



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 22, 1995

Dr. Stephan J. Brocoum
Assistant Manager for
Suitability and Licensing
Department of Energy
Office of Civilian Radioactive
Waste Management
Yucca Mountain Site
Characterization Office
P. O. Box 98608
Las Vegas, NV 89193-8608

SUBJECT: TOPICAL REPORT ON "METHODOLOGY TO ASSESS FAULT DISPLACEMENT
AND VIBRATORY GROUND MOTION HAZARDS AT YUCCA MOUNTAIN"

Dear Dr. Brocoum:

In a letter dated March 16, 1995, the U.S. Department of Energy (DOE) responded to four concerns identified in the U.S. Nuclear Regulatory Commission's acceptance review (Bell to Brocoum, ltr. dated January 12, 1995) of the subject topical report (TR). In that letter, the staff noted that its decision to proceed with a technical review of the subject TR was contingent on an acceptable DOE response to the four concerns.

The staff found DOE's response to be largely acceptable and, as a result, has conducted a review of the TR, in accordance with NRC's Division of Waste Management Topical Report Review Plan dated February 8, 1994. In its review of this first of a series of TRs on faulting and seismic hazards, the staff concentrated on the methodology to "Assess Seismic Hazard." The staff finds that additional information is necessary to complete its review. In particular, DOE should provide: (a) additional information on the expert elicitation process, and (b) satisfactory responses to the enclosed comments.

Regarding the staff's request for information on the expert elicitation process, the staff considers that Study Plan 8.3.1.17.3.6 "Probabilistic Analyses of Vibratory Ground motion and Fault Displacement at Yucca Mountain", Revision 0, does not provide sufficient information on, or discussion of, the expert elicitation process. The staff considers the expert elicitation process to be a key element of this TR and the information provided in the report and the study plan is not sufficient to allow a determination to be made regarding the adequacy of the process. Information should be provided on the methodology to be used and the criteria to be applied, as requested in comment 2 of the enclosure.

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In addition, because our review was focused strictly on the methodology, we may have further comments on aspects of this TR if the issues noted by DOE to be addressed in TRs 2 and 3 are not adequately discussed in those upcoming reports. For example, possible concerns regarding DOE's approach to considering Type I faults in the overall design methodology, are being deferred until review of TR 2.

Finally, the staff review of the TR resulted in the identification of four comments contained in the enclosure.

Sincerely,

Kim for

Michael J. Bell, Chief
Engineering and Geosciences Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated

cc: List attached

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In addition, because our review was focused strictly on the methodology, we may have further comments on aspects of this TR if the issues noted by DOE to be addressed in TRs 2 and 3 are not adequately discussed in those upcoming reports. For example, NRC staff's concerns on set back distance from faults, and the approach that will be taken for considering Type I faults in the overall design methodology, are being deferred until review of TR 2.

Finally, the staff review of the TR resulted in the identification of four comments contained in the enclosure.

Sincerely,

Michael J. Bell, Chief
Engineering and Geosciences Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated

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In addition, because our review was narrowly focused strictly on the methodology, we may have further comments on aspects of this TR if the issues, that DOE has noted will be addressed in topical report 2 and 3, are not adequately discussed in those upcoming reports. For example, the staff has withheld comments on how new information, derived during site characterization about faults and vibratory ground motion, will be considered after the TR has been completed. Also, the staff has withheld comments on the absence from this TR of details on set back distance and the approach that will be taken for considering Type I faults in the overall design methodology.

Finally, the staff review of the TR resulted in the identification of four comments which are detailed in the enclosure.

Sincerely,

Michael J. Bell, Chief
Engineering and Geosciences Branch
Division of Waste Management
Office of Nuclear Safety
and Safeguards

Enclosure: As stated

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CC List for Brocoum letter dated September 22, 1995

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COMMENT 1

DOE needs to clarify and provide technical justification for some of the statements made in the topical report.

BASIS

- Page 10, Item 3. This section states that the methodology can accommodate such issues as temporal and spatial clustering of earthquake occurrence and simultaneous rupture on multiple faults. No discussion is provided on how this will be accomplished.
- Page 17, Section 2.3.2.2. The paragraph states: "If volumetric sources are required to assess fault displacement hazard, their earthquake recurrence relations and maximum magnitudes will be based on available data including seismic, geologic, and tectonic information." Usually, sources are labelled volumetric because there is no known faulting in the area. This is not the case at Yucca Mountain. It is not clear when and how volumetric sources will be used to assess fault displacement hazard.
- Page A-6, the last sentence of the third paragraph states "Source identification and characterization will be carried out iteratively based on results of the probabilistic seismic hazard...". This implies that probability cutoffs will be used to determine which sources are characterized. If this is the intent of this statement, then it would appear to be taking a course of action recommended against in NUREG-1451 and could result in significant sources being left out.
- Page B-4, 2nd to the last paragraph. Define "relatively deterministic behavior."
- Page B-6, B 2.4.2, 1st paragraph. Provide the technical basis for the statement "While theoretical calculations predict that ground motions from normal faulting events should be equivalent to those from reverse faults...".
- Page B-7, Section 2.4.3, 1st paragraph. Provide the basis for the statement "These data indicate at high frequencies, there are no unusual effects observed in the near-fault region." There are references that suggest evidence to the contrary [Boatwright and Boore (1982), and Heaton (1994)]. For example, Heaton (1994) indicates that peak acceleration at a period near 1 second for fault directivity influenced strong motion.
- Pages B-8 and B-9, Section B 3.2. First paragraph of this section, second sentence. It would seem that consideration of site responses to vibratory ground motion should be required or substantial justification be provided for not requiring it. If the results of the empirical and numerical analyses are different, what criteria will be used to determine the results that will be used?

Enclosure

- Page B-9, Section B 3.3, 1st paragraph. Provide the basis for the statement "However, if the variance of the site response is derived from small earthquakes, it may not be applicable to larger earthquakes because of the observed tendency of the variance to decrease with increasing magnitude."

RECOMMENDATION

DOE should clarify these statements and provide documentation and supporting references.

REFERENCES

Boatwright, J., and D.M. Boore, "Analysis of the Ground Accelerations Radiated by the 1980 Livermore Valley Earthquakes for Directivity and Dynamic Source Characteristics," *Bulletin Seismological Society of America*, V. 72, pp. 1843-1865.

Heaton, H., "Strong Ground Motions for the 1994 Northridge Earthquake: Were They Anomalous or a Warning of Things to Come?", *EOS (Supplement)*, V. 44, p. 174.

U.S. Nuclear Regulatory Commission, "Staff Technical Position on Investigation to Identify Fault Displacement Hazards and Seismic Hazards at a Geologic Repository," NUREG-1451, August 1992.

COMMENT 2

Elicitation of experts, as a means of establishing uncertainty, is proposed but details of how the elicitation will be carried out is not provided.

BASIS

- Page 17, last paragraph. The report mentions both the LLNL (Monte Carlo) and EPRI (Logic Tree) approaches, but it is not clear if both approaches will be used or whether one approach will be chosen over the other. Also, Section 2.3.2.5 lacks information regarding the minimum acceptance criteria for demonstrating that uncertainty propagation was adequately implemented using either approach.
- Page B-7, Section B 2.5, last paragraph. Many approaches to ground motion evaluation are given. Clarify whether all such approaches will be a part of the elicitation or whether a specific approach will be recommended?
- Clarify how experts will be chosen to ensure that bias is minimized and potential conflicts of interest are identified.
- Page C-9, C 5.1. The disaggregation process proposed for use at Yucca Mountain should be explained in detail.

RECOMMENDATION

Provide a detailed discussion of the expert elicitation process, especially as it relates to the above-noted concerns.

COMMENT 3

Underground nuclear explosions (UNEs) are proposed as a source of data for determining attenuation with distance or depth, but differences between UNEs and earthquakes do not appear to have been considered.

BASIS

- Page B-10, Section B 3.4.2. Explosions which are at depths similar to that of the repository may not be appropriate for determining attenuation because earthquake source energy is released several kilometers deeper than UNEs.

RECOMMENDATION

Provide the technical basis for using UNEs for determining attenuation, including an analysis that considers the difference in frequency content and depth of UNEs compared to earthquakes.

COMMENT 4

The topical report discusses in some detail vibratory ground motion hazard, but no detailed discussion on fault displacement hazard is presented.

BASIS

- In regard to long-term or permanent closure, for all Type I faults that transect the repository, the maximum fault displacement determined by paleoseismic analysis should be considered for the design if the results of the probabilistic analysis indicate lower design values. This approach is similar to the one used for the Diablo Canyon Long-Term Seismic Program (LTSP) described in the topical report on p. E-11. The staff regarded the results of the deterministic analysis carried out during the LTSP as being controlling over the results of probabilistic analysis with respect to the Hosgri Fault. Had the probabilistic seismic hazard assessment value been lower than the deterministic value, the deterministic maximum magnitude would have been the design basis.
- In most cases, it will not be possible to determine an age of last displacement on subsurface faults unless they can be related to faulting at the surface. It is not clear if the state of activity of these faults is being assessed and considered in the topical report.
- Page A-11, Section A 4.1. As stated in the topical report "...the seismicity on an individual fault does not exhibit a typical linear b-value distribution." Further definition of these values is required to determine the probabilistic design ground motions.
- Page A-12, Section A 4.3, 4th paragraph. A characteristic slip rate function may be more appropriate than an exponential function for single faults. A thorough justification will be required if the characteristic earthquake is based upon a segmented fault model and results are predicted for long-time periods, e.g., 10,000 years.
- Page B-7, Section B 2.4.3, 2nd paragraph. Regarding the statement "...the incidence of directivity effects (and the resulting difference between fault-normal and fault-parallel motions) in dip-slip faulting is expected to be less than for strike-slip faulting...". Does this comport with observations reported at the NTS FOC facility in relation to the 1992 Little Skull Mountain earthquake? There is more information about strong motion directivity available now than when the report was prepared, such as the Northridge 1994, and Kobe 1995, earthquakes. These data should be considered in the analysis. In addition, seismic data, orientation, and magnitude of regional tectonic stresses, and their relation to the orientations and attitudes of faults at the repository, should be considered in the ground motion directivity analysis.
- Page C-7, Section C 3.4. A fault displacement hazard curve should be constructed and used to encompass fault intersections and faults in the surrounding region.
- Page C-10, Table C-1 to C-3. Fault dips and at-depth relationships should be included in one of these tables.

RECOMMENDATION

Provide a detailed discussion on fault displacement hazard that involves the above-noted concerns.