	0.10	3.31	SEUSSN
1988	2	18	0	37	45.40	35.3460	-83.8370	2.40	4	3.50	0.10	3.51	SEUSSN
1988	4	14	23	37	31.10	37.2380	-81.9870	0.00		4.10	0.10	4.11	ANSS
1988	8	27	16	52	29.50	37.7180	-77.7750	14.30	4	3.30	0.25	3.37	SEUSSN
1989	4	10	18	12	16.00	37.1360	-82.0680	0.00		4.30	0.10	4.31	ANSS
1989	6	2	5	4	34.00	32.9340	-80.1660	5.80	4	3.30	0.25	3.37	SEUSSN
1990	8	17	21	1	15.90	36.9340	-83.3840	0.60	5	4.00	0.10	4.01	SEUSSN
1990	11	8	10	8	25.40	37.1080	-83.0310	0.40		3.16	0.30	3.26	SEUSSN
1990	11	13	15	22	13.00	32.9470	-80.1360	3.40	5	3.50	0.10	3.51	SEUSSN
1991	3	15	6	54	8.30	37.7460	-77.9090	15.50	5	3.80	0.10	3.81	SEUSSN
1991	4	22	1	1	20.20	37.9420	-80.2050	14.80	4	3.50	0.10	3.51	SEUSSN
1991	6	2	6	5	34.90	32.9800	-80.2140	5.00	5	3.50	0.25	3.57	SEUSSN
1991	9	24	7	21	7.00	35.7010	-84.1170	13.30	4	3.30	0.10	3.31	SEUSSN
1991	10	30	14	54	12.60	34.9040	-84.7130	8.10		3.06	0.30	3.17	SEUSSN
1992	1	3	4	21	23.90	33.9810	-82.4210	3.30	5	3.50	0.25	3.57	SEUSSN

Table 2.5.2-201 (Sheet 3 of 5)
1985–2005 UPDATE TO THE EARTHQUAKE CATALOG FOR EVENTS ≥ EMB 3.0

Year	Mon	Day	Hr	Min	Sec	Latitude	Longitude	Z (km)	MMI	Emb	Smb	Rmb	CAT
1992	8	21	16	31	56.10	32.9850	-80.1630	6.50	6	4.10	0.10	4.11	SEUSSN
1993	1	15	2	2	50.90	35.0390	-85.0250	8.10	4	3.30	0.10	3.31	SEUSSN
1993	7	12	4	48	20.80	36.0350	-79.8230	5.00	4	3.30	0.10	3.31	SEUSSN
1993	8	8	9	24	32.40	33.5970	-81.5910	8.50	5	3.50	0.10	3.51	SEUSSN
1994	2	12	2	40	24.50	36.8000	-82.0000	5.00		3.42	0.41	3.61	ANSS
1994	4	5	22	22	0.40	34.9690	-85.4910	24.30	5	3.50	0.10	3.51	SEUSSN
1994	4	16	20	10	12.20	35.7520	-83.9680	1.80	5	3.50	0.25	3.57	SEUSSN
1995	3	11	8	15	52.32	36.9590	-83.1330	1.00		3.80	0.10	3.81	ANSS
1995	3	11	9	50	4.44	36.9900	-83.1800	1.00		3.30	0.10	3.31	ANSS
1995	3	18	22	6	20.80	35.4220	-84.9410	26.00		3.25	0.30	3.35	SEUSSN
1995	4	17	13	46	0.00	32.9970	-80.1710	8.40	6	3.90	0.10	3.91	SEUSSN
1995	6	26	0	36	17.10	36.7520	-81.4810	1.80	5	3.40	0.10	3.41	SEUSSN
1995	7	5	14	16	44.70	35.3340	-84.1630	10.00	4	3.70	0.10	3.71	SEUSSN
1995	7	7	21	1	3.00	36.4930	-81.8330	10.00	4	3.06	0.10	3.08	SEUSSN
1995	10	26	0	37	28.96	37.0530	-83.1210	1.00		3.90	0.41	4.10	ANSS
1996	4	19	8	50	14.01	36.9810	-83.0180	0.00		3.90	0.10	3.91	ANSS
1996	6	29	19	30	42.67	37.1870	-81.9500	1.00		4.10	0.10	4.11	ANSS
1997	5	19	19	45	35.80	34.6220	-85.3530	2.70	4	3.06	0.10	3.08	SEUSSN
1997	7	19	17	6	34.40	34.9530	-84.8110	2.80	4	3.61	0.10	3.62	SEUSSN

Table 2.5.2-201 (Sheet 4 of 5)
1985–2005 UPDATE TO THE EARTHQUAKE CATALOG FOR EVENTS ≥ EMB 3.0

Year	Mon	Day	Hr	Min	Sec	Latitude	Longitude	Z (km)	MMI	Emb	Smb	Rmb	CAT
1997	7	30	12	29	25.30	36.5120	-83.5470	23.00	5	3.80	0.10	3.81	SEUSSN
1997	10	28	10	36	46.56	37.1620	-82.0250	1.00		3.42	0.41	3.61	ANSS
1998	4	13	9	56	15.60	34.4710	-80.6030	6.60	5	3.90	0.10	3.91	SEUSSN
1998	6	5	2	31	3.90	35.5540	-80.7850	9.40		3.34	0.10	3.35	SEUSSN
1998	6	17	8	0	23.90	35.9440	-84.3920	11.30	5	3.60	0.10	3.61	SEUSSN
1998	10	21	5	56	46.90	37.4220	-78.4390	12.60	3	3.80	0.10	3.81	SEUSSN
1999	1	17	18	38	5.10	36.8930	-83.7990	1.00	3	3.06	0.27	3.15	SEUSSN
2000	1	18	22	19	32.20	32.9200	-83.4650	19.20	5	3.50	0.10	3.51	SEUSSN
2001	3	7	17	12	23.80	35.5520	-84.8500	6.80	3	3.20	0.10	3.21	SEUSSN
2001	3	21	23	35	34.90	34.8470	-85.4380	0.00	3	3.16	0.27	3.24	SEUSSN
2001	6	11	18	27	54.25	30.2260	-79.8850	10.00		3.33	0.41	3.53	ANSS
2001	7	26	5	26	46.00	35.9710	-83.5520	14.30	3	3.25	0.10	3.26	SEUSSN
2001	12	4	21	15	13.90	37.7260	-80.7520	8.50		3.10	0.10	3.11	SEUSSN
2001	12	8	1	8	22.40	34.7100	-86.2310	0.00	5	3.90	0.10	3.91	SEUSSN
2002	11	8	13	29	3.19	32.4220	-79.9500	3.90		3.50	0.41	3.69	ANSS
2002	11	11	23	39	29.72	32.4040	-79.9360	2.40		4.23	0.41	4.42	ANSS
2003	3	18	6	4	24.21	33.6890	-82.8880	5.00		3.50	0.41	3.69	ANSS
2003	4	29	8	59	38.10	34.4450	-85.6200	9.10	6	4.70	0.10	4.71	SEUSSN
2003	4	29	9	45	45.00	34.4400	-85.6400	3.10		3.01	0.41	3.20	ANSS

Table 2.5.2-201 (Sheet 5 of 5)
1985–2005 UPDATE TO THE EARTHQUAKE CATALOG FOR EVENTS ≥ EMB 3.0

Year	Mon	Day	Hr	Min	Sec	Latitude	Longitude	Z (km)	MMI	Emb	Smb	Rmb	CAT
2003	5	2	10	48	44.00	34.4900	-85.6100	14.50		3.17	0.41	3.37	ANSS
2003	5	5	10	53	49.90	33.0550	-80.1900	11.40		3.06	0.30	3.17	SEUSSN
2003	5	5	16	32	33.90	37.6550	-78.0550	2.80	5	3.90	0.10	3.91	SEUSSN
2003	7	13	20	15	16.96	32.3350	-82.1440	5.00		3.58	0.41	3.77	ANSS
2003	12	9	20	59	18.70	37.7740	-78.1000	10.00	6	4.50	0.10	4.51	SEUSSN
2004	5	9	8	56	10.40	33.2310	-86.9600	5.00	3	3.30	0.10	3.31	SEUSSN
2004	7	20	9	13	14.40	32.9720	-80.2480	10.30		3.06	0.30	3.17	SEUSSN
2004	8	19	23	51	49.40	33.2030	-86.9680	5.00	3	3.50	0.10	3.51	SEUSSN
2004	9	17	15	21	43.60	36.9330	-84.0040	1.30	5	3.70	0.10	3.71	SEUSSN
2005	2	18	14	21	54.00	34.0500	-81.1100	5.00		3.17	0.41	3.37	ANSS
2005	4	5	20	37	43.00	36.1500	-83.6900	10.00		3.01	0.41	3.20	ANSS
2005	8	25	3	9	42.00	35.8800	-82.8000	7.90		3.66	0.41	3.85	ANSS
2005	10	12	6	27	30.00	35.5100	-84.5400	8.20		3.58	0.41	3.77	ANSS

Notes:

Z = hypocentral depth

MMI = Modified Mercalli Index intensity

Emb = estimated body wave magnitude (see Equations 2.5.2-1 and 2.5.2-2)

Smb = estimate of variance for Emb

Rmb = best estimate of body wave magnitude from the largest calculated value of Emb and the variance

CAT = source catalog; SEUSSN = Southeastern United States Seismic Network; ANSS = Advanced National Seismic System

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 063

NRC Technical Review Branch: Geosciences and Geotechnical Engineering Branch 2 (RGS2)

Reference NRC RAI Number(s): RAI 02.05.02-037

NRC RAI:

FSAR Sections 2.5.2.2.1 (pg 2.5-87) and 2.5.1.1.3.2.2 (pg 2.5-39) state that maximum magnitude (mmax) values were converted from moment-magnitude (M) to body-wave magnitude (mb) using the arithmetic average of results from three equations. Three references are cited, including Frankel et al. (1996). As described in the Frankel et al (1996) reference, however, two published equations were applied therein for the mmax conversion (i.e., Johnston, 1994, and Boore and Atkinson, 1987), with each used for a different ground-motion relation. Consequently, it is not clear what is meant by the reference to the Frankel et al (1996) equation. Please clarify the Frankel et al (1996) reference and indicate the specific conversion relations that were used.

Duke Energy Response:

The Frankel et al. (1996) (FSAR Reference 2.5.2-209) equation used in magnitude conversions is described in the second paragraph on page 6 of Frankel et al. (1996) and provided below:

$$M = 3.45 - 0.473mbLg + 0.145mbLg^2;$$

where M = moment magnitude and mbLg = body wave magnitude based on Lg wave amplitude.

References:

None

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

None

Attachments:

None

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 063

NRC Technical Review Branch: **Geosciences and Geotechnical Engineering Branch 2 (RGS2)**

Reference NRC RAI Number(s): **RAI 02.05.02-038**

NRC RAI:

FSAR Section 2.5.2.2.1.3 (pg 2.5-92) cites Source 108 for Law Engineering as "Brunswick, NC Background". This source should be labeled "Brunswick, GA Background" since its location includes Brunswick, GA, not NC. The source coincides approximately with the location of the South Georgia Rift Basin. Please correct the label for Source 108.

Duke Energy Response:

Law Engineering source 108 is named "Brunswick, NC Background" in the 1989 EPRI EQHAZARD Primer (EPRI NP-6452-D) (FSAR Reference 2.5.2-207). Despite its name, Law Engineering source 108 does not include any portion of North Carolina. However, Law Engineering source 108 does include Brunswick, Georgia. This discrepancy is potentially misleading, and apparently is the result of a minor naming error in EPRI NP-6452-D (FSAR Reference 2.5.2-207). In the original 1986 Law Engineering team volume (EPRI NP-4726) (FSAR Reference 2.5.2-201), Law Engineering source 108 is simply named "Brunswick."

To be consistent with EPRI NP-6452-D (FSAR Reference 2.5.2-207), the source name "Brunswick, NC Background" is reported in the FSAR. To avoid confusion, the text of FSAR Subsection 2.5.2.2.1.3 is modified to alert the reader to the misleading nature of the name of Law Engineering source 108. The attached mark-up will be included in a future revision of the Final Safety Analysis Report.

References:

None

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

FSAR Subsection 2.5.2.2.1.3

Attachments:

1) Mark-up of FSAR Subsection 2.5.2.2.1.3

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 1 to RAI 02.05.02-038

Mark-up of FSAR Subsection 2.5.2.2.1.3

COLA Part 2, FSAR, Chapter 2, Subsection 2.5.2.2.1.3, eighth paragraph, is revised as follows:

Brunswick, NC Background (108). The Lee Nuclear Site is located 100 mi. from the Brunswick, NC Background source zone (108). Despite its name, Law Engineering source 108 does not include any portion of North Carolina. However, Law Engineering source 108 does include Brunswick, Georgia. This discrepancy is potentially misleading, and apparently is the result of a minor naming error in EPRI NP-6452-D (Reference 207). To be consistent with EPRI NP-6452-D (Reference 207), the source name "Brunswick, NC Background" is reported herein. This source represents a zone defined by a low-amplitude, long-wavelength magnetic anomaly pattern. The Law Engineering team interprets this pattern as possibly indicating a zone of Mesozoic extended crust. Law Engineering assigns a maximum M_{max} value of m_b 6.8 (**M** 6.8) to this source.

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 063

NRC Technical Review Branch: **Geosciences and Geotechnical Engineering Branch 2 (RGS2)**

Reference NRC RAI Number(s): **RAI 02.05.02-041**

NRC RAI:

FSAR Section 2.5.2.4 (pg 2.5-115) mentions the Catawba, McGuire and Oconee sites in regard to comparing the percent difference of seismic hazard calculated for the Lee site to those other hard-rock sites in the CEUS. These comparisons are presented in FSAR Table 2.5.2-216. However, the locations of the four sites are not shown relative to each other or to regional geology and seismicity. Please provide a figure showing the relative locations of the Lee, Catawba, McGuire and Oconee sites, including generalized geology and seismicity, to accompany the information shown in Table 2.5.2-216.

Duke Energy Response:

Figure 1 shows the locations of the Lee, Catawba, McGuire, and Oconee sites, and includes generalized geology modified after Hibbard et al. (2006) (FSAR Reference 2.5.3-210) and earthquake epicenters from the updated seismicity catalog assembled for the Lee COLA. As shown on Figure 1, all four sites are located within metamorphosed intrusive, volcanic, or sedimentary rocks of Neoproterozoic to Cambrian age. Moreover, all four sites are located in areas of sparse seismicity.

References:

None

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

None

Attachments:

1) Figure 1. Lithotectonic Map Showing Seismicity and Locations of the Lee, Catawba, McGuire, and Oconee Sites.

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 1 to RAI 02.05.02-041

Figure 1. Lithotectonic Map Showing Seismicity and Locations of the Lee, Catawba, McGuire, and Oconee Sites.

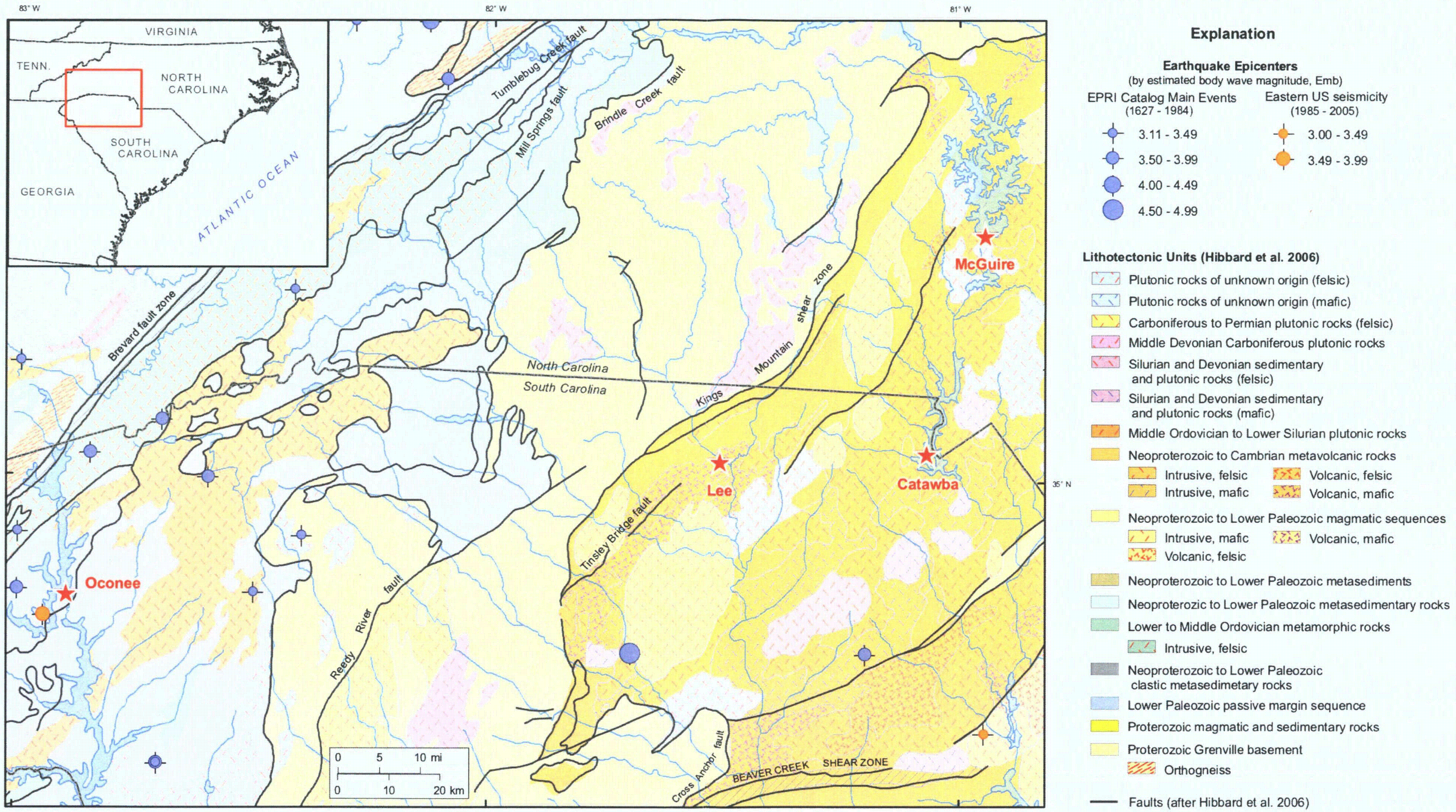


Figure 1. Lithotectonic Map Showing Seismicity and Locations of the Lee, Catawba, McGuire, and Oconee Sites.

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 063

NRC Technical Review Branch: **Geosciences and Geotechnical Engineering Branch 2 (RGS2)**

Reference NRC RAI Number(s): **RAI 02.05.02-043**

NRC RAI:

In FSAR Figure 2.5.2-228 (i.e., the 1 Hz hazard curve), the mean hazard matches the 85 percentile hazard at exceedence frequencies less than ~2e-5. In Figure 2.5.2-229 (0.5 Hz hazard curve), the mean hazard exceeds the 85% percentile hazard at exceedence frequencies less than ~6e-5. This information suggests an extremely "fat-tailed" distribution of hazard at low spectral frequencies (long periods) and higher (0.1 g) ground motions.

Please elaborate on the probability distribution of exceedence frequencies at these periods and ground motion levels.

Duke Energy Response:

The mean hazard in FSAR Figures 2.5.2-228 and 2.5.2-229 is near or above the 85% hazard because the New Madrid seismic zone contributes significantly to the hazard at low spectral frequencies (1 Hz and 0.5 Hz), and because one equation from the EPRI (2004) (FSAR Reference 2.5.2-202) study dominates the hazard for large magnitudes at long distances. The New Madrid seismic zone is about 740 km from the Lee site, and produces magnitudes in the range 7 to 8, and this source contributes significantly to hazard at low spectral frequencies (see FSAR Figures 2.5.2-231, 2.5.2-233, and 2.5.2-235).

Table 1 (Attachment 1) shows median 1 Hz spectral accelerations estimated for the twelve ground motion equations in the EPRI (2004) study, which are the equations used in the seismic hazard calculations for the Lee Nuclear Station FSAR.

The median spectral accelerations (SA) in Table 1 were read from Figures E-2, E-9, E-16, and E-23 of EPRI (2004). Weights for each equation were calculated from the cluster weights and alternative model weights given in Figure 5-3 of EPRI (2004). The "Conditional P[SA>0.1g]" column in Table 1 indicates the probability of exceeding 0.1g spectral acceleration for each ground motion equation, given the occurrence of an earthquake with **M**=8 and R=750 km, and given a generic standard deviation of $\sigma_{\ln\ SA}$=0.6. The total weighted probability of exceeding 0.1g (weighted over the twelve equations) is shown at the bottom.

The last column in Table 1 shows the % contribution to P[SA>0.1g] for each of the twelve equations. One equation (cluster 3, high alternative) contributes 86.7% of the total P[SA>0.1g]. The reason is that, although the weight on this equation is only 0.0363, the median SA value is so high that this equation dominates the total hazard. This dominance is also evident in the "Conditional P[SA>0.1g]" column, where the conditional probability from this equation is more than a factor of 25 higher than all other equations.

In summary, at low spectral frequencies, one ground motion equation gives high spectral acceleration values for large magnitudes and long distances. As a result, this one equation results in seismic hazard in the upper tail of the epistemic hazard distribution, and the mean hazard depends strongly on this one equation. As a result, the mean hazard lies in the upper fractiles of the epistemic uncertainty in hazard.

References:

None

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

None

Attachments:

1) Table 1. Example P[SA>0.1g] from New Madrid Seismic Zone

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 1 to RAI 02.05.02-043

Table 1. Example P[SA>0.1g] from New Madrid Seismic Zone

Table 1. Example P[SA>0.1g] from New Madrid Seismic Zone

Cluster	Alternative	Weight	Figure*	1 Hz median SA**	Conditional P[SA>0.1g]***	% contrib. to P[SA>0.1g]
1	low	0.0509	E-2	6.00E-03	1.37E-06	0.0%
1	middle	0.1732	E-2	9.00E-03	3.00E-05	0.1%
1	high	0.0509	E-2	1.60E-02	1.13E-03	0.9%
2	low	0.0577	E-9	7.00E-03	4.67E-06	0.0%
2	middle	0.1966	E-9	1.00E-02	6.21E-05	0.2%
2	high	0.0577	E-9	1.70E-02	1.57E-03	1.4%
3	low	0.0363	E-16	1.00E-02	6.21E-05	0.0%
3	middle	0.1235	E-16	2.20E-02	5.81E-03	10.7%
3	high	0.0363	E-16	5.50E-02	1.60E-01	86.7%
4	low	0.0401	E-23	2.20E-03	1.01E-10	0.0%
4	middle	0.1367	E-23	5.00E-03	2.98E-07	0.0%
4	high	0.0401	E-23	9.00E-03	3.00E-05	0.0%
				total prob.:	6.68E-03	

* Figure in EPRI (2004) used to read 1 Hz median SA values

** Median spectral acceleration for **M**=8, R=750 km

*** Conditional on the occurrence of **M**=8, R=750 km event using each equation

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 063

NRC Technical Review Branch: **Geosciences and Geotechnical Engineering Branch 2 (RGS2)**

Reference NRC RAI Number(s): **RAI 02.05.02-044**

NRC RAI:

RG 1.208 states that fractile hazard curves should be reported at the 0.05, 0.16, 0.50, 0.84 and 0.95 levels. FSAR Figures 2.5.2-223 through 2.5.2-229 only show mean, median and 0.15 and 0.85 fractile hazard curves. Also, Figure 2.5.2-230 does not illustrate the rock UHRS for 10-6 annual frequencies.

Please include the suggested fractile hazard curves in Figures 2.5.2-223 through 2.5.2-229, and plot the rock UHRS for 10-6 annual frequencies in Figure 2.5.2-230.

Duke Energy Response:

The requested fractile hazard curves and the rock Uniform Hazard Response Spectra (UHRS) for 1E-6 annual frequency of exceedance are included in revised FSAR Figures 2.5.2-223 through 2.5.2-229, and in revised FSAR Figure 2.5.2-230, respectively. The revised figures attached to this enclosure will be incorporated into a future revision of the Final Safety Analysis Report.

References:

None

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

FSAR Figures 2.5.2-223 through 2.5.2-230

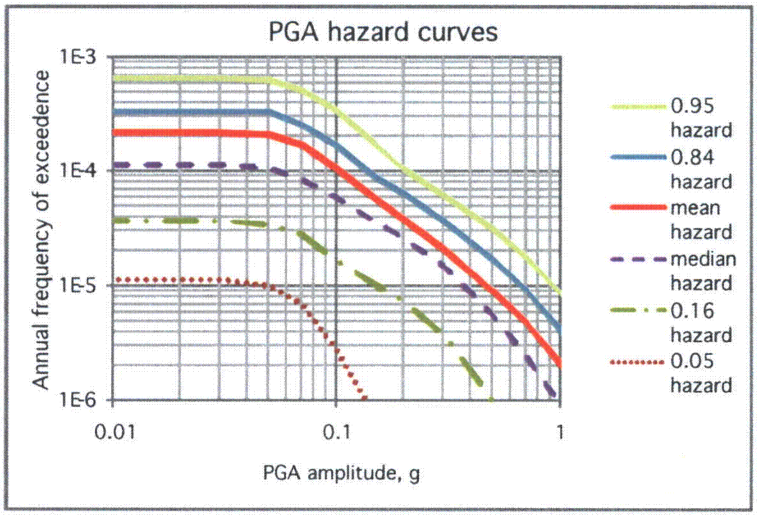
Attachments:

1) Revised FSAR Figure 2.5.2-223
2) Revised FSAR Figure 2.5.2-224
3) Revised FSAR Figure 2.5.2-225
4) Revised FSAR Figure 2.5.2-226
5) Revised FSAR Figure 2.5.2-227
6) Revised FSAR Figure 2.5.2-228
7) Revised FSAR Figure 2.5.2-229
8) Revised FSAR Figure 2.5.2-230

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 1 to RAI 02.05.02-044

Revised FSAR Figure 2.5.2-223



WLS COL 2.5-2

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

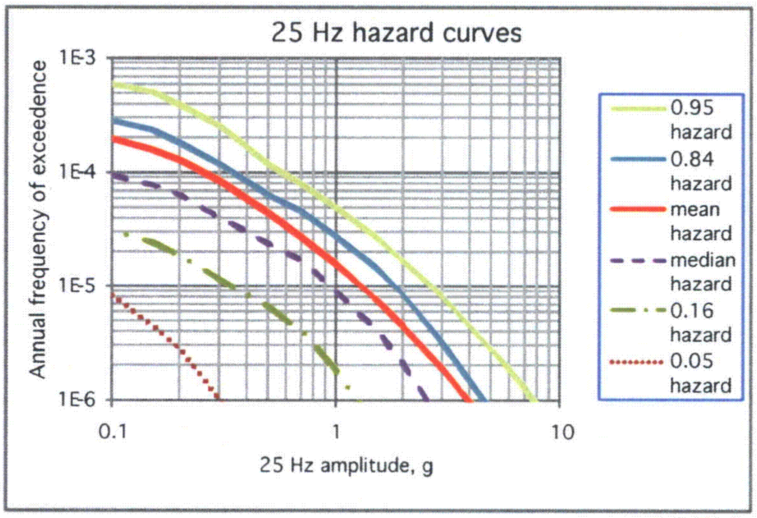
Seismic Hazard Curves for PGA

FIGURE 2.5.2-223

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 2 to RAI 02.05.02-044

Revised FSAR Figure 2.5.2-224



WLS COL 2.5-2

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

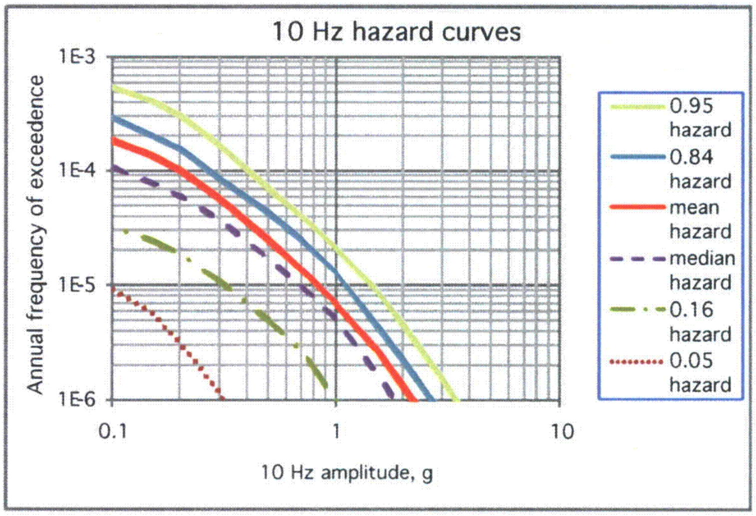
Seismic Hazard Curves for 25 Hz

FIGURE 2.5.2-224

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 3 to RAI 02.05.02-044

Revised FSAR Figure 2.5.2-225



WLS COL 2.5-2

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

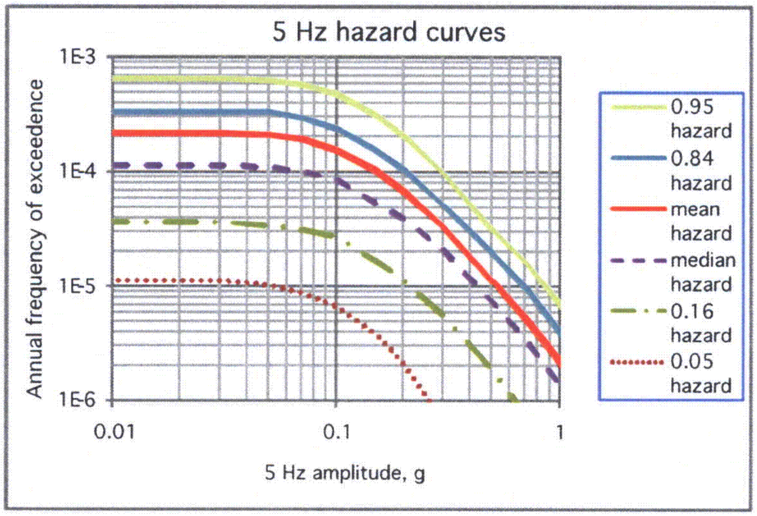
Seismic Hazard Curves for 10 Hz

FIGURE 2.5.2-225

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 4 to RAI 02.05.02-044

Revised FSAR Figure 2.5.2-226



WLS COL 2.5-2

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

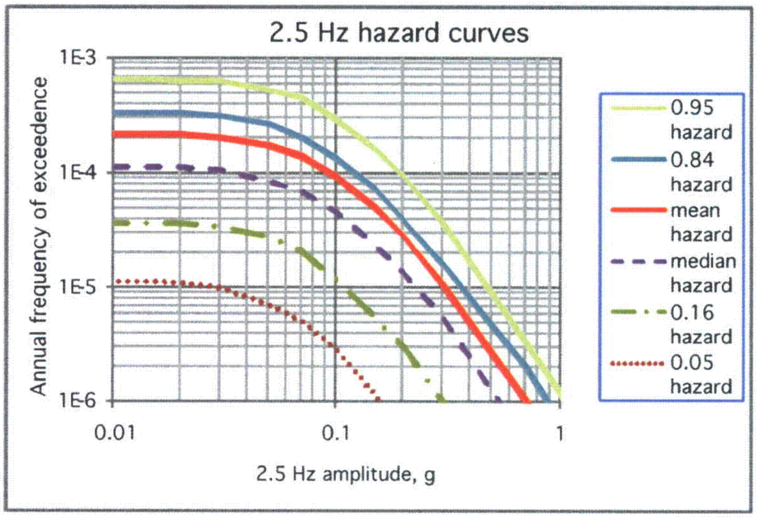
Seismic Hazard Curves for 5 Hz

FIGURE 2.5.2-226

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 5 to RAI 02.05.02-044

Revised FSAR Figure 2.5.2-227



WLS COL 2.5-2

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

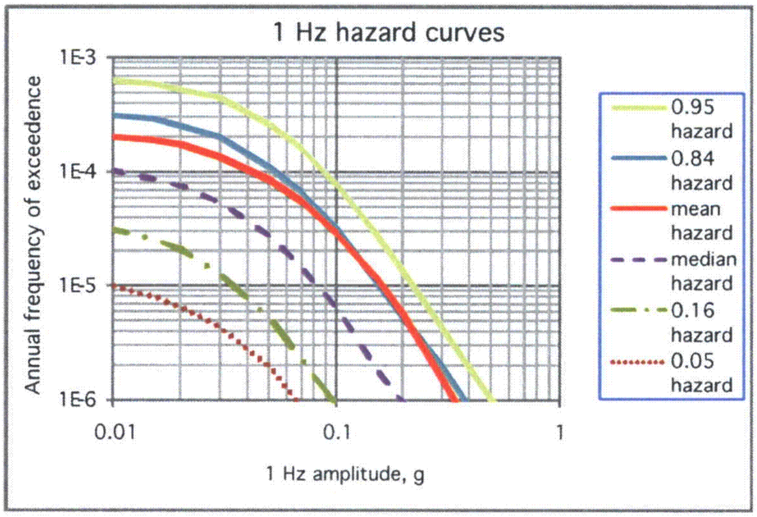
Seismic Hazard Curves for 2.5 Hz

FIGURE 2.5.2-227

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 6 to RAI 02.05.02-044

Revised FSAR Figure 2.5.2-228



WLS COL 2.5-2

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

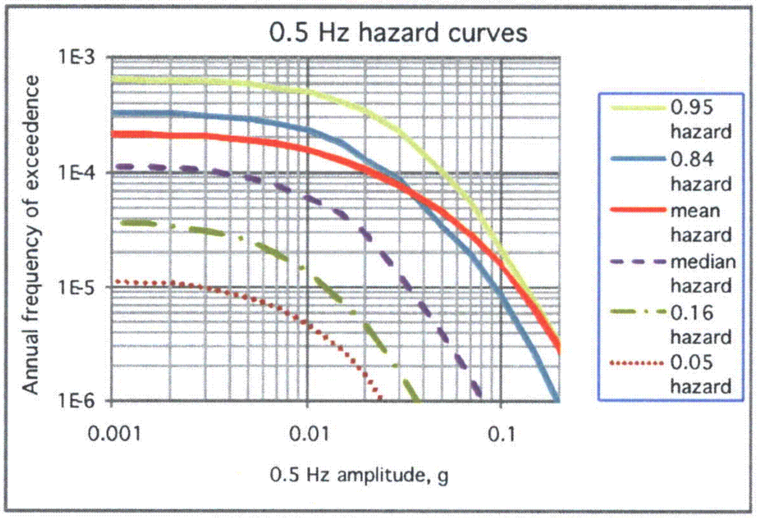
Seismic Hazard Curves for 1 Hz

FIGURE 2.5.2-228

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 7 to RAI 02.05.02-044

Revised FSAR Figure 2.5.2-229



WLS COL 2.5-2

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

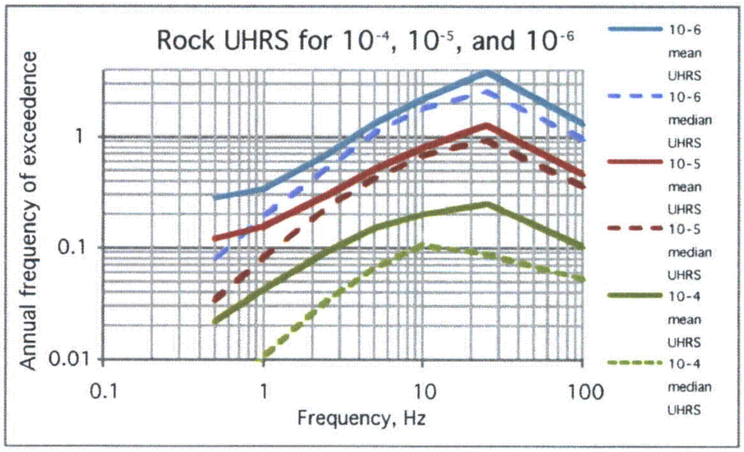
Seismic Hazard Curves for 0.5 Hz

FIGURE 2.5.2-229

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 8 to RAI 02.05.02-044

Revised FSAR Figure 2.5.2-230



WLS COL 2.5-2

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Mean and Median UHRS for 10^{-4}, 10^{-5}, and 10^{-6} Annual Frequency of Exceedence for Seven Structural Frequencies

FIGURE 2.5.2-230

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 063

NRC Technical Review Branch: Geosciences and Geotechnical Engineering Branch 2 (RGS2)

Reference NRC RAI Number(s): RAI 02.05.02-045

NRC RAI:

FSAR Section 2.5.2.4.4 discusses implementation of the Cumulative Absolute Velocity (CAV) model of Abrahamson and Watson-Lamrey (2005). Please provide details on how the CAV filter was implemented and how it impacts the hazard.

Duke Energy Response:

The Duke Energy response to RAI 02.05.02-047 (Enclosure 10 of this letter) corrects the author citation for FSAR Reference 2.5.2-250. The Cumulative Absolute Velocity (CAV) model is applied using the procedure described in Hardy et al. (2006) (FSAR Reference 2.5.2-250 as revised in Enclosure 10 of this letter)), in accordance with Regulatory Guide 1.208. The CAV model accounts for the non-damageability of ground motions from small magnitude, short duration earthquakes. A CAV amplitude of 0.16 g-sec is used as a conservative threshold below which ground motions will not cause damage to engineered facilities. The relevant equation for calculating the probability of CAV > 0.16 g-sec is given in Equations 2-2, 2-4, 2-7, and 2-8 of Hardy et al. (2006). Equation 2-7 of Hardy et al. (2006) is plotted in the attached Figure 1, which is taken from Figure 2-34 of Hardy et al. (2006). CAV depends on the magnitude of the earthquake, on the peak ground acceleration (PGA) level, on the site conditions as represented by the average shear wave velocity in the top 30 m (V_{S30}), and on duration of the ground motion, which is estimated from the magnitude. As Figure 1 shows, as the magnitude of the earthquake increases and/or the PGA level increases, the probability of CAV > 0.16 g-sec increases to unity.

The CAV model was implemented in the seismic hazard calculations by calculating the probability that CAV > 0.16 g-sec, and by modifying the frequency of exceedance of ground motions within the hazard calculations to only include damaging ground motions (i.e., by multiplying by the probability that CAV > 0.16 g-sec). As indicated above, this calculation depends on the magnitude of the earthquake, on the peak ground acceleration (PGA) level, on the site conditions as represented by the average shear wave velocity in the top 30 m (V_{S30}), and on duration of the ground motion, which is estimated from the magnitude. Seismic hazard calculations for spectral accelerations other than 100 Hz (which is equivalent to PGA) are discussed in the Duke Energy response to RAI 02.05.02-047 (Enclosure 10 of this letter).

The effect of the CAV filter on seismic hazard curves is to limit the hazard at low amplitudes to an asymptotic value, which is the frequency of occurrence of damaging ground motions from earthquakes in the region. At high amplitudes, there is little effect of the CAV filter. If the CAV filter had not been applied, the hazard curves would not roll over to the horizontal asymptote but would be higher at small amplitudes. At high amplitudes there would be little to no difference in the seismic hazard curves.

References:

None

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

None

Attachments:

1) Figure 1. Probability of CAV > 0.16 g-sec as a Function of Earthquake Magnitude and PGA Level

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 1 to RAI 02.05.02-045

Figure 1. Probability of CAV > 0.16 g-sec as a Function of Earthquake Magnitude and PGA Level

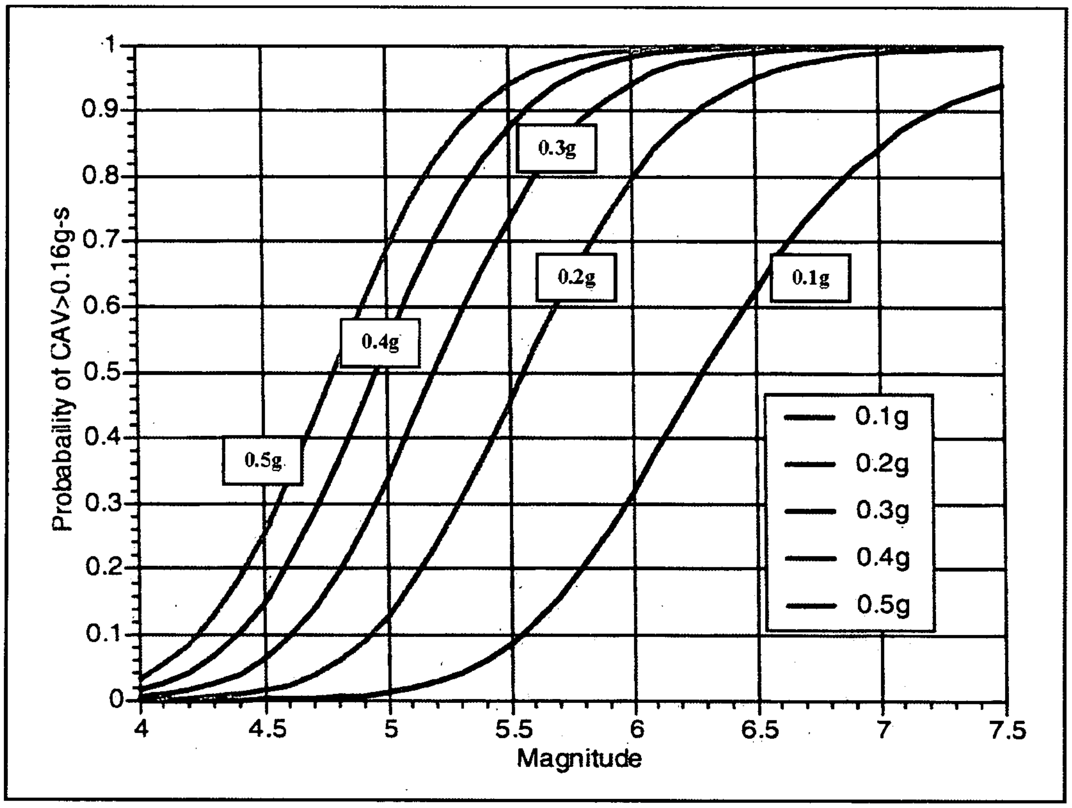


Figure 1. Probability of CAV > 0.16 g-sec as a Function of Earthquake Magnitude and PGA Level

Taken from Figure 2-34 of Hardy et al. (2006) (FSAR Reference 2.5.2-250 as revised in Enclosure 10 of this letter), for a site with V_{S30}=1000 m/s.

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 063

NRC Technical Review Branch: **Geosciences and Geotechnical Engineering Branch 2 (RGS2)**

Reference NRC RAI Number(s): **RAI 02.05.02-046**

NRC RAI:

The FSAR uses the EPRI (2004) ground motion equations in the updated PSHA. Since 2004, however, two new ground motion prediction models for the CEUS have been published. These published models are "Empirical-stochastic ground-motion prediction for eastern North America", Tavakoli and Pezeshk (BSSA, 2005, v.95[6], 2283-2296); and "Earthquake groundmotion prediction equations for eastern North America", Atkinson and Boore (BSSA, 2006, v.96[6], 2181-2205).

Please describe the potential impact of these two new ground motion relations on the results of the PSHA.

Duke Energy Response:

FSAR Table 2.5.2-218 indicates that controlling earthquakes for annual frequencies of 10^{-4}, 10^{-5}, and 10^{-6} have magnitudes in the range **M** = 5.7 to 7.5.

The attached Figure 1 plots ground motion amplitudes for 10 Hz spectral acceleration for magnitude 5.7 (**M** = 5.7) earthquakes versus distance for the twelve equations used from EPRI (2004) (FSAR Reference 2.5.2-202), Tavakoli and Pezeshk (2005) (Reference 1), and Atkinson and Boore (2006) (Reference 2). At all distances, the range of the twelve EPRI (2004) models encompasses the ground motions predicted by the other two references, with the exception of approximately 55-85 km, where the Atkinson and Boore (2006) curve falls below the range of the EPRI (2004) models. The "Weighted Ave" curve (which is the weighted mean of the EPRI (2004) equations) generally falls between the ground motions estimated by other two references.

The attached Figure 2 shows a similar comparison of ground motion amplitudes for 1 Hz spectral acceleration for **M** = 7.5. At all distances, the range of the twelve EPRI (2004) models encompasses the ground motions predicted by the other two references, and the "Weighted Ave" curve (which is the weighted mean of the EPRI (2004) equations) falls between the ground motions estimated by other two references.

On the basis of the comparisons shown in Figures 1 and 2, it can be concluded that the potential impact of the Tavakoli and Pezeshk (2005) and Atkinson and Boore (2006) equations on the seismic hazard analysis would be very small, since the EPRI (2004) equations give similar ground motions over a wide range of magnitudes and distances.

References:

1. Tavakoli, B. and Pezeshk, S., 2005, Empirical-Stochastic Ground-Motion Prediction for Eastern North America, Bulletin of the Seismological Society of America, Dec 2005; 95: 2283 - 2296.

2. Atkinson, G. M. and Boore, D. M., 2006, Earthquake Ground-Motion Prediction Equations for Eastern North America, Bulletin of the Seismological Society of America, Dec 2006; 96: 2181 - 2205.

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

None

Attachments:

1) Figure 1. Predicted Ground Motions for **M** 5.7 at 10 Hz

2) Figure 2. Predicted Ground Motions for **M** 7.5 at 1 Hz

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 1 to RAI 02.05.02-046

Figure 1. Predicted Ground Motions for M 5.7 at 10 Hz

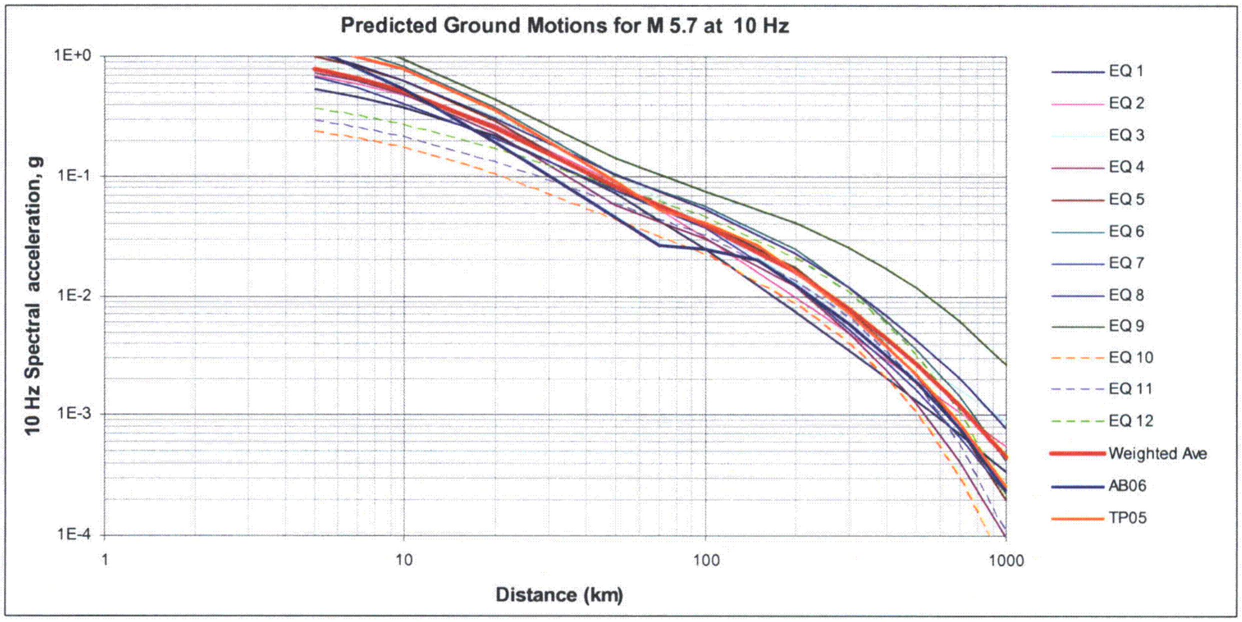


Figure 1. Predicted Ground Motions for M 5.7 at 10 Hz

The Atkinson and Boore (2006), AB06 (thick blue line), and Tavakoli and Pezeshk (2005), TP05 (thick orange line), are compared to EPRI (2004) (FSAR Reference 2.5.2-202) results (thick red line is weighted average, thin lines are the twelve individual models).

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 2 to RAI 02.05.02-046

Figure 2. Predicted Ground Motions for M 7.5 at 1 Hz

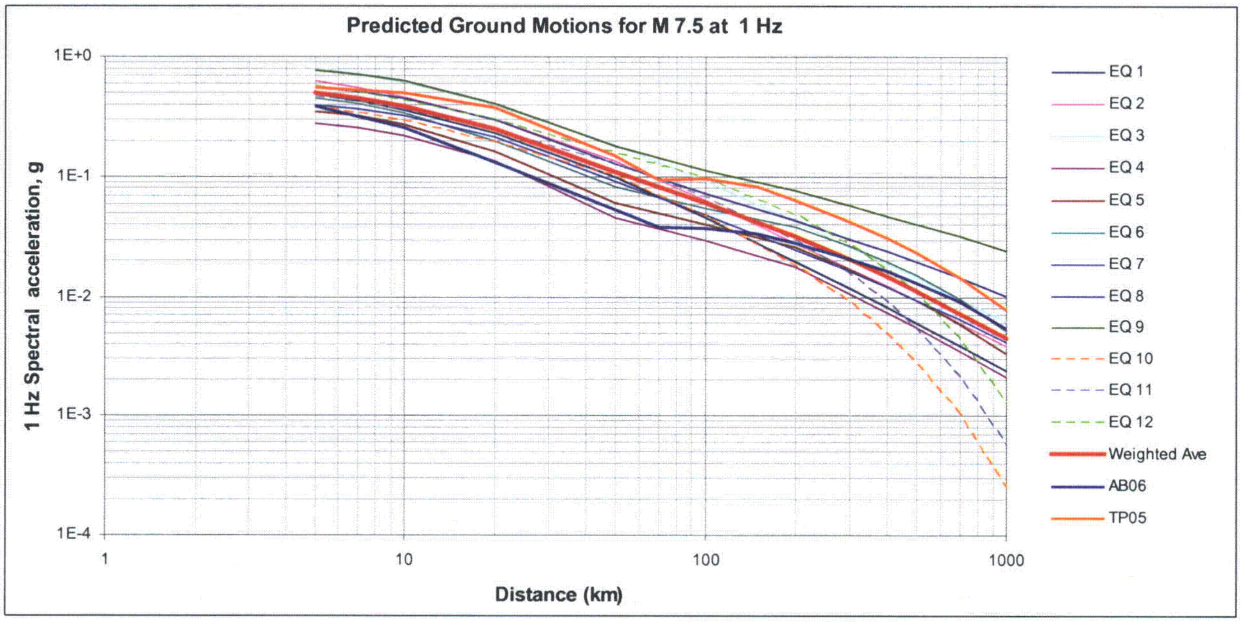


Figure 2. Predicted Ground Motions for M 7.5 at 1 Hz

The Atkinson and Boore (2006), AB06 (thick blue line), and Tavakoli and Pezeshk (2005), TP05 (thick orange line), are compared to EPRI (2004) (FSAR Reference 2.5.2-202) results (thick red line is weighted average, thin lines are the twelve individual models).

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter No. 063

NRC Technical Review Branch: **Geosciences and Geotechnical Engineering Branch 2 (RGS2)**

Reference NRC RAI Number(s): **RAI 02.05.02-047**

NRC RAI:

FSAR Section 2.5.2.4.4 (pg 2.5-121) states that ground motions for frequencies "other than 100 Hz" are assumed to be partially correlated with the ground motions at 100 Hz, so that the filtering is consistent from frequency to frequency. Please clarify what is meant by "frequencies other than 100 Hz".

Duke Energy Response:

The phrase, "frequencies other than 100 Hz," refers to other spectral frequencies at which seismic hazard calculations were made, specifically 25 Hz, 10 Hz, 5 Hz, 2.5 Hz, 1 Hz, and 0.5 Hz. The statement about correlations of ground motions is made in the context of the application of the cumulative absolute velocity (CAV) filter, wherein the deviation of ground motion amplitude at each spectral frequency (from its logarithmic mean value) is correlated to the deviation of ground motion amplitude at a different spectral frequency (from its logarithmic mean value). The correlation model is given in Equations 3-2 and 3-3 of Hardy et al (2006) (FSAR Reference 2.5.2-250 as revised in Attachment 2 of this enclosure). The correlation is specified between values of peak ground acceleration, which is equivalent to spectral acceleration at 100 Hz, and values of spectral acceleration at the other frequencies.

As part of this response, FSAR Subsection 2.5.2.4.4 text, and the citation for FSAR Reference 2.5.2-250, will be revised to include the complete author citation to Hardy et al. (2006), rather than the previous Abrahamson and Watson-Lamery (2005). Likewise, FSAR Reference 2.5.2-250 in FSAR Subsection 2.5.2.8 is revised to include the principal authors listed as Hardy, G., Merz, K., Abrahamson, N.A., and Watson-Lamprey, J. The attached mark-ups will be incorporated into a future revision of the Final Safety Analysis Report.

References:

None

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

FSAR Subsection 2.5.2.4.4

FSAR Subsection 2.5.2.8

Attachments:

1) Mark-up of FSAR Subsection 2.5.2.4.4
2) Mark-up of FSAR Subsection 2.5.2.8

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 1 to RAI 02.05.02-047

Mark-up of FSAR Subsection 2.5.2.4.4

COLA Part 2, FSAR, Chapter 2, Subsection 2.5.2.4.4, third full paragraph, first sentence, is revised as follows:

To correctly model the damageability of small magnitude earthquakes to engineered facilities, the Cumulative Absolute Velocity (CAV) model of Hardy et al. (2006) (Reference 250) is used.

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 2 to RAI 02.05.02-047

Mark-up of FSAR Subsection 2.5.2.8

COLA Part 2, FSAR, Chapter 2, Subsection 2.5.2.8, Reference 250, is revised as follows:

250. Hardy, G., Merz, K., Abrahamson, N.A., and Watson-Lamprey, J., *Program on Technology Innovation: Use of Cumulative Absolute Velocity (CAV) in Determining Effects of Small Magnitude Earthquakes on Seismic Hazard Analyses*, Electric Power Research Institute (EPRI) Report 1014099, August 2006.