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April 24, 2000

ERRATA TO CORRECT APPENDIX 2G OF THE PFSF LICENSE APPLICATION
DOCKET NO. 72-22 / TAC NO. L22462
PRIVATE FUEL STORAGE FACILITY
PRIVATE FUEL STORAGE L.L.C.

References: 1. PFS letter, Donnell to U.S. NRC, Commitment Resolution Letter #26, dated February 23, 2000
2. PFS letter, Parkyn to U.S. NRC, License Application Amendment No. 10, dated March 17, 2000

Amendment #10 dated March 17, 2000, added Appendix 2G, Additional Seismic Evaluations, to the Private Fuel Storage Facility (PFSF) Safety Analysis Report (SAR). The attached revised Appendix 2G corrects an omission in the first submittal.

The first submittal calculated the effect of simultaneous ruptures on ground motion estimates but omitted as part of this calculation an assessment of the effect of simultaneous ruptures on the earthquake magnitude. The revised Appendix 2G enclosed with this letter corrects this omission. Under the Yucca Mountain approach used in Appendix 2G, the seismic moments of the ruptures on individual faults are summed to obtain the seismic moment for co-seismic ruptures on parallel faults. Performing this calculation for the PFSF site results in a magnitude M 7.05 earthquake representing the co-seismic rupture of an M 7 earthquake on the Stansbury fault and an M 6.5 earthquake on the East fault. The corrected Appendix 2G uses an M 7.05 at the closest distance of the East fault to the site to compute the ground motions for a simultaneous rupture of the Stansbury and East faults.

It should be noted that the revisions made to Appendix 2G as described above do not change the conclusion from that of the first submittal, that is, it is expected that consideration of co-seismic ruptures of the Stansbury with the East and West faults in the PHSA would result is a slight decrease in the 2,000-year return period ground motions.

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public

The enclosed errata pages replace Appendix 2G in its entirety. This letter and the enclosed errata pages are being sent to all persons on the PFSF License Application distribution.

We apologize for any inconvenience caused by this error. If you have any questions, please contact me at 303-741-7009.

Sincerely

John L. Donnell
Project Director
Private Fuel Storage L.L.C.

Enclosure
Copy to (with enclosure):
See Attached distribution sheet

APPENDIX 2G

Additional Seismic Evaluations
(8 Pages)

April 24, 2000

Additional Seismic Evaluations

NEW INFORMATION ON THE EAST GREAT SALT LAKE FAULT

Results from the interpretation of recent high resolution seismic survey information across the Great Salt Lake fault indicate multiple Holocene earthquakes on the East Great Salt Lake fault (Dinter and Pechmann, 1999a, b). Specifically, Dinter and Pechmann (1999a, b) report an average vertical slip rate for the Holocene East Great Salt Lake fault of 1 mm/yr (average return period of 3,000 to 6,000 yrs). This fault may link with the Oquirrh fault and possibly with the Oquirrh, Topliff-Mercur Hills faults to form a large Wasatch-scale fault zone. PFS has evaluated this new information on the East Great Salt Lake fault to determine the impact, if any, on PFSF seismic hazard.

In the PSHA analysis for the PFSF (Geomatrix Consultants, Inc., 1999a), the source characterization for the East Great Salt Lake (EGSL) fault included two alternatives. The first alternative (weighted 0.9) was that the EGSL fault is independent of the Oquirrh fault. The second alternative (weighted 0.1) was that the EGSL fault is linked with the Oquirrh fault to form a single seismic source. Thus, the existing model accounts for the linkage. The maximum magnitudes assessed for the EGSL fault and the linked EGSL-Oquirrh faults are similar to those assessed for the Wasatch fault (see Figure 6-6 of Geomatrix Consultants, 1999a). Thus, the existing model accounts for the potential scale of the EGSL fault. The mean slip rates for the EGSL fault in the existing model is 0.38 mm/year. If one assumes that the mean slip rate is 1 mm/year for the EGSL fault, then the hazard (frequency of exceedance) from this fault would be increased by a factor of approximately 3. The EGSL fault is located approximately 60 km from the PFSF site. At this distance, the fault has a very small contribution to the total hazard (see Figure 6-12 of Geomatrix Consultants,

1999a). At the 2,000-year return period ground motion level, the EGSL fault contributes <0.01% of the frequency of exceedance for peak ground acceleration (PGA) and 0.2% of the frequency of exceedance for 1.0-second spectral acceleration (SA). If one increases the mean slip rate for the EGSL fault by a factor of 3, then the total frequency of exceedance for 1.0-second SA would increase by a factor of 1.004 at the 2,000-year return period ground motion level. This would result in a 0.2% change in the 2,000-year return period spectral acceleration.

In conclusion, the new information on the East Great Salt Lake fault has negligible impact on the hazard at the PFSF.

CO-SEISMIC RUPTURE OF THE STANSBURY FAULT WITH THE EAST FAULT, WEST FAULT, OR EAST-WEST COMBINED FAULT

Co-seismic rupture of the East and West faults with the Stansbury fault during the most recent event on the Stansbury fault is not supported by geomorphic and geologic relationships. The age of the most recent event along the Stansbury fault is estimated to be early to middle Holocene (~ 8 ± 2 thousand years old) based on the displacement of a relatively young alluvial terrace surface at the mouth of Antelope Canyon. A significant scarp-forming event on either the East or West faults during this period of time should be recognizable in the present topography. The East and West faults in the site area are overlain by latest Pleistocene lacustrine deposits that were deposited as the lake receded from the Provo shoreline (~ 14.5 to 14.2 thousand years old) to the Gilbert shoreline (~ 11 to 10 thousand years old). Erosion that occurred during the recession of the lake from the Provo to Gilbert shorelines possibly could have eliminated pre-existing fault scarps. Significant fault scarps (greater than approximately ½ m) formed after the lake receded to the Gilbert shoreline likely would not be completely

eroded or obscured by deposition in the site area. No such scarps are identified along either the East or West faults, suggesting that there has been no significant displacement on these faults during the past 10 to 11 thousand years.

Geometric relationships suggest that the faults are independent structures. The East fault in the vicinity of the site lies between 5 to 9 km from the main trace of the Stansbury fault. Within the ranges of fault dips expected for these faults, the faults do not intersect within the upper seismogenic crust. Based on these geometric relationships and lack of evidence to suggest that these faults have ruptured co-seismically, these faults were considered as independent structures in the current PFSF seismic hazard model. Although we cannot preclude the possibility that the Stansbury fault could rupture co-seismically with the East and/or West faults, we judge this event to be highly unlikely. Analog data for historical moderate to large magnitude normal faulting earthquakes suggest that co-seismic rupture (simultaneous release of comparable levels of seismic energy on both faults) of subparallel normal faults separated by 5 or more kilometers is rare, having been clearly documented in only one earthquake, the 1959 Hebgen Lake, Montana earthquake. During this earthquake, two west-dipping faults separated by up to as much as 5 km ruptured co-seismically.

The effect of co-seismic rupture of subparallel faults on ground motions can be evaluated using the results of studies conducted for the proposed commercial nuclear waste repository at Yucca Mountain, Nevada. The assessments of the Yucca Mountain Ground Motion Expert Panel formed the basis for selecting the ground motion models used to assess ground motion hazard at the Skull Valley PFSF site (Geomatrix Consultants, 1999a). The experts also assessed the effects of simultaneous multiple-fault ruptures on ground motions. The effects were expressed as an increase in the median level, expressed as a multiple of the median; and/or an increase in the standard error, expressed as either a multiple of the standard error or an additional error incorporated using the square

root of the sum of the squares (SRSS). The following table summarizes the assessments of the Ground Motion experts for peak ground acceleration (PGA).

Adjustment Factors for Multiple Rupture on Two Faults
Developed by Yucca Mountain Project Expert Panel
For Horizontal Peak Ground Acceleration
(From Tables 6-3 through 6-9 of CRWMS M&O, 1998)

Yucca Mountain Ground Motion Expert	Scale Factor for Median	Scale Factor for Standard Error	Additional Standard Error (SRSS)	Additional Standard Error in Median (SRSS)
J.G. Anderson	1.20	1.0		
D.M. Boore	1.25	1.0		
K.W. Campbell	1.0	1.2		
A. McGarr	1.0	1.2		
W.J. Silva	1.29	1.0		
P.G. Somerville	1.63	1.29*	0.3	0.2
M.C. Walck	1.28	1.03*		0.1

*Computed from additional error using an average standard error of 0.44 for the natural log of peak acceleration.

In the above table, the effects on the standard error assessed by P.G. Somerville and M.C. Walck were converted to a scale factor using a standard error of 0.44 for the natural log of peak acceleration. This is the average standard error in PGA specified by the ground motion attenuation relationships used by the experts for a magnitude **M** ~7 earthquake. Thus, the standard error factor for P.G. Somerville is equal to $\sqrt{0.44^2+0.3^2+0.2^2}/0.44=0.57/0.44=1.29$.

The above table also includes the effect of simultaneous rupture on the magnitude of the earthquake. The approach used in the Yucca Mountain study was to combine the moments of the individual fault ruptures to obtain the moment of the combined rupture. Using the definition of moment magnitude **M** =

$2/3\log(M_o)-10.7$, the combined moments for **M** 6.5 and 7 earthquakes (the expected maximum magnitudes on the East and Stansbury faults, respectively), one obtains a magnitude **M** 7.05 for a combined rupture.

The average effect is a scale factor of 1.22 for the median (computed as the geometric mean of the 7 factors because of the lognormal distribution for peak acceleration) and a scale factor of 1.10 for the standard error. Thus, if it is assumed that the maximum magnitude earthquakes occurred simultaneously on the East and Stansbury faults, the estimated median PGA would be a factor of 1.22 times the median value obtained for the same magnitude earthquake occurring on a single fault and the 84^{th}-percentile PGA would be a factor of approximately 1.28 times the 84^{th}-percentile value obtained for the same magnitude earthquake occurring on a single fault. These adjustments would have to be weighted by the evaluation of the probability that such an event could occur. As discussed above, it is judged highly unlikely that the two faults could rupture simultaneously with large earthquakes. For example, if the assessed probability was 0.1, then, the weighted deterministic estimates of the median and 84^{th} percentile PGA would be factors of 1.02 and 1.03 times those for the same magnitude earthquake occurring on a single fault.

The effect of potential co-seismic rupture of both faults on the assessment of the hazard at the PFSF site can be assessed by examining the results of the seismic hazard analysis conducted for the Yucca Mountain Project (CRWMS M&O, 1998). The seismic source characterization expert teams included the possibility of co-seismic rupture on parallel faults in their characterization of seismic sources. The sensitivity analyses presented in figures in Section 7 of CRWMS M&O (1998) gives an indication of the effect of co-seismic rupture on the annual probability of exceedance. Figure 7-31 shows the sensitivity for the AAR team. The alternatives shown are for 1, 2, 3, or four coalesced faults at Yucca Mountain. If there are four, then each is an independent source. If there are less

than four, then co-seismic rupture occurs on multiple parallel fault traces. The results indicate lower hazard for cases of co-seismic rupture than for independent sources. Figure 7-65 shows the sensitivity for the AAR team. The alternatives shown are the faults always rupture independently or the faults occasionally rupture simultaneously. The results indicate lower hazard for cases of occasional simultaneous rupture than for always independent rupture. Figure 7-85 shows the sensitivity for the DFS team. The alternatives shown are the faults always rupture independently or the faults rupture simultaneously with distributed ruptures. The results indicate lower hazard for cases of distributed simultaneous rupture than for independent rupture. Figure 7-109 shows the sensitivity for the RYA team. The RYA team defined three alternatives for coalesced faults: three independent sources; two independent sources, with rupture on one consisting of co-seismic rupture on two parallel faults; and a single source, with rupture consisting of co-seismic rupture on three parallel faults. Three independent sources produces higher hazard at low ground motion levels. However, at high ground motion, the single source with parallel ruptures on multiple faults produces larger hazard. The SBK time considered the possibility of simultaneous ruptures on parallel faults in their hazard model, but sensitivity analyses are not shown in CRWMS M&O (1998). The SDO team did not consider simultaneous ruptures as an alternative, but rather as an additional source of earthquakes.

In general, the sensitivity analyses presented in CRWMS M&O (1998) indicate that considering parallel faults to rupture co-seismically produces lower hazard than considering them to produce independent earthquakes. The reduction in hazard occurs because, although the ground motions produced by the simultaneous, multiple-fault rupture is larger, the number of independent earthquakes affecting the site is reduced. This effect can be illustrated by the following evaluation of a co-seismic rupture of the two largest faults (Stansbury and East fault).

Based on the source characterization presented in Geomatrix Consultants (1999a) expected maximum magnitudes on the Stansbury and East faults are **M** 7 and 6.5, respectively. Events this size and larger on each fault have expected frequencies of occurrence of approximately 3×10^{-4} per year. The median PGA at the PFSF site for an **M** 6.5 on the East fault is 0.44g (Geomatrix Consultants, 1999b). Using a standard error of the natural log of PGA of 0.48, an **M** 6.5 earthquake on the East fault has a probability of approximately 0.35 of producing a PGA in excess of 0.528g, the 2,000-year design ground motion. Similarly, the median PGA at the PFSF site for an **M** 7.0 on the Stansbury fault is 0.43g (Geomatrix Consultants, 1999b). Using a standard error appropriate of 0.44 (the average value for **M** 7 earthquakes), an **M** 7.0 earthquake on the Stansbury fault has a probability of approximately 0.32 of producing a PGA in excess of 0.528g. Thus, these two earthquakes contribute $0.35^* 3\times10^{-4} + 0.32^*3\times10^{-4} = 2.02\times10^{-4}$ events per year to the annual frequency of exceeding 0.528g.

If one assumes instead that the maximum earthquakes on the two faults occur as a single co-seismic rupture, the resulting median PGA would be 1.22 times the median ground motion for a magnitude **M** 7.05 earthquake occurring on a single fault. Using the ground motion models presented in Geomatrix (1999a), the median PGA for a M 7.05 earthquake occurring at a closest distance equivalent to the East fault is 0.50g. The median ground motion for a simultaneous rupture would be 1.22*0.50g = 0.61g. Using a standard error of 0.44*1.10 = 0.484, a simultaneous rupture of maximum events on both faults would have a probability of approximately 0.62 of exceeding a PGA of 0.528g. However, the frequency of the combined event is 3×10^{-4} per year, and the event contributes $0.62^*3\times10^{-4} = 1.85\times10^{-4}$ events per year to the annual frequency of exceeding 0.528g. If one assumes that every third rupture on each fault is a co-seismic rupture of both faults, the result is an occurrence frequency of 2×10^{-4} per year for independent

ruptures on the two faults and 1×10^{-4} per year for co-seismic ruptures. The resulting hazard contribution from these events is $0.35^* 2\times10^{-4} + 0.32^*2\times10^{-4} + 0.62^*1\times10^{-4} = 1.96\times10^{-4}$ events per year to the annual frequency of exceeding 0.528g.

Thus, it is expected that consideration of co-seismic ruptures of the Stansbury with the East and West faults in the PHSA would result in a slight decrease in the 2,000-year return period ground motions.