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GEOMATRIX

FINAL REPORT – VOLUME I of III

Fault Evaluation Study and Seismic Hazard Assessment

Private Fuel Storage Facility

Skull Valley, Utah

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6.0 POTENTIAL EARTHQUAKE GROUND MOTIONS

The potential for strong ground shaking at the site due to earthquakes is assessed based on a probabilistic seismic hazard analysis (PSHA). Section 6.1 describes the PSHA methodology used in this study. The characteristics of earthquake sources (active faults and seismic source areas) used in the hazard analysis are described in Section 6.2 and the results are presented in Section 6.3. Section 6.4 compares the PSHA results to ground motion estimates based on a deterministic analysis.

The design basis ground motions for the proposed PFSF site were arrived at using a deterministic approach, consistent with Part 72.102 and 10 CFR Part 100 for nuclear power plants. A deterministic approach assumes that the maximum credible earthquake on all capable sources will occur at the closest approach to the site. The controlling source results in the largest ground motions at the site and determines the SSE ground motions. The deterministic design basis ground motions at the proposed PFSF site were presented in the SAR (Section 2.6.2). Deterministic approaches do not incorporate any information related to the frequency of earthquake occurrence, nor do they allow for the explicit inclusion of uncertainties in the location, size, or ground motions associated with earthquakes. For these reasons, Part 100 has been revised (Part 100.23) to allow for probabilistic methodologies to be used to arrive at design basis ground motions. Part 72 has not yet been revised, but the rulemaking plan (SECY-98-126) indicates that probabilistic approaches should likewise be used for dry cask storage installations. Therefore, we have conducted a probabilistic seismic hazard analysis that incorporates the findings of the field studies and associated uncertainties. To evaluate the potential for fault displacement at the site, a probabilistic fault displacement analysis was also conducted (Section 7).

6.1 PSHA METHODOLOGY

6.1.1 Probability Level of Interest

Probabilistic seismic hazard analyses result in "hazard curves" that express the probability (or annual frequency) of exceeding various levels of ground motion. Lower probability levels are associated with progressively higher levels of ground motion. As such, the probability levels express the degree of conservatism in the ground motions to be used for design. The NRC recommends that a risk-informed graded approach to seismic design be used that takes into account the consequences of the possible failure of a system in arriving at an appropriate probability level. The NRC staff recognizes the value of this approach in its evaluation of the request for exemption to Part 72.102(f)(1) Seismic Design Requirement for Three Mile Island

Unit 2 Independent Spent Fuel Storage Installation (SECY-98-071), and in its Rulemaking Plan for revision to Part 72 (SECY-98-126). The Commission stated that "...ISFSI's which do not involve massive structures, such as dry storage casks and canisters, the required design earthquake will be determined on a case-by-case basis..." (45 FR 74697 [1980]). In its Rulemaking Plan, it is stated that the "NRC staff believed that a major seismic event at an ISFSI storing spent fuel in dry casks or canisters would most likely have minor radiological consequences compared with a major seismic event at an NPP, spent fuel pool, or single massive storage structure" (SECY-98-126). The NRC, therefore, recommends that a probabilistic approach be taken and that the probability levels appropriate to the design of a dry cask storage system should be higher (i.e., ground motions lower) than those for a nuclear power plant.

Until the Part 72 rulemaking is completed, there is only indirect guidance from the Staff regarding the appropriate probability level for seismic design. In the exemption to Part 72.102, the seismic requirement (design earthquake or DE) for the TMI-2 ISFSI was 0.35g peak ground acceleration, corresponding to a ~5 x 10^{-4} per year probability level (or ~2,000 year return period). The deterministic SSE at the INEL site was assessed to be 0.56g. In arriving at their decision, the Staff considered the appropriateness of a probabilistic methodology and a risk-informed graded approach. They noted that such a graded approach, which expresses the relative risk posed by the ISFSI, has been developed in DOE Standard 1020 "Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities." The standard takes a graded approach to design critical facilities, requiring facilities with greater accident consequences to use higher design requirements for phenomena such as earthquakes and tornadoes. They conclude, "Dry spent fuel storage facilities such as the TMI-2 ISFSI are PC 3 and must have a design earthquake equal to the mean ground motion with a 2,000-year return period. Considering the minor radiological consequences from a canister failure, and the lack of a credible mechanism to cause a failure, the staff finds that the DOE approach of using the 2,000-year return period mean ground motion as the design earthquake for dry storage facilities is adequately conservative."

The staff also note that the 10 CFR Part 60 Design Basis Event rulemaking also adopts a graded approach. In this approach, a design basis event is based on a probabilistic, risk-graded methodology. For seismic events, the staff has accepted DOE's two-tiered approach toward designing Part 60 SSCs. Those SSCs with potential failure consequences less than the public dose limit of 10 CFR 20.1302(a)(1), 1 mSv (100 mrem), must withstand the 1,000-year return period mean ground motion. Analysis of the consequences associated with a cask failure at the

PFSF are less than the 100 mrem dose limit, thus suggesting that the 1,000-year return period is appropriate.

Based on the above arguments for a risk-informed graded approach, we conclude that an appropriate design probability level for the PFSF site is 5×10^{-4} (2,000-year return period). The design basis ground motions presented in the SAR were based on a deterministic approach and did not incorporate the uncertainties associated with seismic sources, recurrence, or attenuation relationships. The PSHA presented herein does include these uncertainties explicitly, including the findings of the fault studies. The deterministically defined design basis ground motions are compared with the 2,000-year ground motions derived from the probabilistic approach, and are shown to be conservative relative to this criterion.

6.1.2 Implementation of PSHA Methodology in This Study

Basic Model

The methodology used for the probabilistic assessment of ground motion hazard at the Skull Valley site follows that outlined for the Yucca Mountain project as described in USDOE (1997) and CRWMS M&O (1998). The methodology for a PSHA was first proposed by Cornell (1968, 1971). The basic components of the PSHA for ground motion hazard are shown schematically on Figure 6-1. The components are as follows.

1. The sources of potentially damaging future earthquakes are identified. The types of sources typically identified are specific geologic structures, such as faults, and areal source zones representing tectonic provinces or zones of seismicity.

2. The frequency of earthquake occurrence in each source is assessed. This includes an evaluation of the maximum event that a source can produce. The probability distribution of distance from individual earthquakes to the site is also defined by specifying the appropriate spatial distribution model for earthquake location on the seismic source.

3. Appropriate ground motion attenuation models are selected for estimating site ground motions from each source. The estimates include both the expected levels of ground motion and the variation about the expected value that any recording may exhibit.

4. Using the probabilistic models developed in steps (2) and (3), a relationship between ground motion level and probability (frequency) at which it is exceeded is developed, defining a *hazard curve*. Specific ground motion levels for design can then be chosen by selecting an appropriate probability level.

NUCLEAR REGULATORY COMMISSION

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