

RAS 5780

72-22-ISFSI - Staff Exhibit NN-Rec'd 6/5/02



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UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
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October 6, 2000

G. Paul Bollwerk, III, Chairman  
Administrative Judge  
Atomic Safety and Licensing Board  
U.S. Nuclear Regulatory Commission  
Washington, DC 20555

Dr. Peter S. Lam  
Administrative Judge  
Atomic Safety and Licensing Board  
U.S. Nuclear Regulatory Commission  
Washington, DC 20555

Dr. Jerry Kline  
Administrative Judge  
Atomic Safety and Licensing Board  
U.S. Nuclear Regulatory Commission  
Washington, DC 20555

In the Matter of  
Private Fuel Storage L.L.C.  
(Independent Spent Fuel Storage Installation)  
Docket No. 72-22-ISFSI

Dear Administrative Judges:

Enclosed is a copy of the NRC Staff's "Safety Evaluation Report Concerning the Private Fuel Storage Facility," dated September 2000 ("SER"), along with a copy of a letter from Mark L. Delligatti to John D. Parkyn, dated September 29, 2000, transmitting the SER to Private Fuel Storage, L.L.C. ("PFS" or "Applicant"). Electronic copies of the enclosed documents are now available in the NRC's ADAMS system (Accession No. ML003755643).

The enclosed SER incorporates, with certain modifications, the Staff's "Safety Evaluation Report of the Site-Related Aspects of the Private Fuel Storage Facility Independent Spent Fuel Storage Installation," dated December 15, 1999 (revised and reissued January 4, 2000). In addition, the enclosed SER provides the remainder of the Staff's safety evaluation of the PFS license application and resolves all outstanding safety issues concerning that application, including the use of the Holtec International HI-STORM 100 Cask System at the proposed PFS site.

The Staff has previously stated its position with respect to Contention Utah L (geotechnical issues). See "NRC Staff's Notice Concerning Contention Utah K, and Statement of Position Concerning Contention Utah L," dated April 28, 2000. The enclosed SER includes a discussion of matters related to that contention, consistent with the Staff's statement of position (SER Chapter 2). In addition, the SER evaluates PFS' request for an exemption from the provisions in 10 C.F.R. § 72.102(f) that require a deterministic seismic hazard analysis ("DSHA") in determining the impact of earthquakes on the Facility. This exemption

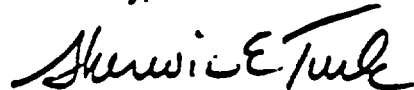
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SECY-02

request has been the subject of other, late-filed contentions submitted by the State of Utah. The SER concludes that PFS' use of a probabilistic seismic hazard analysis ("PSHA") methodology in analyzing potential seismic events, with a 2,000-year return period, is acceptable, and that there is a sufficient basis to grant the PFS request for exemption at the time a license is issued (*Id.*, § 2.1.6.2).

Finally, the enclosed SER presents the Staff's position concerning the remaining issues in Contention Utah K/ Confederated Tribes B. *See Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), LBP-99-35, 50 NRC 180 (1999); *Id.*, LBP-99-39, 50 NRC 232 (1999). As set forth in the enclosed SER, the Staff has concluded that aircraft crashes and other matters raised in Contention Utah K/ Confederated Tribes B do not present a credible hazard for the proposed PFS facility (SER Chapter 15).

Sincerely,



Sherwin E. Turk  
Counsel for NRC Staff

cc w/Encl.:

Jay E. Silberg, Esq.  
Danny Quintana, Esq.  
Denise Chancellor, Esq.  
Connie Nakahara, Esq.  
Diane Curran, Esq.  
John Paul Kennedy, Sr., Esq.  
Joro Walker, Esq.  
Land and Water Fund of the Rockies  
William D. Peterson



UNITED STATES  
NUCLEAR REGULATORY COMMISSION

WASHINGTON, D.C. 20555-0001

September 29, 2000

Mr. John D. Parkyn  
Chairman of the Board  
Private Fuel Storage, L.L.C.  
P.O. Box C4010  
La Crosse, WI 54602-4010

SUBJECT: SAFETY EVALUATION REPORT (TAC NO. L22462)

Dear Mr. Parkyn:

By application dated June 20, 1997, Private Fuel Storage, L.L.C. (PFS), submitted an application to the Nuclear Regulatory Commission (NRC) for a license to operate an away-from-reactor independent spent fuel storage installation (ISFSI) on the Reservation of the Skull Valley Band of Goshute Indians, a federally-recognized Indian Tribe. Subsequently, the NRC staff decided that its safety evaluation of the application would be completed in two segments: first, the staff would complete a safety evaluation report (SER) for systems not directly associated with the storage cask systems proposed by PFS for use at the PFS Facility ISFSI (PFSF); and second, the staff would complete an SER which included at least one of the cask systems proposed for use at the PFSF. An SER covering most of the systems not directly associated with the storage cask systems in the PFS application was initially released on December 15, 1999 (revised and reissued on January 4, 2000). By this letter, the NRC staff is providing the complete SER for the PFS application (see Enclosure). This SER incorporates the previously released SER, revised as appropriate, with the remainder of the staff's safety evaluation of the PFS application, including the proposed use of the Holtec International HI-STORM 100 Cask System. We note that the HI-STORM Cask System is compatible with Holtec International's HI-STAR 100 transportation cask which the staff approved via Certificate of Compliance 9261.

In this SER, the staff takes the position that PFS has demonstrated compliance with all of the applicable regulatory requirements in 10 CFR Part 72, the Commission's regulations for the independent storage of spent nuclear fuel and high-level radioactive waste. However, a licensing determination is not being made at this time. Such a determination must await the completion of the Final Environmental Impact Statement (FEIS) for the proposed PFSF and its related transportation facility in Tooele County, Utah, and of the adjudicatory proceeding on the remaining safety and environmental contentions before the Atomic Safety and Licensing Board. Once the FEIS is published and the adjudicatory proceeding is ended, a licensing determination will be made by the Commission.

You will note that in this SER, the staff also takes the position that PFS should be granted the exemption it requested from 10 CFR 72.102(f), which requires a deterministic seismic hazard analysis (DSHA) approach for determining the impact of earthquakes on the Facility. PFS requested instead to apply a probabilistic seismic hazard analysis (PSHA) approach for analyzing potential seismic events. The staff reviewed this exemption request, as presented in Chapter 2 of the SAR, and conducted an independent evaluation of seismic ground motion hazard at the site based on a survey of existing literature, state of the knowledge in PSHAs and

J. Parkyn

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September 29, 2000

DSHAs, and consideration of existing NRC regulations and regulatory guidance documents regarding seismic analyses. As discussed in Section 2.1.6.2 of the SER, the staff agrees that the use of the PSHA methodology with a 2,000-year return period is acceptable, and there is a sufficient basis to grant an exemption to 10 CFR 72.102(f) at the time a license is issued for the Facility. Please note that the exemption will only be issued if the license is granted.

If you have any questions regarding this letter or the enclosed SER, please contact me at (301) 415-8518.

Sincerely,



Mark S. Delligatti, Senior Project Manager  
Licensing Section  
Spent Fuel Project Office  
Office of Nuclear Material Safety  
and Safeguards

Docket: 72-22

Enclosure: Safety Evaluation Report

cc: PFS Service Lists

**SAFETY EVALUATION REPORT**  
**CONCERNING THE**  
**PRIVATE FUEL STORAGE FACILITY**

**Docket No. 72-22**

## **Engineering Evaluation of Geologic Features**

The static and dynamic engineering soil and rock properties of the various materials underlying the site are evaluated in Section 2.1.6.4 of this SER. The properties evaluated include grain size classification, Atterberg limits, water content, unit weight, shear strength, relative density, shear modulus, Poisson's ratio, bulk modulus, damping, consolidation characteristics, seismic wave velocities, density, porosity, strength characteristics, and strength under cyclic loading.

### **Staff Review**

The staff reviewed the information in Section 2.6.1 of the SAR and found it acceptable because the basic geologic and seismic characteristics of the site and vicinity have been adequately described in detail to allow investigation of seismic characteristics of the Facility. The staff has determined that this information is acceptable for use in other sections of the SAR to develop the design bases of the Facility, perform additional safety analysis, and demonstrate compliance with regulatory requirements in 10 CFR 72.92(a), 72.92(b), 72.102(e), and 72.122(b) with respect to this issue.

### **2.1.6.2 Ground Vibration and Exemption Request**

Earthquake ground motion is discussed in Section 2.6.2 of the SAR, Vibratory Ground Motion. In the SAR, vibratory ground motion is addressed through discussions of historical seismicity and procedures to determine the design earthquake, including identification of potential seismic sources and their characteristics, correlation of earthquake activity with geologic structures, maximum earthquake potential, and seismic wave transmission characteristics.

According to 10 CFR 72.122(b)(2), structures, systems, and components important to safety must be designed to withstand the effects of natural phenomena, including earthquakes, without impairing their capability to perform safety functions. For sites west of the Rocky Mountains, such as Skull Valley, 10 CFR Part 72 requires that seismicity be evaluated by techniques set forth in Appendix A of 10 CFR Part 100 for nuclear power plants. This appendix defines the safe shutdown earthquake as the earthquake that produces the maximum vibratory ground motion at the site, and requires that the structures, systems, and components be designed to withstand the ground motion produced by the safe shutdown earthquake. This seismic design method implies use of a DSHA approach because it considers only the most significant event, and the method is a time-independent statement (i.e., it does not take into consideration the planned operating period of the Facility or how frequent or rare the seismic events are that control the deterministic ground motion). Also, 10 CFR 72.102(f)(1) requires that analyses using the Appendix A methodology use a design peak horizontal acceleration equivalent to that of the safe shutdown earthquake for a nuclear power reactor.

A detailed geological survey conducted by Geomatrix Consultants, Inc.(1999a) identified additional faults in the vicinity of the site. Taking into account these newly discovered faults with the DSHA methodology, the peak horizontal acceleration and peak vertical acceleration values from the seismic event would be 0.72 and 0.80g, respectively (Geomatrix Consultants, Inc., 1999b). These values exceed the SAR proposed design values.

To resolve the issue of seismic design, the applicant submitted to the NRC, a request for an exemption to the seismic design requirement of 10 CFR 72.102(f)(1) to use PSHA along with considerations of risk to establish the design earthquake ground motion levels at the Facility (Parkyn, 1999b). The exemption request also proposes to design the Facility to the ground motions produced by 1,000-year return period earthquakes. These design-ground motions have a peak horizontal acceleration of 0.40g and a peak vertical acceleration of 0.39g, resulting from a recent site-specific PSHA conducted by the Geomatrix Consultants, Inc. (1999a).

As part of the evaluation of PFS's exemption request, the staff conducted an independent technical review of seismic hazard investigations at the proposed site (Stamatakos et al. 1999). The objectives of this seismic investigation were to (i) conduct an independent review of existing seismic hazard studies at Skull Valley, in particular, to identify seismic and faulting issues important to siting the Facility; (ii) evaluate the adequacy and acceptability of PFS's seismic design approach; and (iii) determine an appropriate design basis return period for the PFS-proposed seismic design approach. The staff conducted its evaluation by reviewing information provided by the applicant, surveying other state-of-the-art literature, analyzing the bases of current NRC regulations, and performing independent analyses of geophysical data and sensitivity studies of model alternatives and consideration of uncertainties. This section of the SER summarizes information presented in the SAR and the result of the staff's independent investigation. A summary is included at the end of this section pertaining to the staff's evaluation of the adequacy of the PFS-proposed seismic design for the Facility.

### **Geological and Seismotectonic Setting**

Seismicity in the Basin and Range is generally concentrated along the Wasatch Front, Sierra Nevada and a medial zone called the Central Nevada Seismic Belt (dePolo et al., 1991). Within the region surrounding the proposed site are four seismotectonic provinces: (i) the Basin and Range, (ii) Wasatch Front as part of the Intermountain Seismic Belt, (iii) the Snake River Plain, and (iv) the Colorado Plateau. Of these four seismotectonic provinces, the Wasatch Front is the only one with levels of seismic activity that could affect the proposed site [see Stamatakos et al. (1999) for a more thorough discussion of the seismotectonic provinces].

The Skull Valley site is approximately 50 miles west of the Wasatch Front. The seismotectonic setting of the proposed site was discussed (Private Fuel Storage Limited Liability Company, 2000, Appendix 2D) within the larger context of the tectonic evolution and historic seismicity of the western Cordillera. This discussion included a brief discourse of regional crustal stresses and the driving forces of the Basin and Range extension. The SAR concluded that gravitationally derived buoyancy forces drive extension (Jones et al., 1996; England and Jackson, 1989), although recent global positioning system data used to assess present strain rates across the Basin and Range seem to suggest that external forces from motion of the Pacific and Sierra Nevada tectonic plates also play a role in driving deformation (Thatcher et al., 1999). As concluded in the Revision 2 of the SAR (Private Fuel Storage Limited Liability Company, 2000, Appendix 2D), the site in Skull Valley is presently affected by active tectonic extensional strain and, therefore, will be subjected to future seismicity and deformation.

## **Historical Seismicity**

Geomatrix Consultants, Inc. (1999a) used the earthquake catalog compiled by the University of Utah, which includes historical earthquakes from about 1850 to 1962 and instrument recorded earthquakes from the University of Utah network of 26 statewide stations from 1962 to 1996. The compiled catalog was filtered by Arabasz et al. (1989) to remove duplicates and manmade events such as quarry and mining blasts. All magnitudes were also converted by Arabasz et al. (1989) to a common magnitude scale. Foreshocks and aftershocks were removed following the methodology of Youngs et al., (1987). The largest earthquake in the catalog is the 1909 M 6.0 event. Seismicity is generally concentrated along the Wasatch Front east of the site and in the Central Nevada Belt west of the site.

Because the reporting techniques improved through time, the catalog was incomplete; small magnitude events below about M 5.0 are absent from the record until primitive instruments became available in the early 1930s. As instrumentation improved, the record of smaller and smaller earthquakes became more complete. Completeness of the catalog for different magnitude scales was assessed using the methodology recommended by Stepp (1972) and reported in Youngs et al. (1987). The maximum likelihood technique (Weichert, 1980) was used by Geomatrix Consultants, Inc. (1999a) to derive recurrence parameters.

The staff reviewed the information provided by the applicant and evaluated the applicant's analyses of historical seismicity. The staff found no evidence of historic seismicity in the vicinity of the site. The staff believes that the analyses and information in the SAR provide reasonable assurance that an adequate set of data was used in developing seismic recurrence relationships and determining the maximum earthquake potential in the hazard analyses.

## **Potential Seismic Sources and Their Characteristics**

The seismic source characterization of the Facility was developed from examination of the available literature integrated with detailed site geological studies, including site stratigraphy, geologic mapping, cross-sectional construction, and geophysical investigations (Geomatrix Consultants, Inc., 1999a; Bay Geophysical Associates, Inc., 1999). The most important aspects for the evaluations of seismic hazards were identification and characterization of active faults derived from paleoseismic and geophysical investigations. Identification of a detailed Quaternary stratigraphy was also essential because it provided critical constraints on faulting activity. Based on detailed site investigations and review of the seismotectonic setting, Geomatrix Consultants, Inc. (1999a) identified 29 fault sources and 4 areal sources. A logic tree approach was used to combine alternative models of source geometry, activity, and seismicity to formulate the PSHA.

The staff reviewed the seismic source characterization and found it acceptable because it is thorough and complete. Models used by the applicant for the hazard assessment were appropriate. For example, Geomatrix Consultants, Inc. (1999a) conservatively considered all faults to be planar and to extend through the thickness of the brittle crust rather than considering the possibility that the primary faults could be listric and sole into a seismic detachment above the base of the seismogenic crust. Uncertainties in other aspects of fault geometry and seismic activity were incorporated into the probabilistic assessment. Upper ranges of those parameters that describe fault geometry or seismic activity were constructed to adequately bound geologic and geophysical observations. The historic seismic record was appropriately used to develop b-values for recurrence relationships and to develop the background areal source zone.



One aspect of the staff review included the interpretations of fault geometries for newly discovered East and West faults in Skull Valley based on reflection seismic data and forward modeling of gravity data in Geomatrix Consultants, Inc. (1999a). Staff review of the alternative models shows that the Geomatrix Consultants, Inc. assessment may have led to an overly conservative hazard result. Reanalysis (Stamatakis et al., 1999) of the proprietary industry gravity data does not support the interpretation that the West fault is an independent seismic source. Rather, the staff interprets the West fault as a splay of the East fault, incapable of independently generating large magnitude earthquakes. Therefore, staff finds the probabilistic assessment provided by Geomatrix Consultants, Inc. (1999a) acceptable, and possibly conservative, because the Geomatrix Consultants, Inc. (1999a) model considers the West fault as an active seismic source.

In summary, the staff found that the applicant's considerations of seismic source characteristics and associated uncertainties provide reasonable assurance that all significant source and capable faults have been identified and their characteristics and associated uncertainties are adequately described and appropriately included in the evaluation of the seismic ground motion hazard. Stamatakis et al. (1999) provides more details of PFS's seismic source characterization and the staff's independent sensitivity analyses.

### **Estimate of Ground Motion Attenuation**

For purposes of estimating earthquake ground motions that may occur at the proposed site, the applicant utilized results of the PSHA conducted for the proposed high-level waste repository site at Yucca Mountain (Civilian Radioactive Waste Management System Management and Operating Contractor, 1998). The Yucca Mountain study developed and implemented a methodology for evaluating earthquake ground motions in the Basin and Range that includes the results of scientific evaluations and expert elicitations from seven ground motion experts. The staff found that the use of the Yucca Mountain methodology for the Facility PSHA ground motion analysis is appropriate because (i) it represents the state-of-the-art knowledge and (ii) both the PFS Facility site and site of the proposed geologic repository at Yucca Mountain have seismotectonic characteristics of the Basin and Range.

Geomatrix Consultants, Inc. (1999a) selected the published median ground motion attenuation models and weighted them according to the Yucca Mountain Seismic Hazard Study (Civilian Radioactive Waste Management System Management and Operating Contractor, 1998).

The Yucca Mountain PSHA used a sophisticated methodology for modeling and quantifying the epistemic uncertainty in ground motions. The Yucca Mountain analysis attempted to quantify all of the sources of uncertainty involved in the estimation of strong ground motion. As part of the Facility PSHA, Geomatrix Consultants, Inc. elected to consider only that part of the epistemic uncertainty associated with the choice of different median ground motion models and not the uncertainty in the models themselves. As a consequence, sources of epistemic uncertainty that were quantified in the Yucca Mountain PSHA were not considered in the PFS Facility analysis. This leads to an underestimate of the total epistemic uncertainty and, therefore, an underestimate of the mean seismic hazard at the site. The staff performed sensitivity calculations and determined that the mean frequency of exceedance of ground motions changes by less than a factor of two. Therefore, the staff concludes this effect to be insignificant.

The staff reviewed the characterization of strong ground motion in the Facility seismic hazard analysis and the approach taken to model the epistemic uncertainty, and found them acceptable.

The approach to modeling strong ground motion provides reasonable assurance that the site hazard is adequately estimated.

### **Probabilistic Seismic Ground Motion Hazard**

The Geomatrix Consultants, Inc. (1999a) PSHA uses a well-established methodology and basic equations (e.g., Cornell, 1968, 1971; McGuire, 1976, 1978; Civilian Radioactive Waste Management System Management and Operating Contractor, 1998). Calculation of probabilistic seismic ground motion hazard requires specification of three basic inputs: (i) geometric characteristics of potential sources, (ii) earthquake recurrence characteristics for each potential source, and (iii) ground motion attenuation estimates. Details of these inputs to the PSHA at Skull Valley have been evaluated in Stamatakis et al. (1999) and summarized in previous sections. PSHA calculations include the seismic hazard from each individual source and the total hazard from all potential sources. Such calculations establish hazard curves that depict the relationship between levels of ground motion and probabilities (frequencies) at which the levels of ground motion are exceeded. In Geomatrix Consultants, Inc. (1999a) computations, fault sources were modeled as segmented planar surfaces. Areal sources were modeled as a set of closely spaced parallel fault planes occupying the source regions. The distance density functions were computed assuming that a rectangular rupture area for a given size earthquake is uniformly distributed along the length of the fault plane and located at a random point on the fault plane. Depth distribution for earthquakes was based on depth distribution of recorded historical earthquakes along the Wasatch Front. The rupture size (mean rupture area) of an event was estimated based on the empirical relation of Wells and Coppersmith (1994). The basis for using the mean rupture area is the study of Bender (1984) that shows nearly equal hazard results using the mean estimates of rupture size and considering statistical uncertainty in rupture size. The minimum earthquake magnitude considered in the Geomatrix PSHA was M 5 (Geomatrix Consultants, Inc., 1999a).

Mean and percentile (95, 85, 50, 15, and 5<sup>th</sup>) peak ground motion and 1-Hz spectral (5-percent damped) acceleration hazard curves were calculated and presented in Geomatrix Consultants, Inc. (1999a) for horizontal and vertical motions. The mean peak horizontal acceleration is 0.40 g and 0.53 g for 1,000- and 2,000-year return periods, respectively. The mean peak vertical acceleration is 0.39 g and 0.53 g for 1,000- and 2,000-year return periods, respectively. Equal-hazard response spectra for return periods of 1,000 and 2,000 year (mean annual probabilities of exceedance of  $1 \times 10^{-3}$  and  $5 \times 10^{-4}$ , respectively) were calculated and presented in Geomatrix Consultants, Inc. (1999c).

Contributions of individual seismic sources were calculated and the results show that the dominating sources are the Stansbury, East-Springline, and East Cedar Mountain faults for peak ground acceleration for return periods greater than 1,000 years and for 1-Hz spectral acceleration for a return period greater than 2,000 years. Deaggregation results show that the total hazard is dominated by ground motions from nearby M 6 to 7 events. Sensitivity results indicate that the choice of attenuation relationship is a major contributor to uncertainty in the hazard calculation. Geomatrix Consultants, Inc. (1999a) sensitivity results also indicate (i) alternative models for the geometry and extent of the West fault have little effect on the total hazard because the East fault dominates the hazard from the Skull Valley faults as a result of its higher estimated slip rate, and the alternative models for the West fault have only minor effects on the parameters of the East fault, (ii) the West fault, considered as an independent source or as a secondary feature, has a minimal influence on the hazard, and (iii) the East and Springline faults, combined as a single source, produces slightly higher hazard at low probabilities of exceedance and for longer period motions than separating them as individual fault sources. The

Geomatrix Consultants, Inc. (1999a) summary of contributions to the uncertainty in the total hazard at the proposed Skull Valley site for a return period of 2,000 years shows that the major contributors to the total uncertainty in the hazard are the selection of attenuation relationships, assessment of maximum magnitude, recurrence rate, and magnitude distribution.

### **Deterministic Seismic Ground Motion Hazard**

Site-specific deterministic ground motion hazard for the Facility was assessed by Geomatrix Consultants, Inc. (1997), in which two potentially capable fault sources were identified to be within 7 miles of the site—the East Cedar Mountain and Stansbury faults. Their closest distances to the site were estimated to be about 6 miles to the Stansbury fault and 5.5 miles to the East Cedar Mountain fault. The potential for a random nearby earthquake was considered by including an areal source within 16 miles of the site. Maximum earthquake magnitudes for the two fault sources were estimated using empirical relationships of Wells and Coppersmith (1994) and Anderson et al. (1996) based on estimated maximum rupture dimensions (rupture length and rupture area). The resulting mean estimates of maximum magnitudes are M 7.0 for the Stansbury fault and M 6.8 for the East Cedar Mountain fault. The maximum magnitude for the areal source was estimated to range from M 5.5 to 6.5, with a mean value of 6, based on the Wells and Coppersmith (1993) study on the relationship between earthquake magnitude and the occurrence of associated surface faulting and the assumption that these random earthquakes do not produce significant surface faulting. A mixture of attenuation relationships for strike-slip faults in California and for extensional stress regimes were used to account for uncertainties. These include Abrahamson and Silva (1997), Campbell (1997), Sadigh et al. (1993, 1997), Idriss (1991), and Spudich et al. (1997). In the Geomatrix DSHA, uncertainties were included for maximum magnitude, minimum source-to-site distance, and the selection of attenuation relationships. The recommended 84<sup>th</sup>-percentile peak ground accelerations are 0.67g in the horizontal direction and 0.69g in the vertical direction. These accelerations envelop the calculated accelerations for a rock site and a deep soil site.

The Geomatrix Consultants, Inc. (1999b) DSHA considers the two new faults (i.e., the East and West faults) near the proposed site and in-depth characterization of other capable faults. The detailed characteristics of the two new faults as well as other fault sources are reviewed in Stamatakis et al. (1999). In its updated DSHA, Geomatrix Consultants, Inc. (1999b) considered four nearby fault sources—the Stansbury, East, West, and East Cedar Mountains faults. The mean maximum magnitudes of these fault sources were estimated to be M 7.0, 6.5, 6.4, and 6.5, respectively, based on distributions for maximum magnitude of each source developed in Geomatrix Consultants, Inc. (1999a). The closest distances to the Canister Transfer Building from the surface traces of these faults were estimated to be 9, 0.9, 2.0, and 9 km, respectively. The ground motion models used in the updated DSHA were the set of 17 horizontal and 7 vertical attenuation relationships used in the PSHA (Geomatrix Consultants, Inc., 1999a). These relationships were reviewed and discussed in Stamatakis et al. (1999). The ground motion attenuation relationships were adjusted for near-source effects using the empirical model developed by Somerville et al. (1997). The updated DSHA results show that the ground motion from the East fault generally envelops those from the other sources. The 84<sup>th</sup>-percentile peak ground accelerations for the East fault are 0.72g in the horizontal direction and 0.80g in the vertical direction. When compared with the PSHA results, the controlling deterministic spectra generally are between the 5,000- and 10,000-year return period equal-hazard response spectra.

## Design-Basis Ground Motion

The design ground motion response spectra for the proposed Skull Valley site were developed by Geomatrix Consultants, Inc. (1999c) based on its site-specific PSHA results as reviewed in Stamatakis et al. (1999) and documented in detail in Geomatrix Consultants, Inc. (1999a). The Geomatrix Consultants, Inc. development of design spectra is based on the procedures outlined in Regulatory Guide 1.165 (Nuclear Regulatory Commission, 1997c) and incorporates near-source effects.

The assessment of design ground motions for the Facility is described in Geomatrix Consultants, Inc. (1999c). The design ground motions were determined using the procedure described in Regulatory Guide 1.165 (Nuclear Regulatory Commission, 1997c). However, prior to implementing the Regulatory Guide 1.165 procedure, the site seismic hazard results were modified to account for the near-source effects of rupture directivity and the polarization of ground motions. Adjustments to the PSHA results that account for these effects were made using empirical models developed by Somerville et al. (1997). Based on its review, the staff determined that the deterministic approach of shifting the seismic hazard results to account for rupture directivity and ground motion directional effects is conservative for the frequencies to which these adjustments were applied. Based on the results of Somerville et al. (1997), adjustments were not made for the peak ground acceleration seismic hazard results or for spectral accelerations greater than 1.0 Hz. There is empirical evidence that suggests peak ground accelerations and high frequency ground motions may also be influenced by rupture directivity and source radiation. In addition, there is limited empirical evidence to verify the Somerville et al. (1997) model and to predict, in an absolute sense, the systematic effect of rupture directivity on strong ground motion. However, as discussed in Stamatakis et al. (1999) and Geomatrix Consultants, Inc. (1999c), the random effects of rupture directivity are accounted for as part of the aleatory variability in ground motion. Therefore, it is an effect that is accounted for in the PSHA. In fact, for frequencies less than 1.0 Hz, these effects are double counted in the Facility estimate of design motions.

The Regulatory Guide 1.165 process for determining design basis ground motion spectra involves computing the contributions to the total hazard at the specified design return period (or reference probability) from events in discrete magnitude and distance bins. In the Geomatrix Consultants, Inc. (1999c) calculation, a magnitude bin size of 0.25 was selected. The distance bin size increases gradually from 3 to 32 miles as the source-to-site distance increases from 0 to 150 km. From these contributions and the average magnitude and distance for each bin, a weighted average magnitude,  $\bar{M}$ , and log average distance,  $\bar{D}$ , of the events contributing to the design level hazard were determined for spectral frequency ranges of 5–10 Hz and 1–2.5 Hz. Free-field ground surface response spectral shapes were developed using the 84<sup>th</sup>-percentile peak acceleration and the 84<sup>th</sup>-percentile response spectra for each of the  $\bar{M}$  and  $\bar{D}$  pairs using a weighted combination of the same ground motion attenuation relationships used for the PSHA (Geomatrix Consultants, Inc., 1999a). These response spectral shapes were scaled to the appropriate equal hazard spectra. Design ground motion response spectra were defined to be the envelope of the scaled spectra and equal hazard spectra. This envelope was further scaled by the adjustment factors for near-fault effect as described in Stamatakis et al. (1999). The final response spectra can be found in Geomatrix Consultants, Inc. (1999c). These studies resulted in the following design ground motion accelerations: (1) for a 1,000-year return period earthquake, a peak horizontal acceleration of 0.40 g and a peak vertical acceleration of 0.39 g; and (2) for a 2,000-year return period earthquake, a peak horizontal acceleration of 0.53 g and a peak vertical acceleration of 0.53 g for a 2,000-year return period.

The applicant's exemption request specified a 1,000-year return period to calculate design basis ground motions with the PSHA methodology. The applicant (Parkyn, 1999b) stated (i) a 1,000-year return period is the same as that selected by the U.S. Department of Energy (1997) for preclosure seismic design of important to safety structures, systems, and components for NRC Frequency Category 1 design basis events at the proposed Yucca Mountain high-level waste geologic repository, and (ii) the consequences of a major seismic event at the Facility can be bounded using the HI-STORM 100 system technology and are limited to a storage cask-tipover event, which would result in a dose below regulatory limits. A Frequency Category 1 design basis ground motion refers to a mean recurrence interval of 1,000 years and a Frequency Category 2 design basis ground motion refers to a mean recurrence interval of 10,000 years. As discussed below, the staff has determined that a 2000-year return period is the appropriate value for the PFS Facility site.

#### **Staff Review of Ground Vibration and Request for Exemption to 10 CFR 72.102(f)(1)**

The staff found the applicant's seismic hazard results to be conservative, based on the review of geological and seismotectonic setting, historical seismicity, potential seismic sources and its characteristics, estimate of ground attenuation, estimates of probabilistic and deterministic ground motion hazards, development of design basis ground motion, and independent staff analyses. The staff also found that in the application:

- Seismic events that could potentially affect the site were identified and the potential effects on safety and design were adequately assessed.
- Records of the occurrence and severity of historical and paleoseismic earthquakes were collected for the region and evaluated for reliability, accuracy, and completeness.
- Appropriate methods were adopted for evaluations of the design basis vibratory ground motion from earthquakes based on site characteristics and current state of knowledge.
- Seismicity was evaluated by techniques of 10 CFR Part 100, Appendix A. Seismic hazard, however, was evaluated using a probabilistic approach as stated in the Request for an Exemption to 10 CFR 72.102(f)(1).
- Liquefaction potential or other soil instability from vibratory ground motions was appropriately evaluated.
- The design earthquake has a value for the horizontal ground motion greater than 0.10g with the appropriate response spectrum.
- The applicant's considerations with respect to the approach taken to model the epistemic uncertainty in ground motions and near-source effects are adequate.
- As discussed in Stamatakos et al. (1999), the applicant adequately applied adjustment factors for the near-fault effect using the state-of-the-art techniques and applied procedures described in Regulatory Guide 1.165 (Nuclear Regulatory Commission, 1997c) for developing design-basis ground motion. The associated response spectra and design basis motion levels are adequate.

The staff reviewed the applicant's exemption request to use the PSHA methodology with a 1,000-year return period value by evaluating the technical basis of the PSHA methodology and its use in other Title 10 regulations regarding nuclear facilities and materials. Although 10 CFR Part 72 requires a deterministic approach for the seismic design of an ISFSI site west of the Rocky Mountain Front, a probabilistic approach for seismic design is acceptable by the 1997 amendments to 10 CFR Parts 50 and 100 that apply to new nuclear power plants, and 10 CFR Part 60 that applies to the disposal of high-level waste in geologic repositories. Also, the NRC issued Regulatory Guide 1.165 to provide guidance on PSHA methodology (Nuclear Regulatory Commission, 1997c). In addition, NRC has reviewed and approved the Request for Exemption to 10 CFR 72.102(f)(1) seismic design requirements to allow seismic design using PSHA results of 2,000-year return period earthquakes for the Three Mile Island Unit-2 (TMI-2) ISFSI (Nuclear Regulatory Commission, 1998b; Chen and Chowdhury, 1998). DSHA considers only the most significant earthquake sources and events with a fixed site-to-source distance. PSHA, on the other hand, considers contributions from all potential seismic sources and integrates across a range of source-to-site distances and magnitudes. Furthermore, DSHA is a time-independent statement, whereas PSHA estimates the likelihood of earthquake ground motion occurring at the location of interest within the time frame of interest. The staff concludes that there are sufficient regulatory and technical bases to accept the PSHA methodology for seismic design of the Facility.

The design basis ground motion for a particular structure, system, and component depends on the importance of that particular structure, system, and component to safety. As described in the NRC rulemaking plan for 10 CFR Part 72 (Nuclear Regulatory Commission, 1998a), an individual structure, system, and component may be designed to withstand only Frequency Category 1 events (1,000-year return period) if the applicant's analysis provides reasonable assurance that the failure of the structure, system, and component will not cause the Facility to exceed the radiological requirements of 10 CFR 72.104(a). If the applicant's analysis cannot support this conclusion, then the designated structures, systems, and component should have a higher importance to safety, and the structures, systems, and component should be designed such that the Facility can withstand Frequency Category 2 events (10,000-year return period).

The staff reviewed the applicant's request and supporting analysis to use the 1,000-year return period value and does not find this value acceptable because of the following reasons: (i) the DOE classification of Yucca Mountain proposed high-level waste geologic repository structures, systems, and components to design for Frequency Category 1 and Frequency Category 2 events as it applies to the proposed Yucca Mountain repository has not been reviewed or accepted by the NRC staff; (ii) the applicant has provided no technical basis for classifying all the important to safety structures, systems, and components for the Facility as those that could be designed for NRC Frequency Category 1 design basis events; and (iii) the consequence analysis using the HI-STORM 100 systems technologies includes only a single accident scenario (i.e., cask tipover) that is independent of ground motion level. The applicant did not demonstrate that the cask-tipover event envelops other unanalyzed conditions such as the effect of collapse of the Canister Transfer Building on canisters or the effects of sliding and bearing failures of the foundation and concrete pad on storage casks.

However, the staff has determined that a 2,000-year return value with the PSHA methodology can be acceptable for the following reasons:

- The radiological hazard posed by a dry cask storage facility is inherently lower and the Facility is less vulnerable to earthquake-induced accidents than operating commercial nuclear power plants (Hossain et al., 1997). In its Statement of

Consideration accompanying the rulemaking for 10 CFR Part 72, the NRC recognized the reduced radiological hazard associated with dry cask storage facilities and stated that the seismic design basis ground motions for these facilities need not be as high as for commercial nuclear power plants (45 FR 74697, 11/12/80; SECY-98-071; SECY-98-126).

- Seismic design for commercial nuclear power plants is based on a determination of the Safe Shutdown Earthquake ground motion. This ground motion is determined with respect to a reference probability level of  $10^{-5}$  (median annual probability of exceedance) as estimated in a probabilistic seismic hazard analysis (Reference Reg Guide 1.165). The reference probability, which is defined in terms of the median probability of exceedance, corresponds to a mean annual probability of exceedance of  $10^{-4}$  (Murphy et al., 1997). That is, the same design ground motion (which has a median reference probability of  $10^{-5}$ ) has a mean annual probability of exceedance of  $10^{-4}$ .
- On the basis of the foregoing, the mean annual probability of exceedance for the PFS Facility may be less than  $10^{-4}$  per year.
- The DOE standard, DOE-TD-1020-94 (U.S. Department of Energy, 1996), defines four performance categories for structures, systems, and components important to safety. The DOE standard requires that performance Category-3 facilities be designed for the ground motion that has a mean recurrence interval of 2000 yrs (equal to a mean annual probability of exceedance of  $5 \times 10^{-4}$ ). Category-3 facilities in the DOE standard have a potential accident consequence similar to a dry spent fuel storage facility.
- The NRC has accepted a design seismic value that envelopes the 2000-yr return period probabilistic ground motion value for the TMI-2 ISFSI license (Nuclear Regulatory Commission, 1998b; Chen and Chowdhury, 1998). The TMI-2 ISFSI was designed to store spent nuclear fuel in dry storage casks similar to the PFS Facility.

In summary, the staff agrees that the use of the PSHA methodology is acceptable. A 2,000-year return period is acceptable for the seismic design of the PFS Facility. As discussed in the subsequent chapters of this SER, the design analyses use a spectrum that envelops the 2,000-year return period uniform hazard spectra.

#### **Additional Information on the East Great Salt Lake Fault**

The staff reviewed additional information and analyses provided in Appendix 2G of the SAR (Private Fuel Storage Limited Liability Company, 2000) regarding reported fault characterization data for the East Great Salt Lake fault. Recent high-resolution seismic data collected from the Great Salt Lake and reported in Dinter and Pechmann (1999a,b) indicate a Holocene vertical slip rate for the East Great Salt Lake fault of 1 mm/yr (average recurrence period of 3000–6000 years). The applicant assessed the possibility of the East Great Salt Lake fault being linked with the Oquirrh fault and also with the Toplift-Hill and Mercur faults, which collectively could form a Wasatch-scale fault zone.

The applicant showed in Appendix 2G, that the information about slip in the East Great Salt Lake fault does not significantly change the existing PSHA given in Geomatrix Consultants, Inc.

(1999a). The applicant reiterated that the possibility of a linked East Great Salt Lake-Oquirrh fault was already accounted for in the existing PSHA analyses. In the existing PSHA model, the mean slip rate for the East Great Salt Lake fault was 0.38 mm/yr. The data of Dinter and Pechmann (1999a,b) indicate a higher slip rate of 1 mm/yr. The applicant stated that this increase will have little effect on the PSHA because the East Great Salt Lake and the Oquirrh faults are located too far from the site to generate significant ground motion. The applicant concluded that compared to all seismic sources, the East Great Salt Lake fault contributes only a small fraction to the total hazard, including an assumption of a 1 mm/yr slip rate.

The staff agrees the applicant's analyses are acceptable. The contribution of the East Great Salt Lake fault to the PFS seismic hazard is not significant, including the possible connection with the Oquirrh fault.

### **Co-Seismic Rupture of Stansbury and East Faults**

The staff reviewed information and analyses provided in the SAR (Appendix 2G) regarding possible co-seismic rupture of the Stansbury and East faults or East/West fault and the potential impact of co-seismic rupture on ground motion hazard at the proposed PFS Facility. The staff agrees that co-seismic rupture of the East/West faults with the Stansbury fault is not supported by historic earthquakes, nor is it supported by recent geomorphic or geologic observations. Consequently, co-seismic rupture of these faults during the license period are unlikely. Thus, co-seismic rupture scenario would likely be given a very low weight in fault tree analysis and its contribution to the total hazard would be negligible.

The applicant estimated the potential effect of co-seismic rupture of the Stansbury and East faults on ground motion hazard at the proposed Facility based on scaling factors similar to those proposed for co-seismic rupture at Yucca Mountain, Nevada [developed by the expert elicitation for the Yucca Mountain PSHA (Civilian Radioactive Waste Management System Management and Operating Contractor, 1998)]. In its assessment, the applicant stated that because both Yucca Mountain and the proposed Facility are within the same tectonic setting (extension in the basin and range), the effects of coseismic rupturing on the characteristics of ground motion attenuation is similar. The staff agreed and found using Yucca Mountain scaling factors for the Facility to be acceptable. This finding, however, is specific to the proposed Facility because it is based on specific site conditions and regulatory requirements for the proposed Facility. It is not necessarily applicable to evaluations of co-seismic rupture at other spent nuclear fuel-related facilities.

The effects of simultaneous multiple-fault ruptures on ground motions at Yucca Mountain were estimated as an increase in the median ground motion and an increase in the standard error (Civilian Radioactive Waste Management System, Management and Operating Contractor, 1998). The increase in the median ground motion is expressed as a multiple of the median. The increase in the standard error is expressed as either a multiple of the standard error or as an additional error incorporated using the square root of the sum of the squares. These scaling and additional factors for peak ground acceleration obtained by seven ground motion teams are summarized in tabular format in Appendix 2G. From this table, PFS computed the geometric means of the scale factors from all seven ground motion teams (Civilian Radioactive Waste Management System Management and Operating Contractor, 1998) for both the median ground motion and standard error and used these mean factors to estimate changes in the contributions of maximum magnitude earthquakes on Stansbury and East faults to the total hazard at the proposed PFS Facility. The calculations show that, without co-seismic rupture, a M 6.5 earthquake on East fault and a M 7.0 earthquake on Stansbury fault (the maximum



expected magnitudes on these faults, respectively, Geomatrix Consultants, Inc., 1999a) have probabilities of approximately 0.35 and 0.32, respectively, of producing a peak ground acceleration in excess of 0.53 g. The 0.53 g is the 2000-year return period peak ground motion (Geomatrix Consultants, Inc., 1999a). Considering that events of M 6.5 and larger on each fault have expected frequencies of occurrence of approximately  $3 \times 10^{-4}$  per year (Geomatrix Consultants, Inc., 1999a), these two earthquakes would contribute  $0.35 \times (3 \times 10^{-4}) + 0.32 \times (3 \times 10^{-4}) = 2.0 \times 10^{-4}$  events per year to the annual frequency of exceeding 0.53 g. With co-seismic rupture of the East and Stansbury faults (i.e., assuming instead that the maximum earthquakes on the two faults occur as a single M 7.05 co-seismic rupture, M 7.05 was obtained using the combined moment for a M 6.5 and a M 7.0 earthquake), scaling the median ground motion level and the standard error produced by this earthquake by the mean factors results in a probability of approximately 0.62 of exceeding a peak ground acceleration of 0.53 g. Considering the frequency of the combined event remains to be  $3 \times 10^{-4}$ , the event would contribute  $0.62 \times (3 \times 10^{-4}) = 1.8 \times 10^{-4}$  event per year to the annual frequency of exceeding 0.53 g. This contribution does not exceed the contribution by two independent earthquakes.

The staff concludes that a co-seismic rupture for the Stansbury and the East faults is unlikely and will not impact the existing PSHA results. Therefore, a design earthquake analyses based on the 2000-year return period ground motion is acceptable.

### 2.1.6.3 Surface Faulting

Geomatrix Consultants, Inc. (1999a) documented several small faults in and around the site. These faults are all considered secondary faults related to deformation of the hanging wall above the larger East and West faults. These faults are too small to be independent seismic sources but large enough to be considered in the fault displacement analysis.

Similar to the seismic hazard evaluation, Geomatrix Consultants, Inc. (1999a) developed a probabilistic fault displacement hazard. The fault displacement hazard analysis was built on two methodologies developed for the Yucca Mountain PSHA (Civilian Radioactive Waste Management System Management and Operating Contractor, 1998). These methodologies, termed the earthquake approach and displacement approach, use Basin and Range empirical relationships with site-specific data to generate fault displacement hazard curves similar to seismic hazard curves.

Probabilistic fault displacement hazard results were calculated for three potential secondary faults that are under or near the site. These faults—informally named the C, D, and F faults—were identified from detailed seismic reflection profiles and confirmed by boreholes. The seismic profiles document offset of the unconformity between Promontory soil, deposited between 130–28 Ka, and Bonneville lacustrine deposits, deposited between 28–12 Ka. Vertical separation across the largest strands of the F fault (F-1 and F-4) is approximately 5 feet in the last 60 Ka and 2 feet in the last 20 Ka. A critical observation is that these faults show evidence of repeated fault slip. This is important because it suggests that future faulting events will likely occur along these same faults and not on new faults under the site. In addition, these observations of repeated slip events allowed Geomatrix Consultants, Inc. (1999a) to constrain the average displacement per event for each fault.

Faulting recurrence rates and displacement per event were quantified based on vertical separation of the Quaternary marker horizons. The results show that based on the 95<sup>th</sup>-percentile curve, significant displacements, above 0.04 inch, are expected to occur only with an annual frequency of less than  $3 \times 10^{-4}$ , or once in 3,333.3 years. Significant displacements of

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Intervenor		REJECTED	
Other		WITHDRAWN	
DATE	<u>12/5/02</u>	Witnessed	<u>ARAAASZ</u>
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