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U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555
ATTN: David B. Matthews, Director
Division of New Reactor Licensing

SUBJECT: COMANCHE PEAK NUCLEAR POWER PLANT, UNITS 3 AND 4
DOCKET NUMBERS 52-034 AND 52-035
SUPPLEMENTAL RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION NO. 4725 (SECTION 2.5.2)

Dear Sir:

As a result of a July 26, 2011 public meeting, Luminant Generation Company LLC (Luminant) submits herein supplemental information for the response to RAI No. 4725 (CP RAI #168) for the Combined License Application for Comanche Peak Nuclear Power Plant Units 3 and 4. The supplemental information addresses the affect of man-made local earthquakes.

Should you have any questions regarding the supplemental information, please contact Don Woodlan (254-897-6887, Donald.Woodlan@luminant.com) or me.

There are no commitments in this letter.

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

Executed on October 31, 2011.

Sincerely,

Luminant Generation Company LLC

Donald R. Woodlan for

Rafael Flores

Attachment: Supplemental Response to Request for Additional Information No. 4725 (CP RAI #168)

D090
NRO

cc: Stephen Monarque w/CD

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SUPPLEMENTAL RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI NO.: 4725 (CP RAI #168)

SRP SECTION: 02.05.02 - Vibratory Ground Motion

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 6/9/2010

QUESTION NO.: 02.05.02-26

As part of the site audit conducted on April 7-8, 2010, the staff inspected Calculation Report, TXUT-1908-01, which discusses issues, related to induced seismicity within the site region. In accordance with the guidance in NUREG-0800, Standard Review Plan, Chapter 2.5.2, "Vibratory Ground Motion," and Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion".

Section 2.5.1.2.5.10.2.3 of the FSAR documents that of the ~130 earthquakes identified within Texas in the past 150 years, 22 appear to be associated with oil and gas production (approximately 17% of the total). This estimate does not include the recent swarm of earthquakes that has occurred near the Dallas-Fort Worth airport (DFW). These events are located within the Fort Worth Basin and appear to be located at depths consistent with ongoing oil and gas stimulation activities (pers. comm., Prof. Brian Stump, SMU). The Comanche Peak NPP is also located within the Fort Worth Basin and is underlain by the same major geologic units (Ellenburger Limestone and Barnett Shale) as the DFW region. Figure 2.5.1-228 shows that there are a large number of active gas production wells within 10 miles of the Comanche Peak NPP site.

Section 2.5.1.2.5.10.3 contains a qualitative discussion of the bases for concluding that seismic hazards associated with induced seismicity do not need to be considered in the site-specific PSHA for the Comanche Peak site. In particular the last paragraph of this section concludes that it is unlikely that any earthquake induced by gas production or fluid injection in the Fort Worth Basin would exceed mb 5.0
The staff requests the applicant submit calculations and quantitative evaluations that support the applicant's conclusion regarding the maximum earthquake size associated with gas production or fluid injection in the Fort Worth Basin.

SUPPLEMENTAL INFORMATION:

During a public meeting on July 26, 2011, Luminant agreed to clarify the assessment of recommendations contained in Data Report TXUT-1908-01, Revision 0, which accompanied the response to Question 02.05.02-26. TXUT-1908-01 was developed to address human induced hazards as prescribed in NUREG 0800, Section 2.5.1 (§I.3). This study concluded that there are no immediate safety issues for the Comanche Peak Nuclear Power Plant (CPNPP), but provided four recommendations:

1. Develop a local seismic monitoring program that can detect small earthquakes (m_b = 1 to 3). Monitor the location and size of each earthquake, and periodically (i.e. every six months) investigate whether the rate of seismicity is changing. Because fluid injection slowly builds pressure in a reservoir, it is likely that seismicity, if conditions were favorable for it to occur, would build in intensity with time, allowing remedial action before an event of damaging magnitude would occur.

2. A moratorium on injection within a certain distance of the site might be considered to reduce potential future risk of induced earthquakes. Such a restriction should have little economic effect on the region (this is not limiting economic development of a resource), so it seems a reasonable measure considering the uncertainty in assessing the true risk.

3. The production of gas development should be allowed to proceed naturally to avoid the project site being a place of pore pressure gradient which could potentially increase the risk of seismicity.

4. Further study may be warranted to more comprehensively model the potential risk of seismicity along the lines of the methods of Segall and Fitzgerald (1998) and Davis and Pennington (1989). A problem with the modeling approach is the inability to eliminate uncertainty in the input data (in situ stress magnitudes, permeability distributions, locations and condition of pre-existing faults, etc.), so local monitoring of $m_b < 3$ earthquakes is probably a preferable initial route.

During a conference call with the NRC on May 4, 2011, it was agreed that recommendations 2 and 3 were not within Luminant's control. However, recognizing that the increased micro-seismicity in the Dallas-Fort Worth airport area is likely due to injection operations related to gas extraction of the Barnett Shale since TXUT-1908-01, Rev. 0 was completed in 2007, Luminant commissioned a study to specifically address recommendations 1 and 4 above. Those recommendations have been addressed in TXUT-1908-01, Rev.1 (Attachment 1) and in Project Report TXUT-001-PR-018, Rev. 1 (Attachment 2).

The study involved the following components:

- Obtain and analyze 18 months of broadband, digital seismic data collected at four seismograph stations surrounding the CPNPP to search for small, regional earthquakes.
- Collect and summarize injection well locations, depths, periods of injection and quantities.
- Review recent literature concerning earthquakes induced by fluid injection, focusing particularly on recent activity and on implications for potential hazard at the CPNPP.
- Develop a hypothetical earthquake source model for performing a deterministic, parametric analysis to estimate the ground motion at the CPNPP location.

The results of the study have been documented in TXUT-001-PR-018 "Deterministic Evaluation of Induced Seismic Hazard for CPNPP" (Attachment 2) and are summarized below.

During the 18-month study period, only a single earthquake was identified within 35 km of CPNPP- a very well-recorded M2.3 earthquake that occurred about 10 km WNW of CPNPP. For this earthquake, the preferred epicenter at 32.334°N, 97.895°W was situated within 5 km of several injection wells. The closest well, at a distance of 1 km from the epicenter, injects at a depth of 1.6 km into the Barnett Shale Formation; with injection rates ~100,000 barrels/month between 2007 and 2010. The highest rates were from a well 4 km from the epicenter that injects at a depth of 2.9 km into the Ellenburger Limestone Formation. The rates were variable but about 150,000 barrels/month between 2007 and 2010, and for one month in 2009 as high as 550,000 barrels. An analysis of earthquakes in the Fort Worth Basin that were probably induced by the disposal of frack fluids finds that their magnitudes are small (M3.3 or less) and, where depth information is available, their focal depths appear to be at or slightly below the depths of injection. Thus, future induced earthquakes near CPNPP are likely to have magnitudes of 3.5 or smaller, and focal depths of 1.5-5 km.

An analysis of a compilation of well-documented injection-induced earthquakes found that with two exceptions, events with magnitudes exceeding M4.0 all occur in environments where natural earthquakes with larger magnitudes occur within 100 km of the well. The only exceptions (Snyder, TX; M4.6 in 1978 and M4.4 in 2011) were in a field undergoing decades-long water flooding at more than 100 wells spaced on a ½-km grid. However, with magnitudes of M4.6 and M4.4 and a distance of 290 km from CPNPP site, the Snyder earthquakes pose no physical threat to the facility.

The compilation found no examples where induced earthquakes having magnitudes exceeding M3.5 occurred near injection wells used for waste disposal in environments where the largest nearby natural earthquakes had magnitudes of 3.5 or less. Although 10-15 injection wells occur within 15 km of CPNPP, this analysis suggests that if these were to induce earthquakes, their magnitudes would be smaller than M3.5. (Frohlich, 2011)

Those results were used to guide the development of a hypothetical earthquake source for a deterministic calculation of ground motions for CPNPP. Calculations for ground motion and site response were performed for the following four earthquake magnitude-distance-depth combinations.

Lg Magnitude m_{bLg}	Moment Magnitude **M**	Distance R (km)	Depth h (km)	Seismic Moment Mo (dyn-cm)	Corner Frequency fc (Hz)	Duration T (sec)
3.5	3.41	0	3	1.46E+21	7.45	0.28
4.5	4.16	0	2	1.95E+22	3.14	0.42
3.5	3.41	5	3	1.46E+21	7.45	0.43
4.5	4.16	5	2	1.95E+22	3.14	0.59

Results of the ground motion studies indicate that human-induced events, even at very close distances, will not exceed the Certified Seismic Design Response Spectra (CSDRS) anchored at 0.3g, but they may exceed the site-specific CSDRS anchored at 0.1g in the high frequency range. The exceedance of the 0.1g DCD spectrum at high frequencies is not a source of concern because the associated motions have low damage potential and because there are a number of conservative elements in the analysis. In considering the observed exceedance of the site-specific spectra, one must take into account a number of licensing considerations and conservative elements, as follows:

1. This is a deterministic analysis, which takes conservatively defined earthquake scenarios as its starting point, and the DCD spectra are included only for the sake of reference. Therefore, exceedance of the 0.1g DCD by these hypothetical earthquakes has no licensing implications. In particular, these exceedances are acceptable and there is no impact on the FIRS or on the GMRS.

2. The rock ground-motion equations may over-estimate the motions at the low magnitudes considered in these calculations, as has been observed recently with the NGA equations in California (Chiou and Young, 2010). Although the EPRI (Reference 2) equations rely mostly in Random Vibration Theory (RVT) methods, which are expected to be accurate for small magnitudes, these equations were not fit to magnitudes in this range and it is likely that they over-estimate the motions for magnitudes below 5. There is some evidence that earthquakes

induced by natural-gas operations have lower values of stress drop than tectonic earthquakes. For instance, the M 4.7 2011 Arkansas earthquake has been inferred as having a very low stress drop (Mueller et al., 2011). If this is the case, induced earthquakes have less energy at high frequencies than tectonic earthquakes of the same magnitude.

3. There is ample evidence that motions from small-magnitude earthquakes are less damaging to nuclear structures than motions from larger earthquakes with the same ground-motion amplitude at high frequencies. This is the motivation for the introduction of the CAV filter (EPRI and DOE, 2005) and for the endorsement of the CAV filter in Regulatory Guide 1.208. Although this study did not perform an analysis in terms of CAV to demonstrate it, it is anticipated that the ground motions from these hypothetical earthquakes have lower damage potential than the motions associated with the 0.1g DCD spectrum. Therefore, it is anticipated that these hypothetical ground motions have no structural impact.

In summary, the exceedance of the 0.1 g DCD spectrum at high frequencies is not a source of concern because the associated motions have low damage potential and because there are a number of conservative elements in the analysis. Therefore, should an induced earthquake occur near CPNPP, these results show that it is unlikely to be damaging.

References

1) Chiou, B., and R. Youngs (2010). Ground-Motion Attenuation Model for Small-To-Moderate Shallow Crustal Earthquakes in California and Its Implications on Regionalization of Ground-Motion Prediction Models. Earthquake Spectra 26, 907 (2010)

2) EPRI (2004). CEUS Ground Motion Project, Model Development and Results. Report No. 1008910. Electric Power Research Institute: Palo Alto, CA, 2004.

3) Electric Power Research Institute (EPRI) and U.S. Department of Energy (DOE), "Program on Technology Innovation" (2005). Use of Minimum CAV in Determining Effects of Small Magnitude Earthquakes on Seismic Hazard Analyses. EPRI, Palo Alto, CA and the U.S. Department of Energy: 2005. 1012965.

4) Mueller, C., Cramer, C., and Toro, G. Review of final databases for CENA and other SCRs. NGA-East SSHAC Workshop 2, Oct. 11-13 2011. http://peer.berkeley.edu/ngaeast/wp-content/uploads/2011/10/Tu_PM_1_Cramer_CENA-Database-Status.pdf (Accessed 10/24/2011; see slide 14)

5) EPRI (2006). Program on Technology Innovation: Truncation of the Lognormal Distribution and Value of the Standard Deviation for Ground Motion Models in the Central and Eastern United States. Report No. 1014381. Electric Power Research Institute: Palo Alto, CA, 2006.

6) Frohlich, C. (2011). Categories of Induced Earthquakes and Implications for Hazard at the Comanche Peak Nuclear Power Plant

Attachments (on CD)

1) TXUT-1908-01, Revision 1, Technical Issues Related to Hydraulic Fracturing and Fluid Extraction/Injection near the Comanche Peak Nuclear Facility in Texas.

2) TXUT-001-PR-018, Revision 1, Deterministic Evaluation of Induced Seismic Hazard for CPNPP.

Impact on R-COLA

None.

Impact on S-COLA

None; this response is site-specific.

Impact on DCD

None.