**REQUEST FOR ADDITIONAL INFORMATION**
**Volume 2 – Preclosure**
**Chapter 2.1.1.1 – Site Description as it Pertains to PCSA**
**1st Set (RAIs #1 to #10)**

**RAI #1**

Justify the shear strength and compressibility of alluvium and underlying materials within the zones of influence of proposed surface facility structures that are based on few shallow test data (SAR Section 1.1.5.3.2.6.2.1.1). In particular, describe: (a) the strength and compressibility of alluvium as they vary laterally or with depth; (b) the spatial relationships or relative amounts and mechanical properties of cemented and un-cemented alluvium; (c) the strength and compressibility of tuffs that underlie the alluvium; and (d) justify the assumption that the subsurface materials supporting the foundations (including the tuffs that underlie the alluvium) will be stable and undergo only elastic deformations when subjected to static and seismic loading (SAR Section 1.2.2.5, BSC 2007j. section 6.2.3, page 16).

The applicant estimated the shear strength of alluvium using *in situ* measurements of relative density in a few test pits (4–19 ft deep), and concluded that shear strength of the alluvium (30 ft to 200 ft thick) does not vary laterally or with depth (Attachment I, section I.2.2 page I-19 to I-29, BSC 2002c of SAR Section 1.1.10). SAR Section 1.1.5.3.2.6.2.1.1 did not include compressibility or strength of the underlying tuff. Furthermore, the applicant indicates the occurrence of cemented and un-cemented zones of alluvium and low-density tuff (SAR Section 1.1.5.3.2.6.3), but has not provided information about the spatial relationships or relative amounts and mechanical properties of these materials. Additionally, the applicant, in assessing the performance of surface-facility structures, assumes that the subsurface materials supporting the foundations (including the tuffs that underlie the alluvium) will be stable and undergo only elastic deformations when subjected to static and seismic loading (SAR Section 1.2.2.5, BSC 2007j, section 6.2.3, page 16 ). However, the applicant has not provided supporting technical basis to justify this assumption. Staff needs the information to verify compliance with 10 CFR 63.21(c)(1)(ii) and 63.112(c).

**RAI #2**

Provide information on the stability of subsurface materials underlying the surface-facility structures and any cut or fill slopes near the aging pads or on transportation routes to and from the aging pads, during a full range of potential seismic events in the hazard curve (SAR Section 1.2.2.1).

The applicant's assessment of the performance of surface-facility structures assumes the subsurface materials supporting the foundations will be stable and undergo only elastic deformations when subjected to static and seismic loading (SAR Section 1.2.2.5, BSC 2007j, Section 6.2.3, page 16). However, the applicant has not provided a basis to support the stability assumption. Furthermore, SAR Figure 1.1-129 indicates excavation for a proposed aging pad

could expose the alluvium in a cut slope of up to 60 ft high. In addition, transportation routes that link the aging pads to other surface-facility structures (SAR Figure 1.2.7-2) could involve cut and fill slopes. In addition, the applicant has not provided information on stability analysis of slopes adjoining the aging pads or transportation routes. This information is required to verify compliance with 10 CFR 63.21(c)(1)(ii), and 10 CFR 63.112(c), (e)(8).

**RAI #3**

Justify the adequacy of information on subsurface geotechnical properties from site borings used in the analysis, design and performance of surface facilities. The justification should include discussion on plans, if any, for the number and location of future borings or field tests (SAR General Information Section 5.1.6.4; BSC 2007b, section 7.3.2).

In SAR General Information Section 5.1.6.4, the applicant refers to a soils report BSC 2007b (SAR Section 5.3 General References), supporting geotechnical properties. In Section 7.3.2 of the report, the applicant states that there are very few borings within the borders of the planned buildings and that "another 29 borings will be required to provide sufficient coverage of the planned facilities." The additional information is needed to verify compliance with 10 CFR 63.21(c)(1)(ii) and 10 CFR 63.112(c).

**RAI #4**

Provide the geotechnical information and supporting geophysical analyses from the additional boreholes drilled during 2006 and 2007 (Buesch and Lung 2008, SNL 2008a – SAR Section 1.1-10) to justify that seismic site response analysis for the Geologic Repository Operations Area described in SAR Section 1.1.5.2.5.2 adequately reflects site conditions.

In SAR Section 1.1.5.2.7.2 (pages 1.1-95-1.1-96), the applicant states that geotechnical data from 43 boreholes drilled during 2006 and 2007 were still being processed at the time the License Application was submitted to the NRC. The applicant provided a summary assessment of a subset of the geotechnical information from the 2006 and 2007 site characterization activities based on the alluvium depths observed in 12 of the 43 boreholes (Buesch and Lung 2008, SNL 2008a – SAR Section 1.1-10). The applicant's preliminary conclusion, based on observations from these 12 boreholes, was that the new information was consistent with interpretations based on geotechnical data collected from site characterization activities carried out prior to 2006. However, no data or analysis is provided in the SAR, or in Buesch and Lung 2008, to support this conclusion. The information is needed to complete the review of the DOE site response analysis, and verify compliance with 63.21(c)(1)(ii) and 10 CFR 63.112( c).

**RAI #5**

Provide additional technical bases to support the conclusion in SAR Section 1.1.5.2.7.2 that the thirteen profiles used to model shear wave ($V_S$) and compression wave ($V_P$) velocities in the subsurface strata beneath Midway Valley account for the full range of variability and uncertainty in subsurface material properties of the tuff and alluvium layers underlying the GROA. This information should include additional technical bases to justify that impedance contrasts between densely welded and weakly to moderately welded tuffs, and between tuff and alluvium, are accounted for in the site response analysis (SAR Section 1.1.5.2.5.2).

In SAR Section 1.1.5.2.7.2 (pages 1.1-97-1.1-99), the applicant states that thirteen shear wave velocity profiles were developed for site response modeling to represent the variability of subsurface conditions beneath the GROA. From these base case profiles, the applicant developed a suite of sixty randomized site response $V_S$ and $V_P$ profiles that were used in the site response modeling (BSC 2008 – SAR Section 1.1.10). The applicant concludes that these sixty randomized site response $V_S$ and $V_P$ profiles represent the full variability and uncertainty of $V_S$ and $V_P$ in near subsurface of Midway Valley. It is not clear, from the information presented in the SAR and in BSC 2008, whether the changes in the site response ground motions due to impedance contrast between densely welded and weakly to moderately welded tuffs layers is fully accounted for by the applicant's approach. The information is required to verify compliance with 10 CFR 63.21(c)(1)(ii), 10 CFR 63.112(c) and 10 CFR 63.114(a), (b).

**RAI #6**

Explain how the two reference rock outcrop conditioned seismic hazard curves, one based on the shear-strain-threshold approach, and the other based on the extreme-stress-drop approach, are combined to produce hazard curves shown in SAR Figures 1.1-79 and 1.1-80.

In Appendix A4.5.3 of BSC 2008 (SAR Section 1.1.10 General References), the applicant states that the final conditioned mean seismic hazard curves are developed by combining the conditioned hazard curves using the both the shear-strain-threshold approach and the extreme-stress-approach. However, the applicant has not explained the method used to combine these hazard curves to develop SAR Figures 1.1-79 and 1.1-80. The information is needed to verify compliance with § 10 CFR 63.21(c)(1)(ii),10 CFR 63.112(c), and 10 CFR 63.114(g).

**RAI #7**

Provide an updated probability distribution of threshold shear strain, similar to Fig. 6-7 of BSC 2005a, SAR Section 1.1.10 General References, used to develop SAR Figures 1.1-79 and 1.1-80 (SAR Section 1.1.5.2.5.1 and SAR Section 1.1.10, BSC 2008c Appendix A). Also, provide the updated geotechnical data (shear wave velocity and strain-dependent material properties used for conditioning reference rock-outcrop hazard curves (BSC 2008c, Section A4.5.2).

In BSC 2008c, Section A4.5.2, the applicant states that an updated approach and material properties were used for conditioning reference rock outcrop hazard curves based on the shear-strain-threshold approach. However, the applicant has not provided details of the updated approach. The information is needed to assess compliance with 10 CFR 63.21(c)(1)(ii), 10 CFR 63.112(c) and 10 CFR 63.114(g).

**RAI #8**

Explain how the updated probability distribution of threshold shear strain and the updated probability distribution (density) of bounding horizontal Peak Ground Velocity (PGV) developed in BSC 2008c (SAR Section 1.1.10) are used in Equation A4.2 (BSC 2008c).

In BSC 2008c, Section A4.5.2, the applicant states that an updated approach and material properties were used for conditioning reference rock outcrop hazard curves based on the shear-strain-threshold approach. However, the applicant has not provided details of the updated approach. The information is needed to assess compliance with 10 CFR 63.21(c)(1)(ii), 10 CFR 63.112(c) and 10 CFR 63.114(g).

**RAI #9**

Clarify the technical bases for development of compression wave ($V_P$) velocity profiles for the surface facilities and repository block discussed in SAR Section 1.1.5.2.7.2. (Pages 1.1-98 and 1.1-100). Explain why the directly measured $V_p$ values were not used for the $V_p$ profiles, in contrast to section 6.4.2.5.2 of BSC 2008c (SAR Section 1.1.10 General references) that seems to include directly measured $V_P$ data from boreholes drilled in 2000 and 2001.

In the SAR Section 1.1.5.2.7.2, the applicant states that the $V_P$ profiles were derived from the $V_S$ profiles and smoothed and extrapolated Poisson Ratio curves. In contrast, the applicant states in BSC 2008c that the measured $V_P$ profiles from fifteen boreholes drilled in 2000 and 2001 were used to first generate the smoothed Poisson Ratio curves. The Poisson Ratio curves were extrapolated to greater depths based on vertical seismic profiling (VSP) data. The smoothed and extrapolated Poisson Ratio curves were then combined with $V_S$ profiles to recompute $V_P$ profiles. These recomputed $V_P$ profiles were used in the site response analysis and to support average Poisson Ratio values for the Calico Hills Formation and Prow Pass Tuff. The applicant

has not provided rationale to show why the directly measured $V_P$ measurements were not used for the $V_P$ profiles. Moreover, the applicant states that sensitivity calculations show that uncertainty in the $V_P$ profiles did not significantly alter their modeled results (BSC, 2008c, page 6-53). Yet, the applicant has not provided supporting information to substantiate this claim. The information is needed to verify compliance with 10 CFR 63.21(c)(1)(ii) and 10 CFR 63.112(c).

**RAI #10**

Justify the location and characteristics of faults in Midway Valley within the Geological Repository Operations Area (GROA) zone of influence of fault-displacement (SAR Section 1.1.5.1.4; Figs. 1.1-59, 1.1-61, 1.1-64). In particular, address the results of the 43 additional boreholes drilled during 2006 and 2007 and structural-geologic interpretations (Orrell, 2007, SAR Section 1.1.10) about relationships between, and potential Quaternary slip on, the Bow Ridge block-bounding fault and splays, the Exile Hill fault and splays, and the Midway Valley faults and splays, and potential effects on the seismic hazard. Additionally, explain how the fault maps provided in figures 1.1-59, 1.1-61 and 1.1-64, and the exposed and buried faults in cross sections of the GROA figures 1.1-65, 1.1-66, and 1.1-67 are consistent with each other and with the most recent interpretations of the boreholes data.

In SAR Section 1.1.5.1.4, the location and characteristics of faults in Midway Valley are discussed, and Section 1.1.10 includes a reference (Orrell 2007) about a preliminary reinterpretation of the 43 additional boreholes drilled during 2006 and 2007 and effects on location of the Bow Ridge fault and adjacent faults near proposed aging pads. However, the SAR discussion does not discuss the data and its effects on the fault locations and potential seismic hazard. Apparent inconsistencies in SAR maps and cross sections of the GROA, and the incomplete use of existing potentially relevant data, make the characterization of faults relevant to design considerations for GROA structures and facilities unclear. Staff needs this information to verify compliance with 10 CFR 63.21(c)(1)(ii) and 10 CFR63.112(b), (c) and (d).