Private Fuel Storage, L.L.C.

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April 2, 1999

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U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

REQUEST FOR EXEMPTION TO 10 CFR 72.102(f)(1)
SEISMIC DESIGN REQUIREMENT
DOCKET NO. 72-22/TAC NO. L22462
PRIVATE FUEL STORAGE FACILITY
PRIVATE FUEL STORAGE L.L.C.

Private Fuel Storage L.L.C. (PFS) hereby transmits the attached request for exemption in accordance with 10 CFR 72.7, "Specific Exemptions." The purpose of the exemption request is to change the methodology for calculating the design earthquake for the Private Fuel Storage Facility (PFSF) from a deterministic approach to a probabilistic, risk-informed approach. 10 CFR 72.102(b) requires ISFSI sites west of the Rocky Mountain Front to evaluate seismicity by the techniques of 10 CFR 100 Appendix A, which PFS has done. 10 CFR 100 Appendix A uses a deterministic approach for determining the safe shutdown earthquake at the site of a nuclear power plant, also referred to as the design earthquake (DE). 10 CFR 72.102(f)(1) states "For sites that have been evaluated under the criteria of Appendix A of 10 CFR part 100, the DE must be equivalent to the safe shutdown earthquake (SSE) for a nuclear power plant." PFS requests exemption from the requirements of 10 CFR 72.102(f)(1) which specify that the design earthquake at the PFSF site, which is west of the Rocky Mountain Front, be equivalent to the safe shutdown earthquake for a nuclear power plant calculated using the deterministic methods of 10 CFR 100 Appendix A. PFS requests use of a probabilistic seismic hazard analysis along with consideration of risk to establish the design earthquake at the PFSF.

The use of probabilistic techniques and a risk-informed approach are compatible with the direction provided by the Commission on Direction Setting Issue 12, "Risk-Informed, Performance-Based Regulation", as well as that reflected in the Commission's adoption of probabilistic approaches for the geological and seismic siting of more sensitive nuclear power plants. The analysis provided by PFS relies on widely accepted probabilistic seismic hazard analysis techniques that are consistent with the recent seismic design requirements providing for probabilistic seismic analysis in Parts 50 and 100 that apply to new nuclear power plants, and in Part 60 that applies to the disposal of high-level radioactive wastes in geologic repositories. In addition, the relative risk of the PFSF warrants a design earthquake with lower peak ground accelerations than that calculated using the 10 CFR 100 Appendix A methodology.

The detailed exemption request is attached, which sets forth the basis for changing from deterministic to a probabilistic risk-informed methodology for establishing the design earthquake. Also attached is the report (by Geomatrix Consultants, Inc.) presenting the results of applying the probabilistic seismic hazard analysis methodology to the PFSF site.

Upon approval of the exemption request, PFS commits to the submittal of PFSF site specific storage cask stability analyses for the HI-STORM and TranStor storage casks on the concrete storage pads to quantify the degree of cask sliding or tipping movement, if any, that would result from the new design earthquake. In addition, the storage pads and Canister Transfer Building will be reanalyzed, or the existing design confirmed to be conservative, for the new design earthquake.

Should you have any questions concerning this exemption request, please contact myself at 608-787-1236 or our project director, Mr. John Donnell, at 303-741-7009.

Sincerely,

John L. Donnell for

John D. Parkyn, Chairman
Private Fuel Storage L.L.C.

Attachments

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REQUEST FOR EXEMPTION TO 72.102(f)(1) SEISMIC DESIGN REQUIREMENT FOR THE PRIVATE FUEL STORAGE FACILITY

BACKGROUND

The purpose of this submittal is to change the methodology for calculating the design earthquake for the Private Fuel Storage Facility (PFSF) from a deterministic approach to a probabilistic, risk-informed approach. The design earthquake presented in the PFSF SAR was calculated in accordance with the requirements of 10 CFR 72.102. 10 CFR 72.102(b) requires ISFSI sites west of the Rocky Mountain Front to evaluate seismicity by the techniques of 10 CFR 100 Appendix A. 10 CFR 100 Appendix A uses a deterministic approach for determining the safe shutdown earthquake at the site of a nuclear power plant, also referred to as the design earthquake (DE). 10 CFR 72.102(f)(1) states "For sites that have been evaluated under the criteria of Appendix A of 10 CFR part 100, the DE must be equivalent to the safe shutdown earthquake (SSE) for a nuclear power plant."

Recently, the NRC has revised its regulations (10 CFR Parts 50 and 100) to permit calculation of the design earthquake at new nuclear power plants based on probabilistic seismic hazard analysis (PSHA) methodology, instead of the deterministic methodology presented in 10 CFR 100 Appendix A. The NRC issued Regulatory Guide 1.165 (Reference 1) to provide guidance on PSHA methodology. In addition, the NRC recently amended 10 CFR Part 60 to permit use of probabilistic, risk-informed methodology in designing for hazards (including seismic) at the high-level radioactive waste geologic repository.

While the NRC has indicated that it plans to amend 10 CFR 72.102 to permit use of PSHA methodology and a risk-informed approach to calculate the DE at ISFSI sites, it is unlikely that the rulemaking will be completed before issuance of the PFSF license. Therefore, PFS is requesting an exemption from 10 CFR 72.102(f)(1), which requires that the DE at an ISFSI be equivalent to the SSE for a nuclear power plant. The exemption would permit the DE at the PFSF to be calculated using the more recent PSHA methodology, in accordance with the guidance in Regulatory Guide 1.165, and applying the risk-informed approach of 10 CFR Part 60.

PFS has determined that there is an adequate safety basis for an exemption to the requirements of 10 CFR 72.102(f)(1), supported by a site-specific radiological risk analysis, as discussed below. The exemption would be consistent with Commission policy and regulations applicable to other facilities (i.e. nuclear power plants and high level waste geologic repositories) that carry greater risk than a Part 72 facility. Considering the minor radiological consequences of accidents analyzed at the PFSF, PFS considers that the present Part 72 requirement for calculating the design earthquake is an unnecessary regulatory burden. PFS considers that the use of probabilistic techniques and a risk-informed approach are compatible with the direction provided by the Commission on Direction Setting Issue 12, "Risk-Informed, Performance-Based Regulation" (Reference 2).

The probabilistic, risk-informed approach for establishing the PFSF DE described below is based on calculating the magnitude of a seismic event with a recurrence interval of 1,000 years. Use of a 1,000 year recurrence interval is justified in the PSHA based on dose consequences of accidents at the PFSF and consideration of relative risk, discussed below.

DISCUSSION

10 CFR 72.102(b) requires ISFSI sites west of the Rocky Mountain front, such as the PFSF site, to have seismicity evaluated by the techniques of Appendix A of 10 CFR Part 100, also known as a deterministic seismic hazard analysis (DSHA). PFS has evaluated seismicity of the PFSF site in accordance with 10 CFR 100 Appendix A. Appendix A calculates, based on site-specific investigations, the largest credible earthquake likely to affect a site, regardless of the probability of this event through time. Section 72.102(f)(1) states, "For sites that have been evaluated under the criteria of Appendix A of 10 CFR Part 100, the design earthquake must be equivalent to the safe shutdown earthquake (SSE) for a nuclear power plant." In this context, "DE" and "SSE" refer to the design peak ground acceleration (PGA), with an appropriate response spectrum, caused by the largest credible earthquake.

PFS performed a DSHA in accordance with the requirements of 10 CFR 72.102(f)(1), to calculate the magnitude of the design earthquake at the PFSF, as discussed in the PFSF SAR. PFSF SAR (Rev. 2) Section 3.2.10.1.1 describes the results of this methodology, indicating that the DSHA for the PFS site yields resultant PGA values for an SSE of 0.67 g in two directions of the horizontal plane and 0.69 g in the vertical plane, with an appropriate response spectrum.

Recent highly detailed seismological studies have found additional faulting in the vicinity of the PFSF site (Reference 3). If these faults were accounted for in the DSHA, the resulting PGA values would be slightly higher (approximately 10%) than those presently published in the SAR. The PSHA that is proposed to establish the DE at the PFSF, as discussed in the following paragraphs, does account for these faults.

When 10 CFR Part 72 was first promulgated in 1980, ISFSIs were largely envisioned to be spent fuel pools or single, massive dry storage structures. A DE equivalent to a nuclear power plant SSE seemed appropriate for these facilities, given the potential accident scenarios. Furthermore, for ISFSIs to be located at a nuclear power plant, the DE value was readily available without additional site characterization work, save the geotechnical investigation at the specific ISFSI location. However, an ISFSI storing spent fuel in dry casks is inherently less hazardous and less vulnerable to earthquake-initiated accidents than is an operating nuclear power plant (Reference 4).

The U.S. Nuclear Regulatory Commission recognized this reduced vulnerability in the initial Part 72 "Statements of Consideration," and stated that the DE for cask and canister technology need not be as high as a nuclear power plant SSE: "For ISFSIs 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 until more experience is gained with licensing these types of units" (45 FR 74697).

Both the HI-STORM and TranStor canisters that will be stored at the PFSF are new "multi-purpose" canisters designed for transport as well as storage, which by virtue of their rugged design are less vulnerable to earthquake initiated accidents. Their rugged design is demonstrated to be capable of withstanding stresses resulting from a 30 ft drop of the transport cask, required by 10 CFR 71.73, as well as the hypothetical storage cask tipover accident. Seismic accelerations impose relatively low stresses on the canisters in comparison with those associated with the cask drop and tipover accidents.

On January 10 1997, 10 CFR Parts 50 and 100 were revised to allow the use of the probabilistic seismic hazard assessment (PSHA) methodology to address uncertainties inherent in determining nuclear power plant seismic design values. These revisions were accomplished through the addition of 10 CFR 100.23 and Part 50, Appendix S. The PSHA method considers the frequency, as well as magnitude, of earthquakes that may affect a site. Rather than base seismic design on the largest ground motion likely to ever affect a site, a PSHA derives a site-specific hazard curve showing ground motion level versus annual probability of exceedence or, inversely, ground motion return period. The NRC issued Regulatory Guide 1.165 to provide guidance on calculation of the DE using PSHA techniques.

Since 10 CFR 72.102 currently requires that seismicity be evaluated by the deterministic techniques of Appendix A of Part 100, applicants for ISFSI licenses are not able to utilize the improvements promulgated in the amendments to Part 100 and must follow the rules that applied to nuclear power plants before these amendments. In the proposed rulemaking for Part 72 (Reference 5) however, the staff has proposed to modify the Part 72 seismic requirement to a level commensurate with the risks of cask and canister ISFSIs by providing for the use of PSHA methodology.

In addition, the seismic design philosophy in 10 CFR Part 60 for high-level waste repository surface facilities (also known as the Design Basis Event (DBE) rulemaking) is based on a PSHA. On January 3, 1997, the definitions of design basis event and important-to-safety in Part 60 were revised to allow a probabilistic, risk-informed approach in designing for hazards (including seismic) at a geologic repository, with two design levels based on risk (61 FR 64257). This set an NRC precedent by accepting a risk-informed approach in licensing an above-ground facility (preclosure operations area of the high level waste repository) intended to temporarily store spent nuclear fuel quite similar to an ISFSI licensed under 10 CFR 72. For seismic events, the staff has accepted a two-tier approach toward designing Part 60 structures, systems, and components (SSCs). This approach is summarized in the following quotes from the NRC staff.

In SECY-98-126, Reference 5, concerning the NRC's rulemaking for geological and seismological characteristics for siting and design of dry cask ISFSIs under 10 CFR 72, the NRC staff states under Option 3, its preferred option for amending Part 72, the following related to the Part 60 design basis event rulemaking:

> "The specific approach proposed for dry cask ISFSI systems, structures, and components would be comparable to the 10 CFR Part 60 graded approach to design ground motion for SSCs of pre-closure facilities. This graded approach would allow the structures, systems, and components of dry cask ISFSIs to be designed to either Frequency-Category-1 design basis events or Frequency-Category-2 design basis events, depending upon their importance-to-safety. For seismic events, the staff has accepted the approach described in DOE Topical Report YMP/TR-003-NP, Rev. 2, Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain, pertaining to 10 CFR Part 60. In this approach, Frequency-Category-1 design basis ground motion refers to a mean annual probability of exceedance of 1.0E-03, which corresponds to a 1,000-year return period. Frequency-Category-2 design basis ground motion refers to a mean annual probability of exceedance of 1.0E-04, which corresponds to a 10,000-year return period."

In SECY-98-071, Reference 6, regarding DOE's request for an exemption from the deterministic seismic design requirements of 10 CFR 72.102(f)(1) for an ISFSI that would store TMI-2 spent fuel at INEEL, the NRC staff states:

> "With the Part 60 Design basis event rulemaking, NRC adopted a graded approach similar to DOE Standard 1020 for natural hazard characterization and design. The Design basis event rulemaking defined a framework for two SSC design categories for repository surface facilities. For seismic events, the staff has accepted DOE' s approach of designing SSCs with failure consequences within the public dose limit of 10 CFR 20.1301(a)(1), 1 mSv (100 mrem), to withstand the 1000-year return period mean ground motion. Meanwhile, SSCs with higher potential accident doses must be designed to withstand the 10,000-year return period mean ground motion."

PFS proposes to apply this same approach to establishing the DE at the PFSF. A detailed site specific seismic evaluation of the PFSF was performed, in accordance with the NRC's guidance in Regulatory Guide 1.165. This is compatible with the NRC's current requirements for establishing the DE at a new nuclear power plant site, and in keeping with the staff's plans for establishing DEs at dry cask storage ISFSIs in the future.

Applying the PSHA methodology of Regulatory Guide 1.165, the design earthquake was calculated at the PFSF site for a recurrence interval of 1,000 years. The attached report, prepared by Geomatrix Consultants, Inc., documents the results of this calculation. PFS proposes that the DE for the PFSF be calculated based on PSHA methodology for the 1,000 year recurrence interval, based on consideration of the relative risk associated with this event.

The bounding consequences of a major seismic event at the PFSF using the HI-STORM and TranStor systems technology are limited by a storage cask tipover event, although this would only occur at a ground motion well above the 0.67g horizontal and 0.69 g vertical PGA values presented in PFSF SAR (Rev. 2) Section 3.2.10.1.1. While cask tipover is not a credible event at the PFSF, the canisters are designed to withstand the stresses resulting from a non-mechanistic cask tipover event with no breach and no release of radioactive material from inside the canister. Hypothetical cask tipover accidents are analyzed in Section 8.2.6 of the PFSF SAR (Rev. 2).

PFS analyses of hypothetical, non-mechanistic accidents, beyond the design basis, involving leakage from the canisters calculate off-site doses well below the 0.05 Sv (5 rem) whole body dose limit of 10 CFR 72.106(b). In its second round RAI response letter (Reference 7), PFS presented an analysis of the effects of such a beyond-design basis accident involving failure of a SSC important to safety in which a canister is postulated to leak continuously for 30 days under hypothetical accident conditions with 100% of the fuel rod cladding assumed to have failed, in accordance with the NRC's Interim Staff Guidance-5. The response to RAI 7-1 shows that the total effective dose equivalent (TEDE) from this accident to an off-site individual was calculated to be 74.9 mrem. This analysis conservatively assumed that the individual was continuously located at the PFSF owner controlled area boundary for 30 days. The dose from this hypothetical accident condition, for which no credible mechanism has been identified, is not only well below the 0.05 Sv (5 rem) siting evaluation factor of 10 CFR 72.106(b), but also below the 100 mrem public dose limit of 10 CFR 20.1301(a)(1). The results of this accident analysis will be incorporated into a future revision to the PFSF SAR Section 8.2.7, replacing the hypothetical canister breach accident which will be removed from the SAR in accordance with the NRC's Interim Staff Guidance-3.

This 74.9 mrem TEDE represents the maximum dose from any accident analyzed for the PFSF that will be in the PFSF licensing basis. Based on the NRC's risk-informed policy for establishing the DE stated in the above SECY documents, the 1,000 year seismic recurrence interval is appropriate and conservative for use at the PFSF since worst-case accident consequences are below the 10 CFR 20.1301(a)(1) public dose limit of 100 mrem.

This recurrence interval is the same as that selected by the DOE for preclosure seismic design of important-to-safety SSCs for Frequency-Category 1 design basis events at the Yucca Mountain high level waste geologic repository in Reference 8, which the NRC staff accepted. As stated by the DOE in Reference 8, use of a 1,000 year recurrence interval represents a conservative translation of the qualitative frequency description of Frequency-Category 1 design basis events in 10 CFR 60, i.e., "events that are reasonably likely to occur regularly, moderately frequently, or one or more times before permanent closure of the geologic repository operations area." The use of a 1,000 year recurrence interval would be similarly conservative for the PFSF. In addition, the license for the PFSF will be for 20 years with the potential for license renewal for another 20 years per 10 CFR 72.42, or up to 40 years, which is a shorter duration than the 150 years considered in Reference 8 (Section 3.1.1) for the Yucca Mountain preclosure facility.

Thus, use of a 1,000 year recurrence interval for the PFSF will be conservative and appropriate. As documented in the attached report prepared by Geomatrix Consultants, Inc., the DE calculated using the methodology of Regulatory Guide 1.165 for the 1,000 year recurrence interval is characterized by 0.40 g horizontal and 0.39 g vertical PGAs.

CONCLUSION

PFS has completed both a DSHA and a PSHA for the PFSF site. As discussed in Section 8.2.1 of the PFSF SAR (Rev. 2), the current SSE design basis of 0.67g developed by the deterministic method required by 10 CFR 72.102(f)(1) would not result in cask tipover and no radioactivity would be released. Moreover, even if a cask tipover did occur there is no credible scenario under which the canister confinement barrier would be breached and radioactivity would be released. Based on this absence of radiological consequences from any credible seismic event and the minor radiological consequences from hypothetical beyond-design basis accidents, the present Part 72 requirement for an ISFSI DE is considered an unnecessary regulatory burden. A PSHA was performed using the methodology permitted by 10 CFR 100.23 and 10 CFR 50 Appendix S for new nuclear power plants, applying the guidance of Regulatory Guide 1.165 (documented in the attached report prepared by Geomatrix Consultants, Inc.), resulting in the DE with a 1,000-year recurrence interval to be 0.40 g horizontal and 0.39 g vertical PGA.

The 1,000-year recurrence interval is justified by the low consequences of a worst-case hypothetical beyond-design basis accident at the PFSF, having dose consequences below the 100 mrem TEDE public dose limit of 10 CFR 20.1301(a)(1). Given the absence of radiological consequences from any credible seismic event, it is considered that application of the probabilistic risk-informed approach for calculating the seismic hazard, that the NRC staff adopted in the Part 60 rulemaking, is adequately conservative for the PFSF. Moreover, the expected life span of the PFSF, 20 years with the potential for renewal for another 20 years per 10 CFR 72.42, justifies use of this ground motion as the DE.

The PFSF DE is calculated in accordance with the latest probabilistic methodology that applies to new nuclear power plants, using the risk-informed approach determined to be acceptable in the Part 60 rulemaking that applies to preclosure facilities of Yucca Mountain, considered to be similar to an ISFSI with dry cask storage. Thus, while reducing regulatory burden, granting the requested exemption from IO CFR 72.102(f)(1) will still maintain an adequate design margin for seismic events and will not be inimical to public health and safety.

REFERENCES

1. U.S. NRC Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion," March 1997.

2. U.S. NRC Direction Setting Issue 12 of the Commissions Strategic Assessment Issue Paper, release date: September 16, 1996.

3. Geomatrix Consultants, Inc., Fault Evaluation Study and Seismic Hazard Assessment, Private Fuel Storage Facility, Skull Valley Utah; Final Report, February 1999.

4. Hossain, QA. A.H. Chowdhury, M.P. Hardy, K.S. Mark, J.E. O' Rourke, W.J. Silva, J.C. Stepp, and F.H. Swan, III, "Seismic and Dynamic Analysis and Design Considerations for High-Level Nuclear Waste Repositories," J.C. Stepp, ed., American Society of Civil Engineers, New York, New York, 1997.

5. U.S. NRC SECY-98-126, from L. Joseph Callan (EDO) to the Commissioners, "Rulemaking Plan: Geological and Seismological Characteristics for Siting and Design of Dry Cask Independent Spent Fuel Storage Installations, 10 CFR Part 72, dated June 4, 1998.

6. U.S. NRC SECY-98-071, from L. Joseph Callan (EDO) to the Commissioners, "Exemption to 10 CFR 72.102(f)(1) Seismic Design Requirement for Three Mile Island Unit 2 Independent Spent Fuel Storage Installation, dated April 8, 1998.

7. PFS letter J.D. Parkyn to U.S. NRC Director of Office of Nuclear Material Safety and Safeguards, "Response to Request for Additional Information;" dated February 10, 1999.

8. DOE Topical Report YMP/TR-003-NP, Rev. 2, "Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain", August 1997.

Development of Design Ground Motions for the Private Fuel Storage Facility

Private Fuel Storage Facility

Skull Valley, Utah

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DEVELOPMENT OF DESIGN GROUND MOTIONS FOR THE PRIVATE FUEL STORAGE FACILITY

Prepared for:

Private Fuel Storage Facility
Private Fuel Storage, LLC

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Quality Assurance Category I
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DEVELOPMENT OF DESIGN GROUND MOTIONS

Private Fuel Storage Facility
Skull Valley, Utah

1.0 INTRODUCTION

This report documents the development of design ground motion response spectra for the Skull Valley Private Fuel Storage site based on the result of the probabilistic seismic hazard analysis conducted for the site (Geomatrix Consultants, Inc., 1999). The transformation from the equal-hazard response spectra to design ground motions involves application of USNRC Regulatory Guide 1.165 (USNRC, 1997) procedures and, for this site, incorporation of near-source ground motion effects.

2.0 APPLICATION OF REGULATORY GUIDE 1.165

2.1 APPROACH

Appendix F of USNRC Regulatory Guide 1.165 describes how design ground motion response spectra are to be defined based on a probabilistic seismic hazard analysis. The steps involved when using site-specific response spectra are:

1. Using the specified probability level, develop an equal-hazard response spectrum from the results of a probabilistic seismic hazard analysis (PSHA) for the site.

2. From the results of the PSHA, determine the mean magnitude, $\overline{M}$, and mean distance, $\overline{D}$, for events contributing to the design ground motion level hazard at spectral frequencies of 5 to 10 Hz and 1 to 2.5 Hz. The procedure to be used is described in Appendix C of USNRC Regulatory Guide 1.165.

3. Develop appropriate site-specific response spectra shapes for the events defined by $\overline{M}$ and $\overline{D}$ from step 2. Scale these spectral shapes to the spectral acceleration levels for the average of motions for 5 to 10 Hz and the average of motions for 1 to 2.5 Hz. The envelop of the scaled spectra and the equal-hazard spectra then defines the design-basis ground motion response spectrum.

2.2 STEP 1: EQUAL-HAZARD SPECTRA

Geomatrix Consultants, Inc. (1999) presents the PSHA analysis for the Skull Valley Private Fuel Storage Facility site. The hazard results presented in that analysis are for free-field motions at the ground surface accounting for the estimated local site effects. Using these results, equal-hazard response spectra were developed for return periods of 1,000 years and

2,000 years (mean annual probabilities of exceedance of 1×10^{-3} and 5×10^{-4}, respectively). These spectra are shown on Figure 1.

2.3 STEP 2: DETERMINATION OF $\overline{M}$ AND $\overline{D}$

The procedure to be used for determining $\overline{M}$ and $\overline{D}$ is described in Appendix C of USNRC Regulatory Guide 1.165. The process involves computing the contribution to the total hazard at the specified design level from events in discrete magnitude and distance bins. These relative contributions are multiplied times the average magnitude and distance for each bin, and the product summed over all bins to compute a weighted average magnitude, $\overline{M}$, and log average distance, $\overline{D}$, of the events contributing to the design level hazard. Two spectral frequency ranges are used, the average of motions at 5 and 10 Hz (0.2 and 0.1 sec. periods, respectively) and the average of motions at 1 and 2.5 Hz (1.0 and 0.4 sec. periods, respectively). Appendix C of USNRC Regulatory Guide 1.165 specifies the size of the magnitude and distance bins appropriate for the evaluation of sites in the central and eastern United States and indicates that other bin sizes may be necessary. Because the hazard at the Skull Valley site is primarily due to magnitude 6 to 7.25 events occurring on the nearby faults, a reduced magnitude and distance bin size was used to provide a more accurate representation of the contributions to the hazard. The magnitude bin size was set to 0.25 magnitude units centered on each ¼ magnitude from 5 to 8, and the distance bins were set to: 0-5 km, 5-10, km, 10-15 km, 15-20 km, 20-25 km, 25-30 km, 30-50 km, 50-75 km, 75-100 km, 100-150 km, and 150-200 km.

Figure 2 shows the computed percent contributions to the hazard for each of the specified return periods, spectral frequency ranges, and horizontal and vertical motions. These results indicate that the hazard is due principally to earthquakes occurring within 15 km of the site. Because the contribution from events at distances greater than 100 km is less than 1 percent in all cases, the special provisions for distant sources described in Appendix C of USNRC Regulatory Guide 1.165 need not be applied. The computed values of $\overline{M}$ and $\overline{D}$ are:

Ground Motion Parameter	Spectral Frequency Range	$\overline{M}$	$\overline{D}$ (km)
1,000-year horizontal	5 – 10 Hz	6.3	5
	1 - 2.5 Hz	6.4	5
1,000-year vertical	5 – 10 Hz	6.4	6
	1 – 2.5 Hz	6.4	7
2,000-year horizontal	5 – 10 Hz	6.3	4
	1 – 2.5 Hz	6.5	4
2,000-year vertical	5 – 10 Hz	6.5	6
	1 – 2.5 Hz	6.5	6

2.4 STEP 3: SCALING SITE-SPECIFIC SPECTRAL SHAPES TO EQUAL-HAZARD SPECTRA

Free-field ground surface response spectral shapes were developed for each of the $\overline{M}$ and $\overline{D}$ pairs listed above using the ground motion attenuation relationships developed for computing the hazard (Geomatrix Consultants, Inc., 1999). The spectral shapes were developed by computing 84th-percentile response spectra for each $\overline{M}$ and $\overline{D}$ using a weighted combination of the attenuation relationships and then dividing the resulting spectral accelerations by the computed 84th-percentile peak acceleration. The weights assigned to each of the relationships are given in Appendix F, Table F-1 of Geomatrix Consultants, Inc. (1999). These relationships have been adjusted for local site effects as described in Appendix F of Geomatrix Consultants, Inc. (1999).

Figure 3 shows the results of scaling these spectral shapes to the appropriate response spectral accelerations for each equal-hazard spectrum. In general, enveloping the three response spectra results in, at most, only minor increases in the ground motions above those specified by the equal hazard spectra. These increases arise, in part, from including more spectral frequencies in the spectral shapes than were used to compute the equal-hazard spectra, providing better interpolation and smoother spectral shapes.

3.0 INCORPORATION OF NEAR-SOURCE EFFECTS

The hazard at the Skull Valley site is due to the occurrence of large-magnitude earthquakes on nearby faults. Recent studies, focused primarily on strike-slip earthquakes, have indicated that there are effects of rupture directivity on strong ground motions that are observable and systematic in the near field of large earthquakes. These effects have been quantitatively defined by Somerville and others (1997) using empirical data. They describe two effects, one resulting from directivity of rupture (a Doppler effect) and one representing a systematic difference between fault-normal and fault-parallel motions (the horizontal response spectral attenuation relationships used to define the equal-hazard response spectra and the spectral shapes shown on Figure 3 represent the geometric mean of the two horizontal components). The effects first become significant at a spectral frequency of 1.67 (0.6-second period) and increase with decreasing spectral frequency (increasing period).

The magnitude of these effects is related to the size of the earthquake and to the geometric relationship between the site, the length of the rupture, and the location of the point of rupture initiation. For dip-slip faults, these are parameterized by the term $y\cos(\phi)$, where ϕ is the angle between the rupture surface and a line drawn from the point of rupture initiation and the site and y is the distance from the point of rupture initiation to the site measured along the fault divided by the length of rupture measured in the direction of slip (for dip slip faults, the rupture width). Because most large normal faulting earthquakes appear to initiate near the base of the seismogenic crust, sites located on the fault trace will have $\phi = 0$ and y near 1.0, and will thus experience the maximum effect of both directivity and systematic fault-normal-to-fault-parallel differences in ground motion.

The impact of these effects on the spectra shown on Figure 3 was evaluated by considering the contributions of the different sources to the total hazard at return periods of 1,000 and 2,000 years. From Figure 6-12 of Geomatrix Consultants, Inc. (1999), the majority of the hazard for horizontal motions comes from the four nearby faults: the East, West, Stansbury, and East Cedar Mountains faults. For each fault, the parameters ϕ and y were conservatively set to the values associated with rupture at the closest point on the faults, with rupture initiation occurring at the base of the seismogenic crust. Thus, y was set equal to 1.0 for all faults and ϕ was set to 1.6°, 3.0°, 19.5°, and 54.9° for the East, West, Stansbury, and East Cedar Mountains faults, respectively. The appropriate adjustment factor for each fault was computed using the relationships presented in Somerville and others (1997) and the mean magnitude contributing to the hazard for each fault. The hazard curves for each fault were then scaled in the horizontal (ground motion) direction by these factors and then reinterpreted to obtain frequencies of exceedance at common ground motion levels. These were, in turn, summed to obtain a new composite hazard curve for these faults and the result added to the hazard from all other sources to obtain an adjusted total hazard for horizontal ground motions. An additional source of some conservatism in this process is the fact that the standard deviation in the ground motions should be slightly reduced because the inclusion of a systematic directivity effect should improve the ability of the attenuation relationships to predict the observed ground motion data. However, this effect has not been evaluated for dip-slip faults and has been ignored in this analysis.

The adjusted hazard curves were then interpolated to obtain spectral accelerations for return periods of 1,000 and 2,000 years. The resulting ratios of the adjusted to unadjusted spectral accelerations are:

Ratio of Near-Field Adjusted to Unadjusted Spectral Accelerations

Return Period	Spectral Period (sec)	Directivity only	Directivity plus Fault-Normal/ Average	Directivity plus Fault-Parallel/ Average
1,000 years	1.0	1.05	1.10	1.00
	2.0	1.10	1.27	1.02
	4.0	1.16	1.53	1.04
2,000 years	1.0	1.05	1.11	1.01
	2.0	1.13	1.25	1.03
	4.0	1.19	1.54	1.01

4.0 DESIGN GROUND MOTION RESPONSE SPECTRA

Design ground motion response spectra were developed by scaling the envelop of the response spectra shown on Figure 3 by the near-fault effects adjustment factors listed above. Ratios for intermediate frequencies were obtained by linear interpolation on log(period), with the ratio set to 1.0 for all periods less than 0.6 second (frequencies greater than 1.67 Hz). For vertical motions it was assumed that the near-fault effect for directivity only found for horizontal motions applies. The resulting response spectra are shown on Figures 4 and 5 and are tabulated in Table 1.

5.0 REFERENCES

Geomatrix Consultants, Inc., 1999, Fault evaluation study and seismic hazard assessment, Private Fuel Storage Facility, Skull Valley, Utah: report prepared for Stone & Webster Engineering Corporation, February, 3 vols.

Somerville, P.G., Smith, N.F., Graves, R.W., and Abrahamson, N.A., 1997, Modification of empirical strong ground motion attenuation relations to include the amplitude and duration effects of rupture directivity: Seismological Research Letters, v. 68, p. 199-222.

USNRC, 1997, Regulatory Guide 1.165 Identification and characterization of seismic sources and determination of safe shutdown earthquake ground motions: U.S. Nuclear Regulatory Commission, March.

TABLE 1

DESIGN GROUND MOTION RESPONSE SPECTRA
Skull Valley Private Fuel Storage Facility
Skull Valley, Utah

1,000-year Return Period Spectral Accelerations (g, 5% damping)				
Period (sec)	Horizontal		Period (sec)	Vertical
	Fault Normal	Fault Parallel		
PGA	0.404	0.404	PGA	0.391
0.03	0.404	0.404	0.02	0.391
0.05	0.500	0.500	0.05	0.761
0.075	0.631	0.631	0.075	0.932
0.1	0.792	0.792	0.1	1.001
0.15	0.995	0.995	0.15	0.952
0.2	1.086	1.086	0.2	0.791
0.3	1.060	1.060	0.3	0.547
0.4	0.964	0.964	0.4	0.419
0.5	0.868	0.868	0.5	0.333
0.75	0.615	0.591	0.75	0.211
1.0	0.425	0.389	1.0	0.138
1.5	0.265	0.225	1.5	0.0814
2.0	0.191	0.154	2.0	0.0579
3.0	0.120	0.0875	3.0	0.0362
4.0	0.0924	0.0627	4.0	0.0283
2,000-year Return Period Spectral Accelerations (g, 5% damping)				
Period (sec)	Horizontal		Period (sec)	Vertical
	Fault Normal	Fault Parallel		
PGA	0.528	0.528	PGA	0.533
0.03	0.528	0.528	0.02	0.533
0.05	0.662	0.662	0.05	1.030
0.075	0.835	0.835	0.075	1.268
0.1	1.046	1.046	0.1	1.369
0.15	1.317	1.317	0.15	1.296
0.2	1.437	1.437	0.2	1.104
0.3	1.406	1.406	0.3	0.780
0.4	1.284	1.284	0.4	0.594
0.5	1.166	1.166	0.5	0.476
0.75	0.851	0.814	0.75	0.306
1.0	0.605	0.547	1.0	0.203
1.5	0.379	0.323	1.5	0.123
2.0	0.272	0.223	2.0	0.0882
3.0	0.179	0.128	3.0	0.0557
4.0	0.138	0.0908	4.0	0.0440

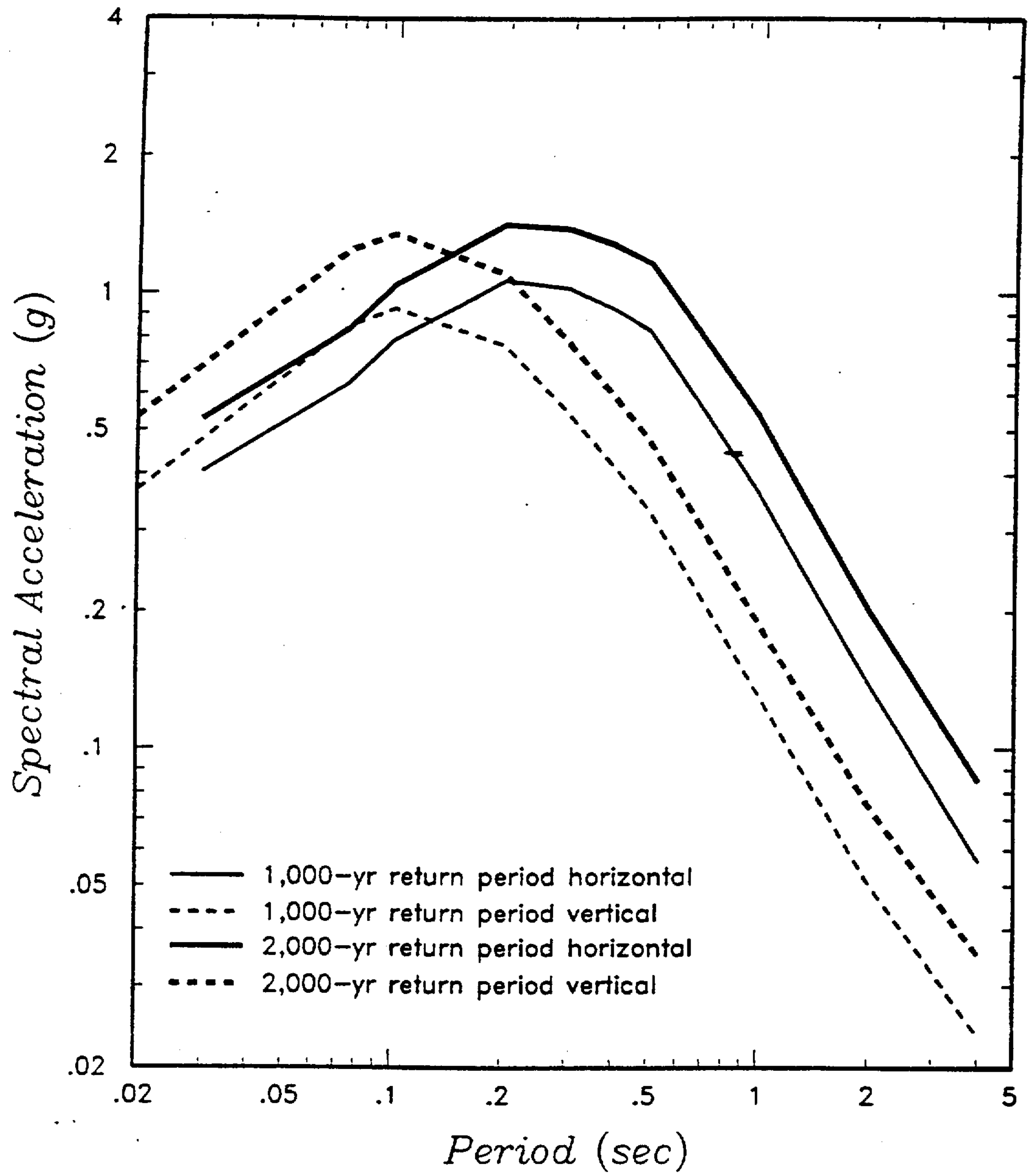


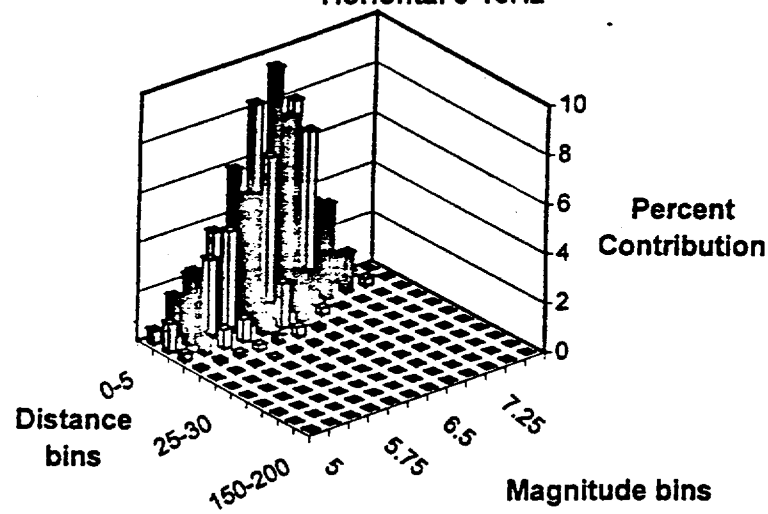
Fig 1

GEOMATRIX

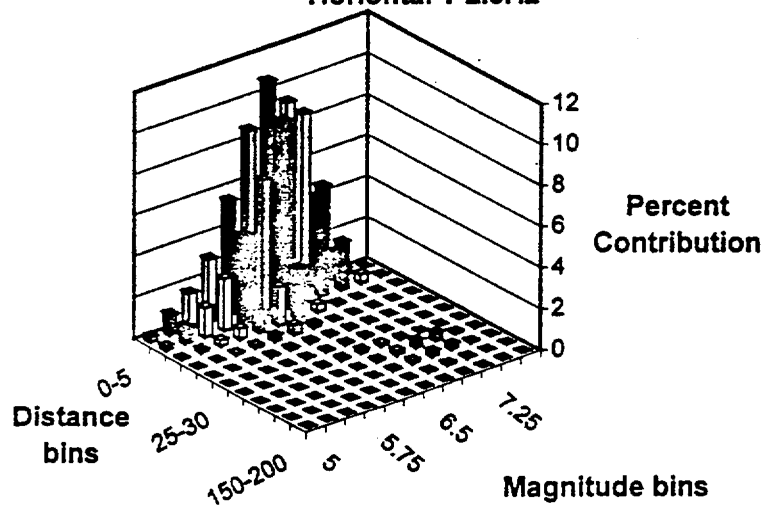
EQUAL HAZARD RESPONSE SPECTRA (5% DAMPING) FOR THE SKULL VALLEY SITE
Private Fuel Storage Facility

Project No.	4790
Figure	1

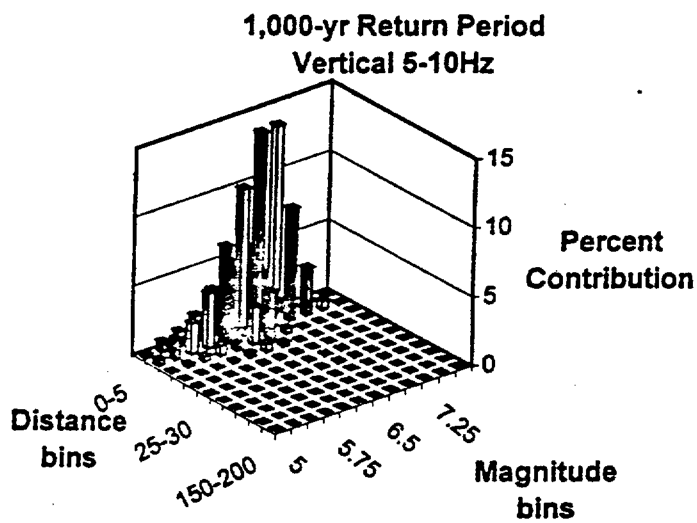
1,000-yr Return Period
Horiontal 5-10Hz

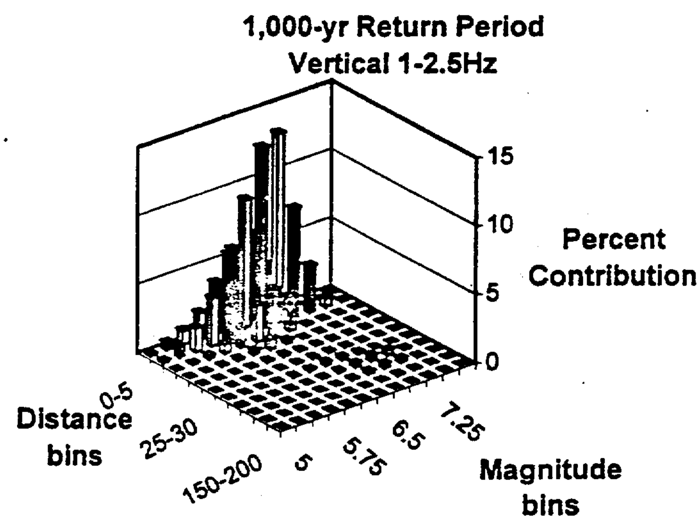


1,000-yr Return Period
Horiontal 1-2.5Hz



GEOMATRIX	PERCENT CONTRIBUTIONS OF EVENTS FOR SPECIFIED MAGNITUDE AND DISTANCE BINS TO THE HAZARD Private Fuel Storage Facility — Page 1 of 4	Project No. 4790 Figure 2





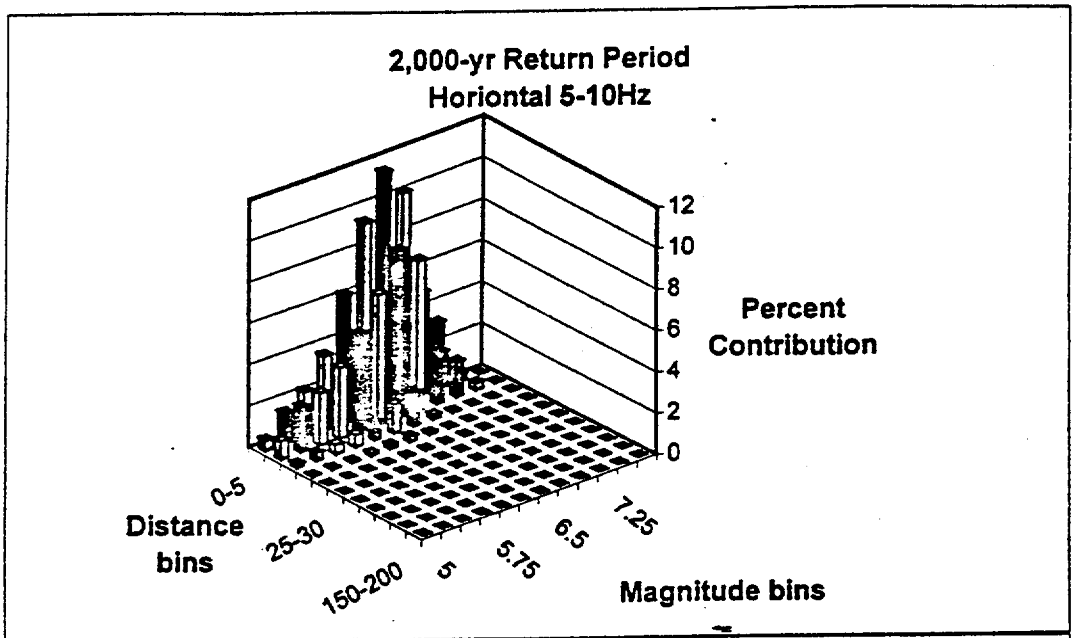
GEOMATRIX

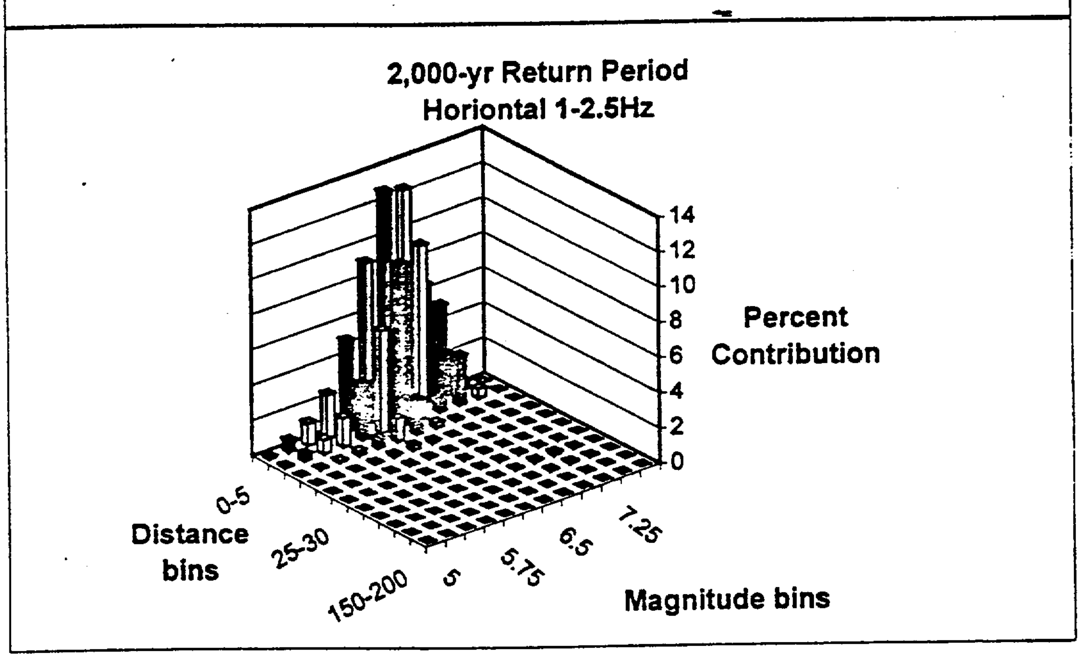
PERCENT CONTRIBUTIONS OF EVENTS FOR SPECIFIED MAGNITUDE AND DISTANCE BINS TO THE HAZARD
Skull Valley, Utah

Page 2 of 4

Project No. 4790

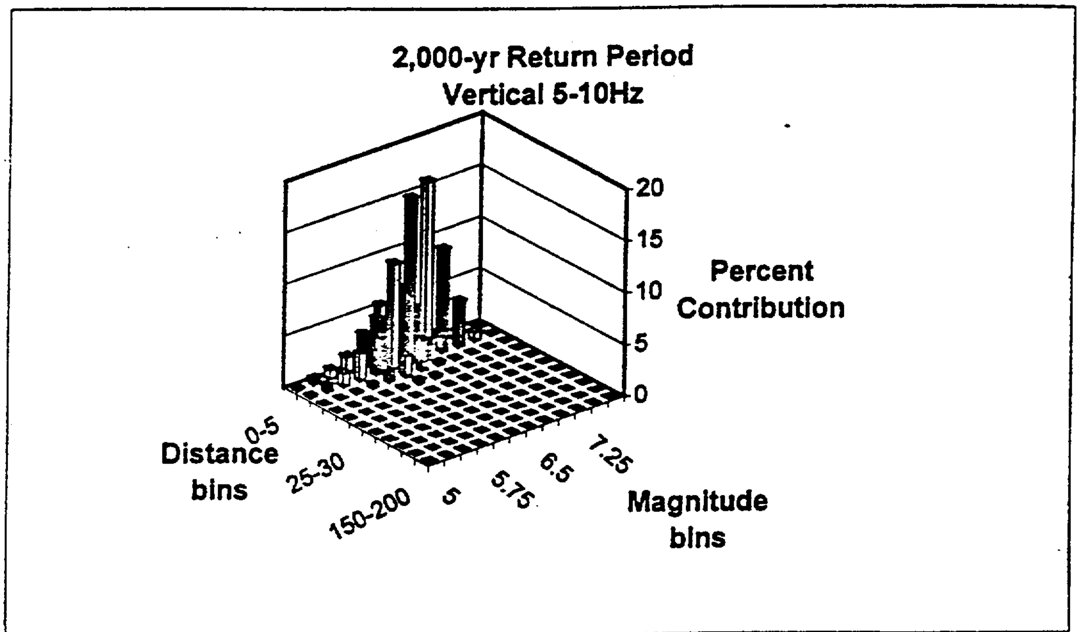
Figure 2

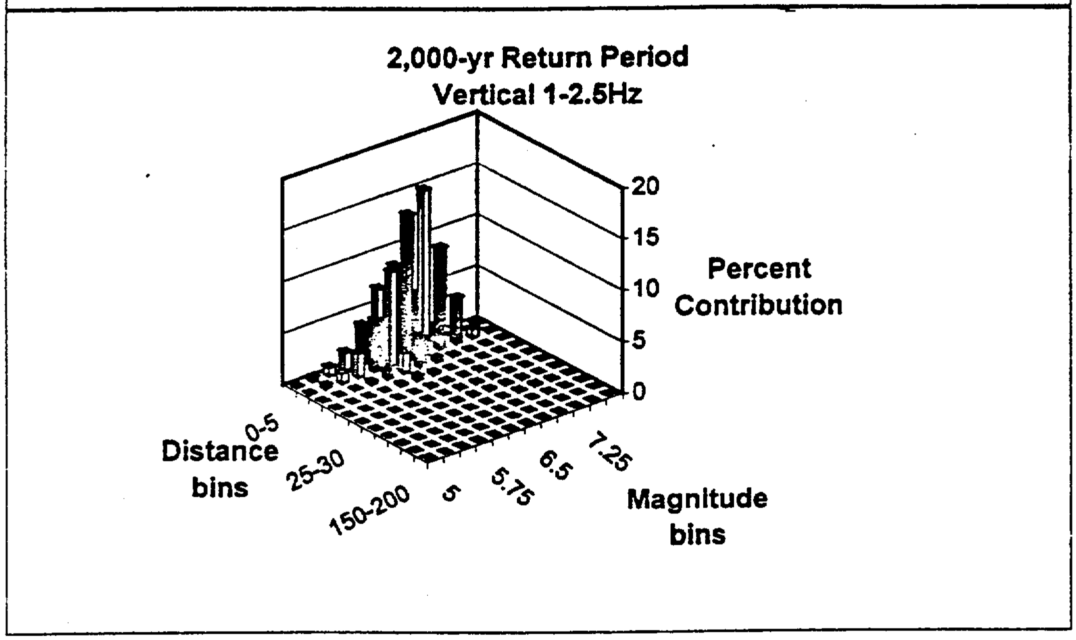




GEOMATRIX	PERCENT CONTRIBUTIONS OF EVENTS FOR SPECIFIED MAGNITUDE AND DISTANCE BINS TO THE HAZARD Private Fuel Storage Facility — Page 3 of 4	Project No. 4790 Figure 2

Non-GDS





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GEOMATRIX	PERCENT CONTRIBUTIONS OF EVENTS FOR SPECIFIED MAGNITUDE AND DISTANCE BINS TO THE HAZARD Skull Valley, Utah — Page 4 of 4	Project No. 4790 Figure 2

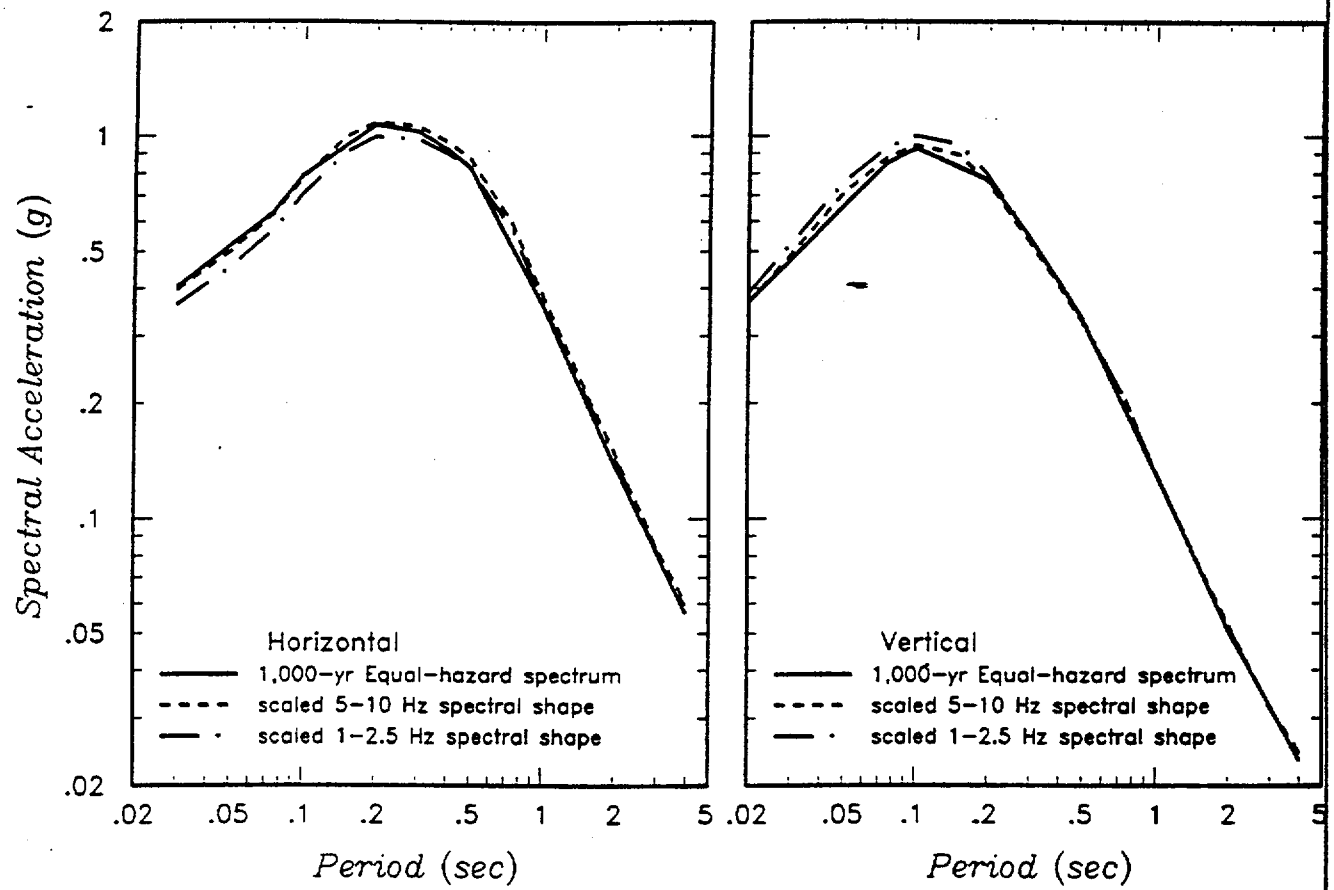


Fig 3

GEOMATRIX

COMPARISON OF EQUAL-HAZARD RESPONSE SPECTRA AND SCALED SPECTRAL SHAPES
Private Fuel Storage Facility

Project No.
4790
Figure
3

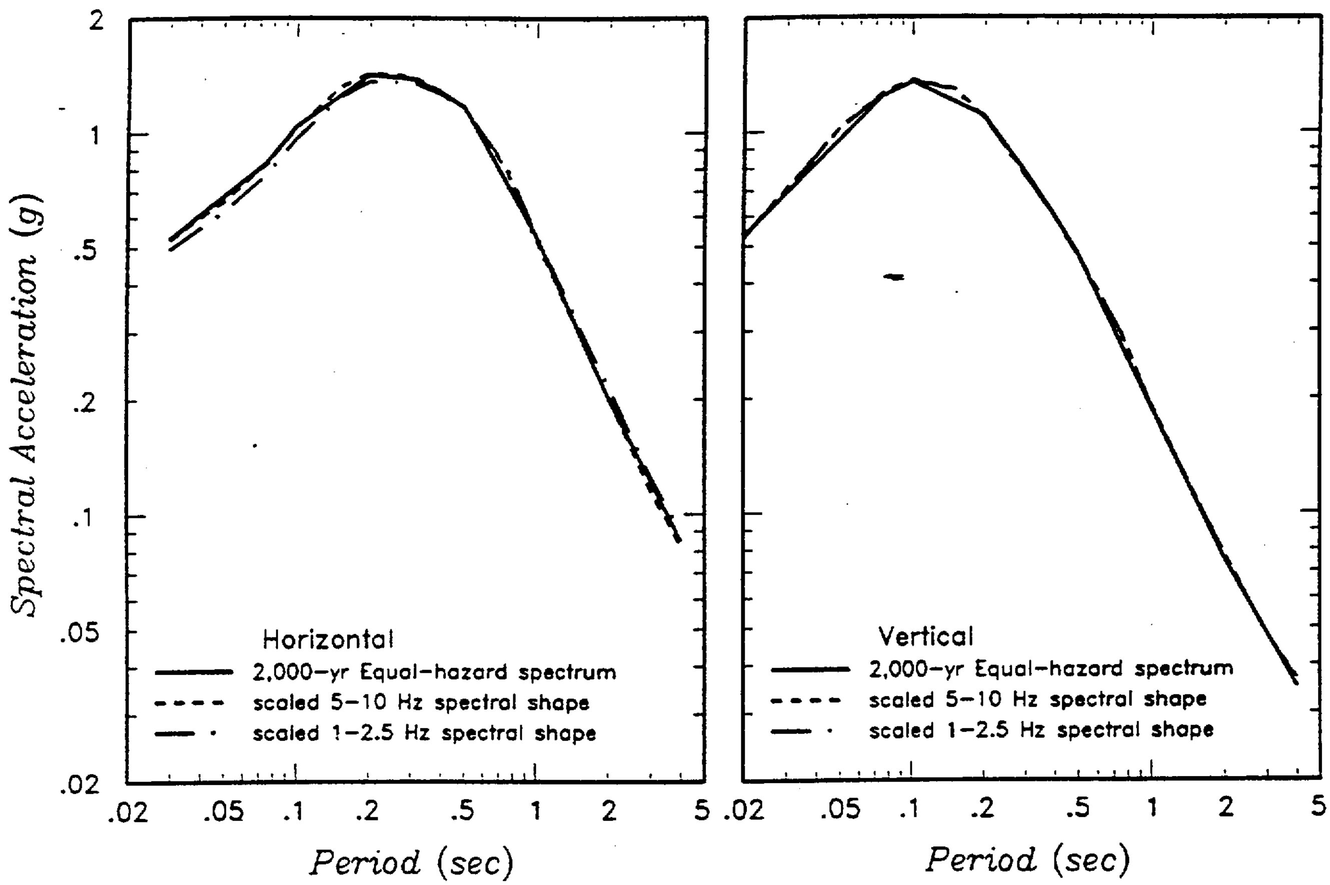
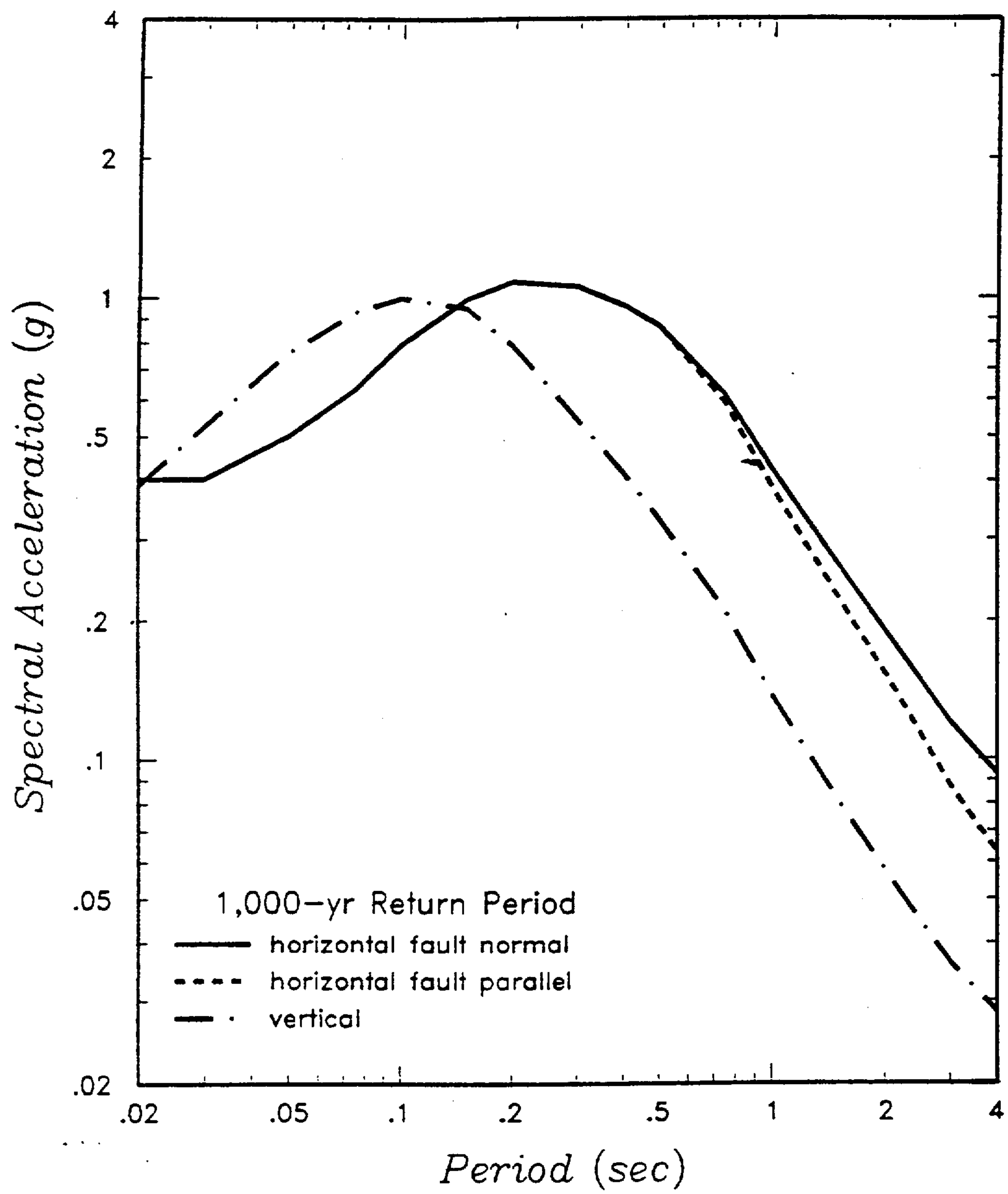


Fig 3 (cont'd)

GEOMATRIX	COMPARISON OF EQUAL-HAZARD RESPONSE SPECTRA AND SCALED SPECTRAL SHAPES Skull Valley, Utah Page 2 of 2	Project No. 4790 Figure 3



Spectral Acceleration (g)
4
2
1
.5
.2
.1
.05
.02
.02
.05
.1
.2
.5
1
2
4
Period (sec)
1,000–yr Return Period
horizontal fault normal
horizontal fault parallel
vertical

Fig 4

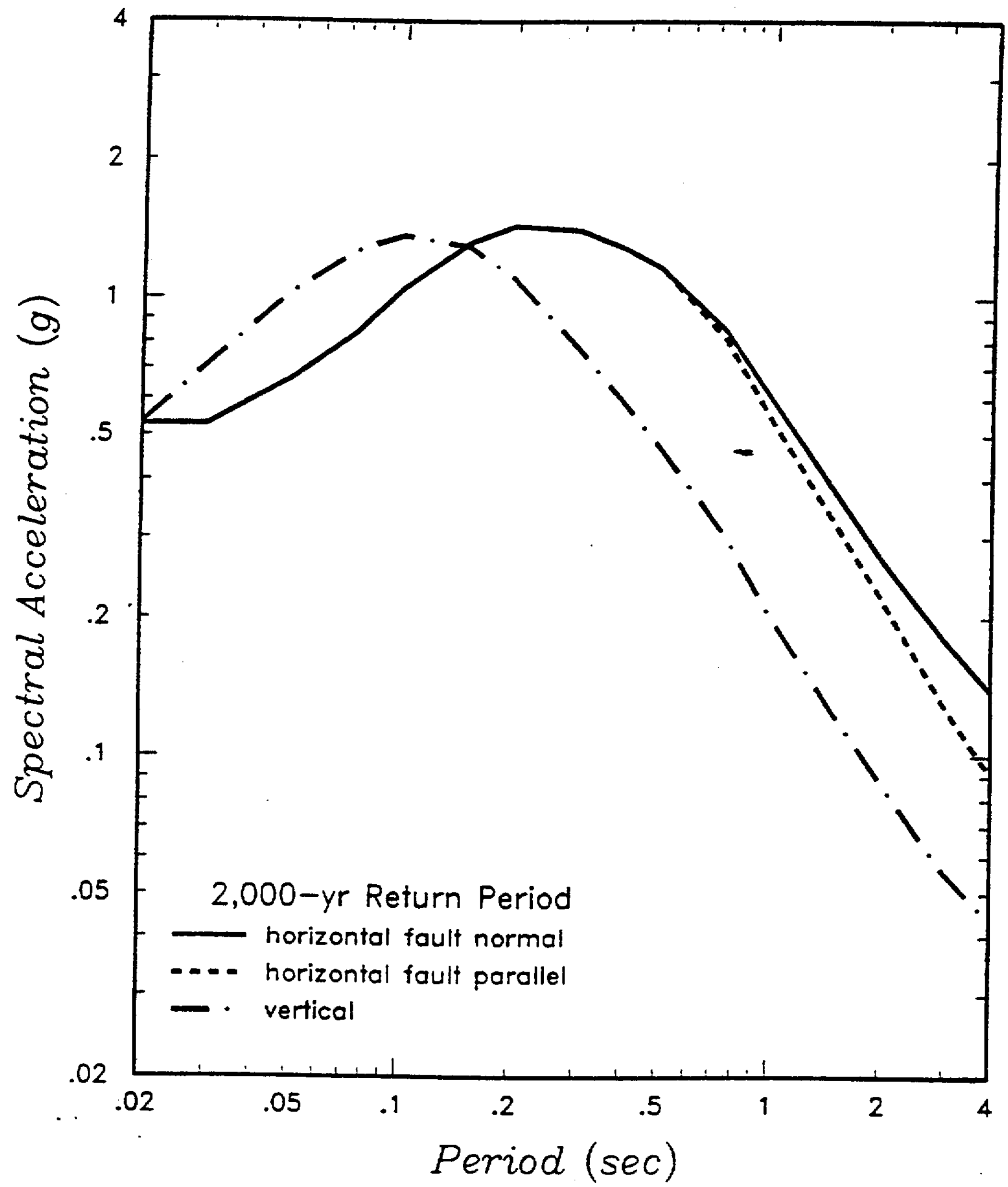


Fig 5

GEOMATRIX	DESIGN GROUND MOTION RESPONSE SPECTRA (5% DAMPING) BASED ON 2,000-YEAR RETURN PERIOD HAZARD Skull Valley, Utah	Project No. 4790 Figure 5