PMComanchePekNPEm Resource

From: Alan Nelson [anelson@usgs.gov]
Sent: Wednesday, November 11, 2009 10:53 AM
To: Seber, Dogan
Cc: 'Kathleen M Haller'; 'Stephen C Harmsen'; 'nbeeler'
Subject: RE: More Comanche Peak RAI responses
Attachments: USGS Responses to Luminant responses to Comanche Peak RAIs 2.5.1_2.5.2_2.5.3 11Nov09.doc

Dogan,

Attached are USGS comments on Luminant's responses to RAIs for Comanche Peak. Email us with questions. Steve and Nick would be best to answer questions about section 2.5.2.

The adequacy statements on at the ends of comments follow the format worked out by Alice and Russ Wheeler to alert NRC as to the comments that we think are most important.

Cheers,

alan

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Golden CO 80401

From: Seber, Dogan [mailto:Dogan.Seber@nrc.gov]
Sent: Monday, October 26, 2009 10:13 AM
To: Kathleen M Haller; 'Stephen C Harmsen'; 'nbeeler'; Alan Nelson
Subject: RE: More Comanche Peak RAI responses

Dear All,

Attached please find more Comanche Peak RAI responses. Despite the date on the letter, I just got this response on Friday afternoon, and have been busy sorting out the Meers Fault issue. As you will see the Meers fault RAI (2.5.2-16) has resulted in significant recalculations and updates to the FSAR. The applicant indicated that their initial calculations provided in Rev 0.0 of the FSAR contained errors. The attached pdf file includes the complete response to this RAI (primarily in Appendix 5) as well as responses to some other RAIs in 2.5.1 (and 2.5.4 and 2.5.5). My quick look suggests that the applicant has left out still some additional revisions to some of the FSAR figures because of the Meers fault updates. We will get these sorted out in the next few days. Please let me know if you have any comments.

Best,

Dogan

Hearing Identifier: ComanchePeak_COL_NonPublic
Email Number: 1217

Mail Envelope Properties (000001ca62e7$1c816550$55842ff0$)

Subject: RE: More Comanche Peak RAI responses
Sent Date: 11/11/2009 10:53:28 AM
Received Date: 11/11/2009 10:53:37 AM
From: Alan Nelson

Created By: anelson@usgs.gov

Recipients:
"'Kathleen M Haller'" <haller@usgs.gov>
Tracking Status: None
"'Stephen C Harmsen'" <harmsen@usgs.gov>
Tracking Status: None
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MESSAGE	1670	11/11/2009 10:53:37 AM
USGS Responses to Luminant responses to Comanche Peak RAIs 2.5.1_2.5.2_2.5.3 11Nov09.doc	131136	

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Technical Letter Report
to the U.S. Nuclear Regulatory Commission

Interagency Agreement No. NRC–07–001 **JCN/Contract No. Q–4151**
Task Order No. 14, Review of the Comanche Peak Application for Combined Operating License in the Areas Relating to Geology and Seismology

Comanche Peak Nuclear Power Plant, Units 3 and 4 (CPNPP3&4)
Applicant: Luminant Power
TAC No. RX0454

USGS Comments on Responses to RAIs for the Comanche Peak, Texas, site

(FSAR Sections 2.5.1, 2.5.2, 2.5.3)
Submitted 11 November 2009

By Alan Nelson (USGS, Golden), Steve Harmsen (USGS, Golden), Kathleen Haller (USGS, Golden), and Nick Beeler (USGS, Menlo Park)

This report contains U.S. Geological Survey (USGS) comments on the applicant's responses to NRC requests for additional information (labeled NRC Questions below).

Section 02.05.01 - Basic Geology and Seismic Information

NRC QUESTION NO.: 02.05.01-1
FSAR Subsections 2.5.1.1.3.1 and 2.5.1.1.3.2 discuss regional gravity and aeromagnetic data for the CPNPP site. In the FSAR, you conclude that no features (other than the Meers) "are recognizable in the regional aeromagnetic field that would indicate a capable tectonic source within the site region." Prior to that, you stated that the aeromagnetic signature associated with the Meers fault is related to "Late Paleozoic thrusting and not an expression of the recent kinematic history of the fault." Please explain the limits to using gravity and aeromagnetic data for identifying capable tectonic structures in the CPNPP site region and the likelihood that Cenozoic deformation features would provide a recognizable signature in the data.

<u>USGS comments</u>
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.01-2
In your discussion of regional Quaternary tectonic structures in FSAR Sub-Section 2.5.1.1.4.3.6, you do not include a discussion of the Washita Valley Fault. Given that Quaternary-age displacement has been suggested along this fault, please explain why you did not include a discussion of this feature.

<u>USGS comments</u>

The response is adequate and no further information is required.

QUESTION NO.: 02.05.01-3

FSAR Subsections 2.5.1.1 states "this section discusses the physiography, geologic history, stratigraphy, and tectonic setting within a 200-mi radius of [Comanche Peak Nuclear Power Plant] CPNPP." The Quaternary Period, particularly the Holocene, is the most important segment of geologic time from a seismic safety standpoint.

"Quaternary alluvial sequences" and "Quaternary terrace and alluvial units" are mentioned in FSAR Section 2.5.1.2.3. Please describe how the Quaternary terrace and alluvial units relate to the geologic history of the site. Please provide a more thorough discussion of the geologic history and stratigraphy of the site region and site vicinity during the Quaternary period (especially the past few hundred years), particularly episodes of erosion and deposition in response to climate and sea-level changes of the late Quaternary.

USGS comments

The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.01-4

FSAR Section 2.5.1.1.2, and other sections, reference figures such as FSAR Figures 2.5.1-202 and 2.5.1-205, which show that the thick crust underlying the CPNPP site transitions to much thinner crust less than 100 km to the east, and to rocks of the southern Oklahoma aulacogen a similar distance to the northeast. Thus, the geologic setting and tectonic history of the eastern and northeastern parts of the site region are similar to other extended margins where large historic earthquakes have occurred, such as the 1886 Charleston and the 1811-1812 New Madrid earthquakes. Please provide a complete discussion (with additional figures, if needed) of the potential for large earthquakes on known or unknown structures within thick and thin transitional crust (i.e., extended margin) in the site region. Please explain how conclusions provided by Schulte and Mooney (2005) may influence your assessment of the CPNPP site.

Reference: "An updated global earthquake catalogue for stable continental regions; reassessing the correlation with ancient rifts," Geophysical Journal International, v. 161, p. 707-721, Schulte, S.M., and Mooney, W.D., 2005.

USGS comments

The requested discussion was provided, but the use of the updated EPRI-SOG model for seismic sources in the CPNPP site region, particularly the weights assigned to magnitudes in the M4.5-7.7 range, was not adequately justified and such justification may be required for the NRC to make a credible safety finding. Although the applicant is correct that there is no new source-specific information available in the site region, there is new information about Mmax based on global analog areas and new data that bear on the earthquake potential of the site region. At several meetings during 2006-2009 where maximum magnitudes in extended crust, like that beneath part of the site region, was discussed extensively the consensus of the seismic-hazard community was that magnitudes higher than those recommended in 1986 are needed. Given the above, it is likely that if the same experts involved in the

EPRI-SOG study were consulted today, they would conclude that a significantly higher Mmax is needed in the Oklahoma aulacogen and areas underlain by extended margin in the CPNPP site region.

NRC QUESTION NO.: 02.05.01-5
FSAR Subsection 2.5.1.1.3.1 describes a circular gravity anomaly in the southeastern portion of the site region associated with the Llano Uplift. However, FSAR Figure 2.5.1-205 shows the Llano Uplift in the southwestern portion of the site region. Please clarify if the circular gravity anomaly is associated with the Llano Uplift in the southwestern portion of the site region, or with another feature in the southeastern portion of the site region.

USGS comments
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.01-6
FSAR Subsection 2.5.1.1.4.1.2 describes the regional tectonic history up to the Early Miocene period. Please describe the regional tectonic history from the Early Miocene period to the present.

USGS comments
Only minimal additional description of regional tectonic history is provided in the response. An expanded discussion of late Tertiary and Quaternary tectonic history is scientifically advisable but not necessary for the NRC to make a credible safety finding.

NRC QUESTION NO.: 02.05.01-7
FSAR Subsection 2.5.1.1.4.3.4.2 discusses Mesozoic age normal faults, including the Luling-Mexia-Talco fault zone.
(1) Please explain the evidence for your conclusion that the Luling fault zone is geologically associated with the Mexia-Talco fault system and whether this entire fault system is related to the movement of "Jurassic salt at depth."
(2) Please explain the statement that "this fault system is spatially coincident with the Pennsylvanian Ouachita fold and thrust belt..." and provide a more thorough discussion of the Luling fault zone including:
a. evidence that displacement associated with the Luling fault zone is related to salt movement at depth, or that it is related to basement structures,
b. the relationship between the Luling fault zone and the Tertiary-age Balcones fault zone
c. evidence that displacement on the Luling fault zone may be related to reactivation of Ouachita structures, and
d. evidence for Cenozoic displacement or seismicity that may be linked to ongoing deformation of the Luling fault zone.

USGS comments
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.01-8

FSAR Sub-section 2.5.1.1.4.3.4.2 describes the normal faults of the Mount Enterprise-Elkhart Graben (MEEG) system. Both pre-1986 and post-1986 publications suggest, as the FSAR points out, that there is evidence for Quaternary deformation associated with the MEEG. Please provide additional evidence, explanation and discussion to support your conclusion that "there is no new information bearing on the Quaternary activity of the MEEG fault system requiring a revision of the [Electric Power Research Institute] EPRI seismic source characterization of this region." Specifically,

(1) Please provide a detailed figure that shows the locations of the geographic and structural features mentioned in FSAR Section 2.5.1.1.4.3.4.2, including the locations of the published evidence for displacement on the MEEG.

(2) Please provide a more detailed summary of the data (including deposits, landform morphology, and age estimation) for late Quaternary faulting on the MEEG. Please also explain the evidence that supports the "estimated age of 37 thousand years for the late Quaternary gravels" stated in the FSAR.

(3) The FSAR states "Presumably, this was the evaluation of the EPRI Earth Science Teams (ESTs)," regarding the MEEG fault system. Please provide the evidence and any relevant sources that support the assumption that the MEEG is not a source of tectonic deformation.

(4) The FSAR states that Ewing (FSAR reference 2.5-228) suggested that seismicity associated with the MEEG may indicate "continuing deformation." Please explain the origin of the seismicity and why this seismicity is or is not an indicator of displacement on the MEEG faults.

(5) The FSAR points out that Crone and Wheeler (FSAR Reference 2.5-271), a compilation of data, did not identify or discuss the MEEG as a potential tectonic fault. Please address whether Crone and Wheeler evaluated all potential tectonic features in the CEUS (central and eastern United States). If not, please explain specifically how this information supports the FSAR conclusion that the MEEG is not a capable tectonic structure.

(6) FSAR Section 2.5.1.1.4.3.4.2 states that [William Lettis & Associates] WLA "conducted a field reconnaissance study" of the MEEG. Please describe this study in greater detail, including the locations investigated, the types of outcrops, surfaces and sediments examined, and the descriptions of evidence, or lack of evidence, found at each location. Please justify the applicant's conclusion, based on these investigations that no evidence was found "to support post-Eocene tectonic activity on the MEEG."

(7) Several references listed in FSAR Section 2.5.1.1.4.3.4.2 indicate recent movement on the faults of the MEEG. Please justify your conclusion, based on these publications, that this is not a capable tectonic feature.

(8) Provide a more detailed discussion of whether or not salt movement at depth could produce modern slip of 4 mm/yr on overlying normal faults, and whether stratigraphic relations of the displaced gravel favor sudden surface displacement of tens of centimeters or gradual creep. Please cite examples of other places in the Gulf Coast region, or other similar regions, where salt movement has caused similar rates of surface deformation.

<u>USGS comments</u>

The field reconnaissance study by WLA briefly investigated the tectonic features cited by Collins et al. (1980) as evidence for Quaternary faulting but did not investigate other parts of the MEEG as shown on Figure RAI 2.5.1-8, Figure 1. Nevertheless, all questions asked in the RAI are adequately addressed and no further response is required.

NRC QUESTION NO.: 02.05.01-9

FSAR Section 2.5.1.1.4.3.5, discusses the Tertiary-age Balcones fault zone, and states that there is some evidence (FSAR References 2.5-266 and 2.5-274) for post-Eocene movement on the Balcones faults. Please provide a detailed description of the Balcones fault zone and address the capability of this fault zone, including any seismicity, or lack of seismicity, that may be associated with this fault zone, and the potential for these geologic structures to be reactivated in the current stress regime.

USGS comments
The response is adequate and no further information is required.

QUESTION NO.: 02.05.01-10
The MEEG system is located approximately 129 miles from the CPNPP site. Based on suggestions that this system may exhibit post-Eocene displacements, you conducted a field reconnaissance study to look for post-Eocene deformation. The Balcones fault zone is located approximately 75 miles (at its closest mapped position) from the CPNPP site and may also exhibit post-Eocene movement. In addition, Collins et al., (1990) suggests that a paleoseismic study is needed to determine if there is recent activity on the Balcones fault zone.
Please explain what, if any, post-Eocene deformation, including paleoseismic features, may be associated with the Balcones fault zone, or the Luling-Mexia-Talco fault system, and if a field investigation was conducted to look for such deformation. If a field investigation was not conducted to evaluate deformation on the Balcones or Luling-Mexia-Talco fault systems, please explain why an investigation was not necessary.
Reference: "Faults and fractures in the Balcones fault zone, Austin region, central Texas," Guidebook 13, Austin Geological Society, Austin Texas, 12 p., Collins, E.W., and Laubach, S.E., 1990.

USGS comments
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.01-11
FSAR Section 2.5.1.1.4.3.6 states that "Only one fault within the site region has been identified as demonstrating possible evidence for Quaternary activity: the Meers fault in Oklahoma." Please explain, in light of the FSAR's sixteen pages documenting evidence for very late Quaternary faulting on the Meers fault, the FSAR's conclusion that Quaternary activity on the Meers is "possible."

USGS comments
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.01-12
Section 2.5.1.1.4.3.6.2 describes the Criner fault. In order for the NRC staff to fully evaluate the potential for (or lack of) Quaternary activity on the Criner fault, additional information is needed.
(1) Please provide a more detailed figure illustrating the locations of the geographic and structural features mentioned in FSAR Sub-section 2.5.1.1.4.3.6.2, including the investigated sites that are described in the FSAR.

(2) Describe in greater detail the 1989 reconnaissance investigation of the Criner fault, including the "insufficient evidence available to prove or disprove the capability of the fault." Please explain in detail why the assumption of an M7 earthquake on the fault would have "...no safety impact on the plant."
(3) Describe in greater detail the .follow-up studies conducted by Geomatrix Consultants," including evidence for landslides and the age of the small alluvial fans.
(4) The FSAR (p. 2.5-37) states that WLA "conducted a field reconnaissance study' along the escarpment of the Criner fault. In your discussion please include the locations investigated; the types of outcrops, surfaces and sediments examined; descriptions of evidence, or lack of evidence, found at each location; and the expertise of those conducting the relevant investigations. Please provide a thorough justification of your conclusions regarding the capability of the Criner fault, based on evidence gathered in this investigation.

<u>USGS comments</u>
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.01-13
FSAR Section 2.5.1.1.4.3.7.2, describing the Cheraw fault, notes that Crone et al. (1997) (FSAR Reference 2.5-323) found evidence for three surface-rupturing events in the past 25,000 years. Please explain whether the Cheraw fault is a capable fault, and whether it is included as a seismic source in the FSAR.

<u>USGS comments</u>
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.01-14
Despite its distance from the CPNPP site, FSAR Section 2.5.1.1.4.3.7.3 discusses the current understanding of the New Madrid seismic zone (NMSZ) as a seismic source because it is one of the closest sources to the CPNPP site. The updated NMSZ source model does not include new paleoseismic results related to the southern end of the Reelfoot Rift system.
(1) Please explain whether the southern end of the Reelfoot Rift system, which is closer than the NMSZ (approximately 580 km from the CPNPP site), is also capable of M>7 earthquakes. Please discuss the applicability of studies by Tuttle, et al., (2006), and Cox, et al., (2007), and explain how the extended NMSZ source impacts the seismic hazard at the CPNPP site.
(2) Please discuss if and to what extent paleoliquefaction features in southeastern Arkansas and northeastern Louisiana indicate that previously unrecognized seismogenic sources may exist in those areas. Please discuss studies by Al-Shukri, et. al. (2005); Cox, et al, (2004); and Tuttle, et al., (2006), and explain how these other seismogenic sources, which are closer to CPNPP than the NMSZ, impact the seismic hazard at the CPNPP site.

Additional References:
"Spatial and temporal characteristics of paleoseismic features in the southern terminus of the New Madrid Seismic Zone in eastern Arkansas," Seismological Research Letters, Volume 76, pp. 502-511, Al-Shukri, H. J., Lemmer, R. E., Mahdi, H. H., Connelly, J. B., 2005.

"Preliminary assessment of sand blows in the southern Mississippi Embayment," Bulletin of the Seismological Society of America, Volume 94, pp.1125-1142, Cox, R. T., Larsen, D., Forman, S. L., Woods, J., Morat, J., and Galluzzi, J., 2004.
"Very large earthquakes centered southwest of the New Madrid seismic zone 5,000-7,000 years ago," Seismological Research Letters, Volume 77, pp.755-770, Tuttle, M. P., Al-Shukri, H., Mahdi, H., 2006.
"Seismotectonic implications of sand blows in the southern Mississippi embayment," Engineering Geology, volume 89, pp. 278-299, Cox, R. T., Hill, A. A., Larsen, D., Holzer, T., Forman, S. L., Noce, T.,
Gardner, C., and Morat, J., 2007.

USGS comments
Because of the great distance between the CPNPP site and the liquefaction features discussed in response to this RAI the response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.01-15
FSAR Subsection 2.5.1.2.4.1 describes two basement faults beneath the Cretaceous rocks within a 25-mi radius of the CPNPP site. However, the location of these basement faults is not shown in FSAR Figure 2.5.1-216, a geologic map of the site vicinity. Please provide a description of where the basement faults were mapped in the 25-mi radius or illustrate the location of these faults on the appropriate figure.

USGS comments
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.01-16
FSAR Subsection 2.5.1.2.4.2 states that "no tectonic structures (such as faults, folds, or shear zones) were found within 5 mi. of the CPNPP Units 3 and 4 site" but does describe two disruptions within the site area. FSAR Figure 2.5.1-217 labels these two disruptions as "Fold in Paluxy" and "Fold near Dam". Please clarify if these map features are folds or the disruptions described in the FSAR.

USGS comments
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.01-17
Section 2.5.1.2.5.1 mentions a "Field reconnaissance of the region and immediate site area…," including surveys of "…Quaternary deposits within nearby river and stream valleys…" to evaluate 1) the "…presence of liquefaction features…", 2) "…signs of deformation…", and 3) a "…lineament analysis followed by field confirmation surveys."
(1) Please describe separately, in detail, each part of the overall field investigation that addressed each of the three types of investigations numbered above (liquefaction features, signs of deformation, and lineament analysis), including:
(a) the locations investigated,
(b) the types of outcrops, surfaces and sediments examined,

(c) the origins of features, and
(d) any other evidence found during the surveys that may bear on the Quaternary seismic and deformation history of the site region and site vicinity. Please fully explain the extent to which each type of investigation indicates "no evidence of seismic activity, either recent or historic."
(2) Explain what the phrase "…signs of deformation…" means and provide complete details on possible deformation features that were found and the evidence used in their interpretation.
(3) For the "…lineament analysis followed by field confirmation surveys.", please provide a complete description of the surveys and analysis of features with appropriate figures, including details of methods and imagery used, aerial extent, identification criteria, identified lineaments, and conclusions regarding the origin of each identified lineament in the site vicinity.

USGS comments
The questions were addressed in this and other responses to other RAIs. The response is adequate, except that no updated figures clarifying the origin of numbered lineaments on Figure 2.5.3-201 was provided and the Lineaments Report (WLA, 2007) referenced on that figure was not provided or explained. Updated figures and explanation of WLR (2007) is scientifically advisable but not necessary for NRC to make a credible safety finding.

NRC QUESTION NO.: 02.05.01-18
As discussed in FSAR Sections 2.5.1.1.2 and 2.5.1.1.4, faults that were active during Mesozoic rifting and that are now buried by Mesozoic and Cenozoic deposits are likely to occur below the site region. Direct study of these buried faults in outcrop is not possible. Elsewhere in the Central and Eastern US (CEUS) where similar geologic conditions exist, researchers use liquefaction features induced by large earthquakes to estimate timing, source areas, magnitudes, and recurrence intervals of large prehistoric earthquakes. Partly as a result of such studies, in the last 15 years there is wider recognition that seismicity migrates within crustal zones over periods of thousands to tens of thousands of years (e.g., Nelson et al., 1999; Schweig and Ellis, 1994; Coppersmith, 1999; Tuttle et al., 2006; Cox et al., 2007). Holocene and late Pleistocene deposits (e.g., fluvial, alluvial deposits) that are likely to be susceptible to liquefaction during large earthquakes occur in the CPNPP site region, for example, along the Brazos River and its tributaries. In the context of the search for liquefaction features mentioned in Section 2.5.1.2.5.1, please explain how the wider recognition that crustal seismicity migrates applies to the CPNPP site region.

USGS comments
The response adequately answers the question asked, and in doing so, makes a strong case for the need for a much more extensive search for evidence of liquefaction in alluvial deposits of the Brazos River drainage and other drainages in the site region. The reconnaissance search described in the response to RAI 02.05.01-17 was clearly not adequate to identify potential liquefaction features that might exist in the site vicinity or site region. Whether or not Holocene liquefaction features exist in the site region is unknown because a thorough search for such features has not been made.

QUESTION NO.: 02.05.01-19
FSAR Section 2.5.1.2.5.10 discusses the effects of man's activities on seismic hazard, such as induced seismicity from oil and gas extraction activities. Natural earthquakes are known or suspected to trigger

events far from the mainshock, such as the 1992 Little Skull Mountain earthquake (M5.6) that was far from but triggered by the Landers, California, mainshock, and earthquakes in Ohio possibly triggered by the 1811-1812 New Madrid earthquakes (Hough, 2001).
a) Please explain if there is any potential for triggered seismicity close to the CPNPP site from a natural earthquake, particularly an earthquake in a distant source zone such as the Rio Grande Rift.
b) Please explain how the potential hazard from triggered seismicity is accommodated in the FSAR when the underlying probabilistic seismic hazard analysis (PSHA) assumes independent events.
c) Please clarify the following statement in FSAR Subsection 2.5.1.2.5.10.2.3: "There are almost no cases of human actions causing large earthquakes (FSAR Reference 2.5-359)." Please explain why a reference that only documents Texas earthquakes was cited.

USGS comments
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.01-20
Please provide the following text and figural corrections:
a) Please label all features on all figures, including but not limited to all structures mentioned in the text of the FSAR, in Sections 2.5.1.1.4.3.3 (p. 2.5-21) through 2.5.1.1.4.3.4.2 (p 2.5-23)..
b) For Figure 2.5.1-202b, please clarify whether “King and Beikman, 1974” should be included in the reference list, and provide reference numbers for “Nichols and Waddell.”
c) Please provide the reference number for “Nichols and Waddell” on Figure 2.5.1-204, provide the citation for the cross section line, and enhance or enlarge the text in the small inset and the key.
d) Please clarify whether “Walper” should be listed as a reference for Figure 2.5.1-208.
e) Please provide the CPNPP site location on FSAR Figure 2.5.1-208
f) For Figure 2.5.1-229, please clarify whether “Pollastro 2007” references the “Pollastro et. al 2007” study.
g) Please provide the correct referenced publication listed as “Reference 2.5-266.”

USGS comments
The response is adequate and no further information is required.

Section 02.05.02 Vibratory Ground Motion

NRC QUESTION NO.: 02.05.02-1
In FSAR Subsection 2.5.2.1.2 you stated that the updated earthquake catalog covers an area bounded by 28° N to 38° N and 93° W to 104° W. The update area does not completely cover all of the EPRI seismic sources used in your hazard calculations. Please justify the use of a limited spatial extent in your earthquake catalog update for the Comanche Peak site. Please describe how you account for any earthquakes occurring since 1985 within the EPRI sources, but outside of the area of your update that might potentially impact seismic source parameters used in hazard calculations at the Comanche Peak site.

USGS comments

The applicant's response discusses one of the several EPRI/SOG teams whose source characterization might be affected by the occurrence of an M5 earthquake in the *western*most part of the Oklahoma aulacogen (typo should be corrected). The response discussed increasing Mmax for some logic-tree branches for zone 26 of the Law EPRI/SOG team.

Related source-characterization details may also require some modification, besides the one discussed by the applicant. For example, the 10 August 2005 New Mexico epicenter also appears to be within the Oklahoma aulacogen as defined by the Bechtel group. Although this group's Mmax distribution would not need to be modified by the occurrence of an M5 earthquake, its Pa of 0.2 as reported in Table 2.5.2-202 of the FSAR might need to be modified to 1.0 (also see comment on RAI 02.05.02-12). An increase of the Pa for the Oklahoma aulacogen from 0.2 to 1.0 might have a significant effect on hazard curves at the Comanche Peak site.

Another EPRI/SOG team whose Oklahoma aulacogen characterization may include the New Mexico M5 source is Woodward Clyde's. Their Pa of 0.084 for Source 46a as reported in Table 2.5.2-207 might need to be revised to 1.0, like that corresponding to the Bechtel source. The applicant needs to address the effect on hazard that would follow from these increases in Pa and any other increases in Pa and/or Mmin for other EPRI/SOG sources as a result of including the New Mexico earthquake in the hazard modeling. Addressing these questions is necessary for NRC to make a credible safety finding on these issues.

NRC QUESTION NO.: 02.05.02-2

In Tables 2.5.2.-202 through 2.5.2-207 you listed seismic sources that contribute more than 1% of the total hazard at the Comanche Peak site. It is not clear to the staff if these contributing sources are based on the results of the original EPRI PSHA study or they are based on the results of your own assessments conducted using the updated ground motion prediction models and the latest Comanche Peak earthquake catalog. If it is the former, please discuss in detail why you concluded that changes in ground motion prediction models and/or the updated catalog (e.g., Mmax updates) would not result in higher hazard contributions from these unused seismic sources.

<u>USGS comments</u>

The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.02-3

In Subsection 2:5.2.4.2.1 you described the results of a sensitivity study to determine whether the original earthquake recurrence rates used in the 1989 EPRI study still apply to the seismic sources used in the Comanche Peak PSHA study. Your sensitivity study focused on two test zones rather than the actual EPRI seismic source geometries. Please explain why the conclusions reached by using these two test zones are applicable to all of the EPRI seismic sources used for the Comanche Peak site, especially considering that seismic sources, in general, are independent of each other.

<u>USGS comments</u>

The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.02-4

In Subsection 2.5.2.1.3.1 you described your interpretation of the tectonic environment that produced the moderate-sized (M=5.8) earthquake of April 14, 1995 in western Texas. In your PSHA analysis, rather than updating the EPRI Mmax values of many of the seismic sources, you opted to create a new seismic source to accommodate any potential hazard that may result from an easterly extending Rio Grande Rift model. In your conclusions, you also stated that in your hazard calculations this new source resulted in less than 1% of the total hazard at the site and as a result, you did not incorporate it in your final PSHA calculations. Please provide further scientific evidence including a list of publications and reports that studied the April 14, 1995 earthquake and reached a conclusion that this earthquake is tectonically related to the Rio Grande Rift system. Please also provide further information on how the hazard calculated at the Comanche Peak site would be impacted if you were to update the EPRI source model parameters, such as Mmax values to accommodate this 5.8 magnitude event, as it is normally done when EPRI source models are used as a starting point to calculate seismic hazard at a COLA site.

USGS comments

The discussion answering the first of the two questions argues that the earthquake of April 14, 1995 in western Texas is related to the RGR source zone in the west rather than SCR source zones in the east. However, the exact location of the boundary between these source zones in west Texas is uncertain, and because the Alpine Texas earthquake is so close to the boundary (and its epicenter has its own uncertainty), it would be appropriate to assign 50% weight to models that include it in the east instead of west. According to this way of viewing location uncertainty (both boundary location and epicenter), source zones that have this epicenter in their interior, such as Background Zone 2, or BZ2 (Bechtel), should be updated with Mmax minima greater than 5.8 along the logic-tree branches that put this earthquake in the eastern region; alternate logic-tree branches could leave the old EPRI/SOG Mmax distributions alone (although the USGS model here is extended margin with a much higher Mmax). Taking this step will alter the hazard at the site because the site is in, for example, BZ2.

The Geologic Map of Texas shows the approximate epicenter of the Alpine earthquake to be in northwestern Brewster Co., approximately 10 km inside a diffuse belt of sparse, short normal faults that strike northwest and cut Oligocene and Eocene lavas. The fault belt extends about 10 km farther northeast than the epicenter, and many times that to the southwest. The compilation of west Texas Quaternary fault scarps for the USGS Quaternary faults database shows clearly that the approximate location of the epicenter is about 90 km east of the closest Quaternary fault scarps. The maps only go as far east as the Marfa 1 deg. x 2 deg. quadrangle. The Marfa map shows faults 918d (West Lobo Valley fault zone, Sierra Vieja section) and 920 (unnamed fault southeast of Candelaria) as about 60 km west of the town of Marfa. Marfa is at the east edge of the quadrangle, and Alpine is another 30 km farther east. Both small, unrecognized surface ruptures and(or) small, entirely subsurface normal faults are quite plausible in this area. Note that the occasional normal-faulting earthquake is known from the CEUS.

The response to the second question takes issue with the request to explain how updating the EPRI source model parameters, such as Mmax values, to accommodate this 5.8 magnitude earthquake would impact the calculated hazard at the CPNPP site. Because the Alpine earthquake is not known to be related to the RGR source zone there is a strong technical basis for determining its impact if it is placed in an eastern SCR source zone. The response is not adequate because the impact was not explained and shown to be of minimal concern to the site hazard. An adequate response is necessary for NRC to make a credible safety finding.

NRC QUESTION NO.: 02.05.02-5
In Subsection 2.5.2.4.2.3.2.3 you stated that “Epistemic uncertainty in return periods for characteristics earthquakes on the Meers fault is implemented through return period branches on a logic tree.” The FSAR does not include this logic tree. Please provide a copy of this logic tree.

USGS comments
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.02-6
In Subsection 2.5.2.4.2.3.3.2 you stated that rather than using areal sources to represent the Rio Grande Rift seismic source, you used a point source because it is more conservative. Please describe why this is a more conservative approach.

USGS comments
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.02-7
FSAR Subsection 2.5.2.5 states that 'The average shear wave velocity of Layer C is greater than 6000 ft/sec". FSAR Figure 2.5.4-239 shows the average shear wave velocity of Layer C is less than 6000 ft/sec. Please assess the differences between the text and Figure 2.5.4-239 and provide any correction.

USGS comments
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.02-8
In FSAR Subsection 2.5.2.5 you stated “Velocity data for the deep profile was limited to only a few wells”. The FSAR does not provide the actual number and location of these wells. Please provide additional information on the location and geologic environment of these wells you used in estimating deeper velocities at the site. Also, provide further information on how projections were made to the site given the geology and the well locations relative to the site.

USGS comments
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.02-9
In FSAR Subsection 2.5.2.6.1.2 you stated that 'The vertical DCD spectrum equals or does not exceed the horizontal DCD spectrum for frequencies above 3.5 Hz. The conclusion is that the vertical DCD spectrum will also exceed the vertical GMRS".
a. Please further justify this conclusion.
b. Please explain why a qualitative argument is used to estimate the vertical GMRS rather than a quantitative methodology.

USGS comments
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.02-10
In supplement to FSAR Subsection 2.5.2.6.1.2 you stated that 'The Comanche Peak site is a deep, soft-rock site with shales and limestones near the surface having shear-wave velocities of about 2600 fps, and the V/H ratios for this site condition will be similar to those for hard rock sites". Please provide further justification of this statement.

USGS comments
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.02-11
In FSAR Subsection 2.5.2.1.3.2, you stated that "Other historic events are discussed in the FSAR for CPNPP Units 1 and 2, but intensity observations and isoseismal maps published by Frolich and Davis suggest that these events were not likely to be felt at CPNPP Units 3 and 4." Please further clarify this statement by describing the number, locations and characteristics of the other historic events, and their maximum modified Mercalli intensity values at or near the CPNPP site.

USGS comments
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.02-12
The Oklahoma aulacogen is an identified seismic source within the 200 mi of the CPNPP site and it is included in several of the EPRI/SOG source models as discussed in Subsection 2.5.2.2.1. The majority of these models, however, assign a low Probability of Activity (Pa) for the Oklahoma aulacogen (in the range of 0.08 to 0.6).
a. Please justify that these low probabilities are still adequate for this source.
b. Does the recognition of the Meers fault, which marks the southern boundary of the Oklahoma aulocogen, as a Holocene fault with a Pa of 1.0, require a revision of the Pa values assigned for the Oklahoma aulocogen?
c. Does the pronounced seismicity observed within the seismic sources related to the Oklahoma aulocogen require increasing the Pa values and Mmax values for these sources?

USGS comments
In their response the applicant states that: (1) an updated characterization of the Meers fault was developed for the site CPNPP site, and (2) post-EPRI/SOG research is not inconsistent with the EPRI/SOG characterization of the aulacogen when the updated Meers fault characterization is considered.

A scientific credibility issue with the above statement is that the one active fault in Oklahoma, the Meers fault, is assumed to be surrounded by inactive crustal rock, in the sense that this surrounding rock is

incapable of hosting a M5 or greater earthquake. It is hard to find precedents in either active tectonic crust or SCR crust where one mapped fault contains all of the seismic hazard in a large region with a very high probability. One characterized fault almost certainly does not capture all possible seismic treat in a source region.

In tectonically active regions significant earthquakes commonly occur off well-characterized faults. For example, the M7 Loma Prieta earthquake initiated on the San Andreas fault, and ruptured mostly off the fault as a reverse-slip earthquake. Another example is the M6.7 Northridge earthquake. Even though faults in the San Fernando Valley and vicinity were reasonably well-characterized before the Northridge earthquake, this earthquake occurred on a blind thrust which was determined only in hindsight to be a potential hazard.

Particularly in SCRs many earthquakes come as a surprise, in the sense that they occur on faults that are not previously characterized as active. No faults have been unambiguously associated with either the Charleston 1886 mainshock or the 1811-1812 New Madrid earthquakes, and these are both in regions that have been intensively studied for decades. All historical earthquakes in the M5 to M6 range in the CEUS have occurred on faults that have not been characterized as active by paleoseismic or other data.

The evidence supports the Oklahoma aulacogen as capable of producing earthquakes greater than M5, because it contains a fault with known M>5 earthquakes, and substantial seismicity at M<5 has occurred off the fault within the aulacogen in the recent historical record. Given the relatively low rate of earthquake activity, it should not be required that one observe a M>5 earthquake in this region during a few decades to conclude that the aulacogen is active. Note also that the applicant states in a letter, dated Oct 28, 2009, that an earthquake with M=5 was recorded in the Oklahoma aulacogen, albeit near the edge. This New Mexico earthquake is discussed in the response to RAI 02.05.02-1 and may provide sufficient evidence to require a revision of Pa to 1.0 when characterizing seismic activity within the Oklahoma aulacogen. In the Rio Grande Rift a point source model with maximum regional magnitude, located at the minimum distance from the CPNPP site, was used to characterize unmapped sources in the region. Why is a similar approach, using the Meers estimated maximum magnitude, not used for the Oklahoma aulacogen?

Further justification of the applicant's response to these questions is necessary for NRC to make a credible safety finding on these issues.

NRC QUESTION NO.: 02.05.02-13

In FSAR Subsections 2.5.2.4.2.2.1 and 2.5.2.4.2.2.2 you discussed how the Mmax distribution for EPRI source models was updated based on recent earthquake observations. The procedure used raises the lower bound on maximum magnitude to the magnitude of the largest observed earthquake. Please explain why the observed largest magnitude earthquake is suitable for Mmax determinations in seismic sources with limited observations and lower seismicity rates, such as the South Coastal Margin and the NM-Texas block. Please justify your assumption that the maximum observed earthquake magnitude should be used as the Mmax in these sources.

<u>USGS comments</u>

For the NM-Texas block the applicant's justification of the assumption that the maximum observed earthquake magnitude should be used as the lower range boundary of Mmax for these sources, 'is justified by the fact that this update simply follows the original methodology of the Law EST.'

In the case of the South Coastal Margin source the applicant's justification is 'that this update was developed following the pertinent NRC regulatory guidance.'

In neither case does the applicant provide a scientific or statistical justification for the assumption that the maximum observed earthquake magnitude over a few decades of historical record is a scientifically adequate lower boundary for Mmax for these sources. Further justification is scientifically advisable and may be necessary for NRC to make a credible safety finding.

NRC QUESTION NO.: 02.05.02-14

In FSAR Subsection 2.5.2.4.2.3.1 you stated that the treatment of the NMSZ in the PSHA calculations is essentially the same as what was done in Bellefonte and Clinton PSHA studies. However, the Bellefonte and Clinton PSHA studies used both time-dependent and time independent source models. The FSAR does not mention a time-dependent treatment of the NMSZ.

a. Is the time-dependent treatment of the NMSZ the same as that used in the Bellefonte FSAR? What basic renewal model is applied, Brownian passage time or some other model?

b. Please discuss the important parameters and their uncertainties used for the NMSZ. For example, mean recurrence interval, coefficient of variation, or alpha, time since last main shock cluster to beginning of proposed plant operations, or t0, and exposure time, Δt. Please define exposure time, e.g. time from beginning of commercial power generation to plant decommissioning or other appropriate end-time.

<u>USGS comments</u>

The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.02-15

In FSAR Subsection 2.5.2.4.2.3.2.2 you described the data used to determine the maximum magnitude for the Meers fault using source rupture length, source rupture area, and the maximum surface displacement data. The maximum surface displacement data produced an Mmax of 7. The staff is concerned about the lack of multiple displacement data along the Meers fault which makes it uncertain whether or not the two displacement values used are closer to the mean or the maximum displacement.

a. Please justify more fully using the limited surface displacement data available for the Meers fault with the maximum displacement regression equations of Wells and Coppersmith, rather than the average displacement regression equations of Wells and Coppersmith, which would yield a higher maximum magnitude.

b. Please further justify the use of uneven weights (0.2, 0.6, 0.2) for the three magnitude estimates in calculating the Meers fault's impact on the hazard curves.

<u>USGS comments</u>

The response provides an adequate answer to question a. above. However, because a single measurement of net slip along the fault is very unlikely to be a maximum value, even along a part of the fault with the highest surface displacements, the symmetrical weights given to the distribution of maximum magnitudes are not adequately justified. Either the range on Mmax should be extended to account for the full plausible range of this parameter, or weights should be strongly skewed towards the greater estimates of magnitude because this parameter is intended to estimate a maximum value.

NRC QUESTION NO.: 02.05.02-16

The Meers fault is about 270 km from the CPNPP site with an Mmax distribution of 6.85±0.15 (Table 2.5.2-213) and a dominant recurrence interval of 1265 years. Considering these parameters, the staff is unclear why the Meers source's contribution to mean hazard is almost invisible in the 1 to 2.5 Hz deaggregations, and only a small contributor to the 5 to 10 Hz deaggregations of Figures 2.5.2-223 to 227. Please explain the near invisibility of the Meers source in FSAR Figures 2.5.2-223 to 227.

USGS comments
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.02-17
FSAR Subsection 2.5.2.4.2.3.3.1 states that the fault source characterization for Rio Grande Rift (RGR) faults is based on a simplification of the USGS National Seismic Hazards Maps. Some the RGR faults extend into Mexico near the Big Bend of the Rio Grande River. However, faults south of the USA/Mexico border are not considered in the National Seismic Hazards Maps and faults south of the border are not listed in Tables 2.5.2-214 and 215 of the FSAR.
a. Please explain if any attempt was made to characterize RGR seismic hazard from faults that extend into Mexico.
b. Please explain how you accounted for seismic hazard arising from other potential seismic sources located in Mexico.

USGS comments
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.02-18
In FSAR Subsection 2.5.2.4.4 you stated that "Anchoring the LF spectral shape to all frequencies was necessary because otherwise the LF spectral shape exceeded the HF spectral shape at high frequencies. This exceedence results from the contribution of extreme ground motions ($\varepsilon > 1$, see for example Figure 2.5.2-224) at low spectral frequencies, and a resulting UHRS shape that differs for the median shape predicted in NUREG/CR-6728." The staff is not clear on how these adjustments were made. Please describe further details by providing the low-frequency and high-frequency spectral shapes together and whether or not any higher ground motions, mentioned as "extreme ground motions" were disregarded by using the high frequencies in low-frequency spectral matching.

USGS comments
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.02-19
FSAR Subsection 2.5.2.6.1.1 states that "Figure 2.5.2-234 shows the horizontal GMRS spectrum taken from Table 2.5.2-228…" However, the GMRS shown on the mentioned figure and the values provided in the table do not match. Please clarify why there is a difference. Please also explain the differences in the GMRS curves shown in Figure 2.5.2-234 of the FSAR and Figure 2.5.2-247 of the supplemental document.

USGS comments

The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.02-20

Please provide the following data in digital format:

a. Smooth Rock UHRS values for annual exceedance frequencies of 10-4, 10-5, and 10-6

b. Geographic coordinates of all seismic source geometries used in the Comanche Peak PSHA study

c. Median Amplification Factors used in site response calculations for 10-4, 10-5, and 10-6 annual exceedance frequencies in digital format.

d. The shear wave velocity profile used in site response calculations in digital format.

e. Mean total hazard curves for 0.5, 1, 2.5, 5, 10, 25, and 100 Hz as well as the hazard curves of all individual seismic sources

f. Shear modulus and damping degradation curves shown in FSAR Figure 2.5.2-232

g. Soil UHRS curves electronically for 10-4, 10-5, and 10-6 annual exceedance frequencies

h. Updated earthquake catalog

USGS comments

The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.02-21

1. The following is a list of editorial corrections that the staff has identified. Please provide an updated text that includes these corrections.

a. FSAR Subsection 2.5.2.1.2, the southern Oklahoma aulacogen is not outlined on Figure 2.5.2-202 as suggested by the FSAR.

b. FSAR Subsection 2.5.2.2.1.1 cites the wrong figure in the statement: "The Ouachita source zone extends from Arkansas into east Texas (Figure 2.5.2-233) and was defined to encompass the extent of the Ouachita fold belt within this region." Citation should read "2.5.2-203."

c. FSAR Subsection 2.5.2.4.1 refers to current COLA calculations in Tables 2.5.2-208 and 2.5.2-209 as 2007, but they are labeled as 2008 in the tables.

d. In FSAR Subsection 2.5.2.4.2.3.2, the reference to Figure 2.5-211, should be to Figure 2.5.1-211.

e. FSAR Subsection 2.5.2.4.2.3.3 uses the term "tensile stress regime." Is the correct term "extensional stress regime"?

f. FSAR Subsection 2.5.2.4.4 refers to the shaded cells in Table 2.5.2-220. There are no shaded cells in Table 2.5.2-220.

g. In FSAR Subsection 2.5.2.6.2, Table 2.5.2-227, there are superscript numbers associated with particular values as if there were notes or footnotes (e.g. shallow site profile'). Are there corresponding notes?

USGS comments

The response is adequate and no further information is required.

Section 02.05.03 Surface Faulting

NRC QUESTION NO.: 02.05.03-1
FSAR Section 2.5.3.1.2 states that "The [United States Geological Survey] USGS has compiled information related to all known Quaternary faults, liquefaction features, and possible tectonic features in the [central and eastern United States] CEUS." Please clarify whether or not this is a complete compilation or evaluation of all known Quaternary faults, liquefaction features, and all possible tectonic features and what are its limitations for the purposes of concluding that a feature is, or is not, a capable tectonic structure.

<u>USGS comments</u>
The response is adequate and no further information is required.

NRC QUESTION NO.: 02.05.03-2
In Section 2.5.3.2 the FSAR briefly mentions a lineament analysis using 1940's air photos. Please describe the analysis in much greater detail, preferably in Section 2.5.1 where tectonic features in the site vicinity are discussed. Please include the following:
a) What other types of imagery were used in the lineament analysis;
b) Are the lineaments numbered on figure 2.5.3-201;
c) Please explain the "lineament report (WLA, 2007)" referenced on figure 2.5.3-201 and whether or not it is referenced and described in the FSAR;
d) Please explain the origin of each lineament, or group of lineaments, and state the evidence for their inferred origin.

<u>USGS comments</u>
Most of the text of the response is adequate, but questions b) and c) of RAI No. 02.05.03-2 above were not answered. No updated figures clarifying the origin of numbered lineaments on Figure 2.5.3-201 was provided and the Lineaments Report (WLA, 2007) referenced on that figure was not provided or explained. Updated figures and explanation of WLA (2007) is scientifically advisable but not necessary for NRC to make a credible safety finding.

NRC QUESTION NO.: 02.05.03-3
In FSAR Section 2.5.3.8.2, you state, "It has been concluded that anthropogenic activities occurring near the site do not pose a hazard for surface deformation." Please explain in detail the basis for this conclusion, and what parts of the FSAR explain the evidence and analysis fully justifying this conclusion.

<u>USGS comments</u>
The response is adequate and no further information is required.