

CALCULATION TITLE PAGE

CLIENT & PROJECT PFSLLC/Private Fuel Storage Facility					Total Pages = 8 PAGE 1 OF 8	
CALCULATION TITLE (Indicative of Objective): Tornado Strike Probability Calculation					QA CATEGORY (✓) <input checked="" type="checkbox"/> - Safety Related <input type="checkbox"/> - Non Safety Related <input type="checkbox"/> - Non Safety Related with special regulatory significance (NSQ) <input type="checkbox"/> - Non Nuclear Plant	
CALCULATION IDENTIFICATION NUMBER						
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05996.01	E(B)	001	N/A	--		
APPROVALS - SIGNATURE & DATE			REV. NO. OR NEW CALC. NO.	SUPERSEDES CALC. NO. OR REV. NO.	CONFIRMATION REQUIRED (✓)	
PREPARER(S)/DATE(S)	REVIEWER(S)/DATE(S)	INDEPENDENT REVIEWER(S)/DATE(S)			YES	NO
<i>S. A. Vigeant</i> 6-18-97 S. A. Vigeant	<i>Carl A. Mazzola</i> for 6-20-97 K. O'Neil	<i>Carl A. Mazzola</i> 6-20-97 C. Mazzola	0	N/A		✓
DISTRIBUTION						
GROUP	NAME & LOCATION	COPY SENT ✓	GROUP	NAME & LOCATION	COPY SENT ✓	
RECORD MGT. FILE	RECORDS (orig) R4.2 MANAGEMENT	✓				
PROJECT FILE	S. MACIE, DEN	✓				
ENV SCIENTIST	S. A. VIGEANT 245/03	✓				
	FIRE FILE	✓				

REVIEW STATEMENT FOR SAFETY RELATED CALCULATIONS

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Review of this calculation was based on the methods below:

Calc. Revision No. 0Calc. change Notice No. -1) Review of:

- a) Inputs to assure that they have been properly selected and correctly used in the calculation. (Check One)

i) Limited review (provide justification) ☐ii) Line by line review ☒Initial Upon
Completion

- b) Assumptions to assure their validity and need for later confirmation.
- ☒

- c) Methodology to assure the appropriateness of the overall approach, its implementation, and the correctness of the specific equations utilized.

i) Limited review (provide justification) ☐ii) Line by line review ☒

- d) Result to assure reasonableness and accuracy
- ☒

- e) If alternate calculation is performed to verify c) and d) check here and attach calculation as an appendix
- ☐

2) Check of Calculation (Check One)

- a) Complete numerical check
- ☒

- b) Numerical check of critical items (state items and justification below)
- ☒

3) Administrative check of format and content ☒4) Comments/JustificationReview Methods Selected as Indicated Above

Independent Reviewer



Date Supervisor concurrence

Date

Satisfactory Completion of Review (Calculation is approved for Issue)

Checker

Date Reviewer

Date

Independent Reviewer

Date

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<u>REVISION STATUS</u>			
REV. No.	DATE	DESCRIPTION/REASON FOR REVISION	AFFECTED PAGES
0	See Pg 1	ORIGINAL ISSUE	ALL

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OBJECTIVE

The purpose of this calculation is to determine the annual probability of a tornado striking the PFSF facility in Skull Valley, Utah.

ASSUMPTIONS

1. The surface area upon which a tornado strike probability is based is the 1-degree latitude-longitude box centered on the PFSF site in accordance with the recommendation of Thom (Ref. 1).
2. All tornadoes observed within Tooele County, Utah are conservatively included in the probability calculation as the 1-degree latitude-longitude box falls entirely within Tooele County but the county is larger than the 1-degree latitude-longitude box.

METHOD

The analytical method used to calculate the tornado strike probability is taken from guidance provided in Thom (Ref. 1).

Occurrences of tornadoes within a 1-degree latitude-longitude square centered on the PFSF site, all occurring in Tooele County, have been summarized as follows:

<u>No.</u>	<u>Date</u>	<u>Path Length</u> (miles)	<u>Path Width</u> (yards)	<u>F-Scale</u>
1	05/03/1993	0.1	15	F1
2	09/23/1992	N/A	N/A	F0
3	08/30/1992	0.8	200	F0
4	07/25/1991	10	100	F1

This list of four tornadoes covering the period from 1975 to 1995 is based on the publication "Storm Data" (Ref. 2). This is the best available source of information for this calculation. For each tornado, this list identifies the date of occurrence, path length in miles, path width in yards, and the Fujita Scale classification. The Fujita scale is described on page 8.

According to Grazulis (Refs. 4 & 5), there were no reported "significant" tornadoes in Tooele County for the period 1880-1995 and there were only four "significant" tornadoes reported in the entire state. Grazulis defines "significant" for purposes of his

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publication as any tornado that has done confirmable F2 or greater damage or has killed a person. As such, it would be reasonable to use 1880-1993 as the period of record for the tornado strike probability calculation since the less than F2 tornadoes probably add very little to the overall probability. However, the conservative approach of using 1975-1995 as the period of record was chosen.

Using this information, the probability of a tornado striking a point within the 1-degree latitude-longitude square centered on the PFSF site can be estimated as follows (Ref. 1):

$$P = zt/A$$

where: P = mean probability of a tornado strike per year
 z = geometric mean tornado path area (mi²)
 t = mean number of tornadoes per year
 A = area of 1-degree square (mi²)

The geometric mean tornado path area (z) based on the above list is then:

<u>Tornado No.</u>	<u>Area</u>
1	(0.1 mi) (15 yds) (1 mi/1760 yds) = 0.000852 mi ²
3	(0.8 mi) (200 yds) (1 mi/1760 yds) = 0.0909 mi ²
4	(10 mi) (100 yds) (1 mi/1760 yds) = 0.568 mi ²
 z = (0.000852 x 0.0909 x 0.568) ^{1/3} mi ² = 0.0353 mi ²	

Tornado No. 2 is not included as there is no information available on path area. Thus, only three tornadoes enter into the probability calculation.

The mean number of tornadoes (t) per year based on 3 observed tornadoes within the 1-degree box over a 21 year period of record is then:

$$t = 3 \text{ tornadoes}/21 \text{ years} = 0.14 \text{ tornadoes/year}$$

The area (A) of the 1-degree box centered on the site can be estimated in square miles according to 4774.3 cos(L) (Ref. 3) where L is the latitude of the middle of the box. With an estimated latitude of 40.3 degrees north, A is:

$$A = 4774.3 \cos(40.3) = 3641 \text{ mi}^2$$

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Therefore, the probability of a tornado striking the PFSF site is estimated to be:

$$p = (0.0353 \text{ mi}^2) (0.14 \text{ tornadoes/year}) / (3641 \text{ mi}^2) \\ = 1.36 \times 10^{-6} \text{ strikes per year}$$

or a recurrence interval of approximately 700,000 years.

REFERENCES

1. Thom, H. C. S., 1963, Tornado probabilities: Monthly Weather Review 91, pp. 730-736.
2. National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service, National Climatic Data Center, 1975-1995, Storm data and unusual weather phenomena with late reports and corrections.
3. Ramsdell, J. V. and G. L. Andrews, 1986, Tornado climatology of the contiguous United States: Prepared by Pacific Northwest Laboratory for the U.S. Nuclear Regulatory Commission, NUREG/CR-4461, PNL-5697.
4. Grazulis, Thomas P., 1993, Significant tornadoes 1680 - 1991: Published by The Tornado Project of Environmental Films, St. Johnsbury, Vermont.
5. Grazulis, Thomas P., 1997, Significant tornadoes update, 1992-1995. Published by The Tornado Project of Environmental Films, St. Johnsbury, Vermont.
6. U. S. Atomic Energy Commission, 1974, "Design Basis Tornado for Nuclear Power Plants", Regulatory Guide 1.76.

RESULTS/CONCLUSIONS

The estimated annual probability of a tornado striking the PFSF facility is 1.36×10^{-6} strikes per year. As this value is based on only 3 tornado occurrences over a period of 21 years, it is very sensitive to each tornado used in the calculation. For example, if the small tornado #1 were not observed and only 2 tornadoes were used in the calculation, the estimated annual probability would increase to 5.94×10^{-6} strikes per year due to the elimination of the small path area for tornado #1 from the geometric mean.

However, the estimated value of 1.36×10^{-6} strikes per year compares with an arithmetic average tornado strike probability of

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9.72 x 10⁻⁷ per year and an expected probability of 3.06 x 10⁻⁶ per year (based on a log normal distribution) for the entire state as computed in NUREG/CR-4461 (Ref. 3) based on tornadoes for the period 1954 to 1983. Therefore, it is concluded that the 1.36 x 10⁻⁶ strikes per year probability level is representative of this site.

Regulatory Guide 1.76 (Ref. 6) also supports the low tornado strike probability estimated in this calculation as it indicates that the geographic region west of the front range has the lowest values of the design basis tornado parameters in the U. S.

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Fujita Tornado Intensity Scale for Tooele County Tornadoes

<u>Classification</u>	<u>Wind Speed</u>	<u>Description of Damage</u>
	(mph)	
F0 Gale Tornado	40 - 72	Light damage. Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.
F1 Moderate Tornado	73 - 112	Moderate damage. The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.