UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	
PRIVATE FUEL STORAGE L.L.C.	)	Docket No. 72-22
	)	
(Private Fuel Storage Facility)	)	

DECLARATION OF JAMES L. COLE, JR., WAYNE O. JEFFERSON, JR., AND RONALD E. FLY

James L. Cole, Jr., Wayne O. Jefferson, Jr., and Ronald E. Fly state as follows under penalties of perjury:

I. WITNESSES

A. James L. Cole, Jr.

1. I am Senior Director, Safety of the Air Transport Association and an associate with Burdeshaw Associates, Ltd. Burdeshaw Associates is a consulting firm in the Washington, D.C. area that provides services to clients in the areas of aviation, transportation, military operations, and government affairs. In 1994 I retired from the United States Air Force with the rank of Brigadier General. I am providing this declaration in support of a motion for summary disposition of Contention Utah K in the above captioned proceeding to indicate the risk of aircraft or air-delivered ordnance accidents impacting the proposed Private Fuel Storage Facility (PFSF) for the storage of spent nuclear fuel in Skull Valley, Utah.

2. My professional and educational experience is summarized in the curriculum vitae attached as Exhibit 1 to this declaration. I have extensive experience in and

State's
Exhibit 39

knowledge of aircraft operations and aviation safety. From 1991 to 1994, I served as Chief of Safety of the United States Air Force and directed the entire USAF safety program. I was responsible for accident prevention and investigation in all aspects of ground and air operations. I was also commander of the 89th Airlift Wing (which transports the President of the United States) and vice commander of a C-141 wing. I have 6,500 total flying hours with 3,000 flying hours in heavy jet aircraft. I was also an instructor pilot and flight examiner (check pilot) in the C-141 aircraft.

3. I was responsible for PFS's assessment of the risk to the PFSF posed by aircraft crashes and ordnance impacts, with respect to, generally speaking, overall aviation safety, data and information concerning military and civilian air traffic in the region of the PFSF and aircraft accident rates, and all aspects of civilian aviation. I also reviewed in depth the Air Force's mishap reports for the F-16 for the ten year period from FY1989 through FY1998. During over three years as USAF Chief of Safety, I personally reviewed and approved every Air Force Accident Safety Investigation report for all types of aircraft. On all relevant aspects of the assessment I provided my judgment regarding pilot actions and responses to emergencies.

B. Wayne O. Jefferson, Jr.

4. I am an associate with Burdeshaw Associates, Ltd. In 1989 I retired from the United States Air Force with the rank of Major General. I am providing this declaration in support of a motion for summary disposition of Contention Utah K in the above captioned proceeding to indicate the risk of aircraft or air-delivered ordnance accidents impacting the proposed PFSF for the storage of spent nuclear fuel in Skull Valley, Utah.

5. My professional and educational experience is summarized in the curriculum vitae attached as Exhibit 2 to this declaration. I have extensive experience in and knowledge of U.S. Air Force aircraft operations and weapons testing and training operations. I served in the Air Force for over 30 years, including service with the Strategic Air Command as a B-52 wing commander. I have 4,450 flying hours in 9 different aircraft

types. My experience also includes service in senior positions on the Air Staff, Joint Staff and on the faculty of the U.S. Air Force Academy. Since I retired from the Air Force I have been a consultant in management, management training, and quantitative probabilistic analysis. My education includes a master's degree in operations research and a master's in business administration.

6. I was responsible for PFS's assessment of the risk to the PFSF posed by aircraft crashes and ordnance impacts, with respect to, generally speaking, the quantitative calculations PFS performed concerning the probability that a crashing aircraft would impact the PFSF. I also reviewed in depth the Air Force's mishap reports for the F-16 for the ten year period from FY1989 through FY1998. On all relevant aspects of the assessment I provided my judgment regarding pilot actions and responses to emergencies.

C. Ronald. E. Fly

7. I am an associate with Burdeshaw Associates, Ltd. In 1998 I retired from the United States Air Force with the rank of Colonel. I am providing this declaration in support of a motion for summary disposition of Contention Utah K in the above captioned proceeding to indicate the risk of aircraft or air-delivered weapon accidents impacting the proposed PFSF for the storage of spent nuclear fuel in Skull Valley, Utah.

8. My professional and educational experience is summarized in the curriculum vitae attached as Exhibit 3 to this declaration. I have extensive experience in and knowledge of U.S. Air Force aircraft operations and training operations. I served in the Air Force for 24 years as an F-16 pilot, instructor, and wing commander. I have approximately 1,200 flying hours in the F-16 as a pilot and instructor. From 1997 to 1998 I served as Commander of the 388th Fighter Wing at Hill Air Force Base, Utah, during which time I flew F-16s on the UTTR. I was also Commander of the UTTR beginning Oct. 1, 1997 when the range was transferred to the 388th FW from Air Force Material Command. In addition to my flight operations and training operations experience, I also have experience in strategic planning, operational analysis, international affairs, space

operations, and logistical support. Furthermore, I am specifically knowledgeable about the operations of military and civilian aircraft that fly in and around Skull Valley, Utah, including the military aircraft that fly from Hill Air Force Base and on or around the UTTR and Dugway.

9. I was responsible for PFS's assessment of the risk to the PFSF posed by aircraft crashes and ordnance impacts, with respect to, generally speaking, military aircraft operations on and around the UTTR and F-16 emergency procedures. I reviewed in depth the Air Force's mishap reports for the F-16 for the ten year period from FY1989 through FY1998. On all relevant aspects of the assessment I also provided my judgment regarding pilot actions and responses to emergencies.

II. BACKGROUND

10. In the bases for Contention Utah K, as admitted by the Licensing Board, the State asserts in part that Applicant Private Fuel Storage (PFS) inadequately considered the hazard to the PFSF of credible accidents involving materials or activities at or emanating from Salt Lake City International Airport, Hill Air Force Base, the UTTR, and Dugway (which is the location of Michael Army Airfield). We have reviewed information and data concerning the potential hazard to the PFSF from aircraft crashes and the use of air-delivered weapons in testing and training at these facilities and have determined that they pose no credible or significant hazard to the PFSF. Our assessment is set forth in a formal report attached as Exhibit 4, entitled, "Private Fuel Storage, Aircraft Crash Impact Hazard at the Private Fuel Storage Facility," Revision 4 (August 10, 2000) ("Aircraft Report"). Our analysis and the conclusions from the report are summarized in Part III below.

11. As part of our assessment, we reviewed all of the available Air Force F-16 Class A Mishap Aircraft Accident Investigation Reports from the period fiscal year 1989

through fiscal year 1998.[1] Those reports are prepared under Air Force Instruction 51-503 after each aircraft mishap to determine the cause of the accident for the purposes of preserving all available evidence and providing a complete factual summary for use in claims, litigation, disciplinary actions, adverse administrative proceedings, and other purposes in accordance with AFI 51-503. The reports follow a set format which sets forth the details of the circumstances surrounding the accident, including: a summary of the history of the flight, the flight mission, preflight activities and planning, the actual flight activity, crash impact information, the functioning of the emergency escape mechanism, rescue activity, maintenance and mechanical factors, supervisory factors, pilot qualifications and performance, navigational aids and facilities, weather, and pertinent directives and publications. Each report may conclude with a statement of opinion by the investigating officer as to the cause of the accident. The flight activity section in particular gives the relevant information as to pilot actions after the emergency begins, including efforts to avoid populated areas and built up structures on the ground. By obtaining these reports, PFS has been able to determine the causes of F-16 accidents likely to occur in Skull Valley and on the UTTR. In total, we reviewed 126 accident reports, covering mishaps in which 121 F-16s were destroyed.

12. In recent responses to PFS discovery requests, the State of Utah has taken issue with some aspects of our assessment. In Part IV of this declaration we respond to the State's specific challenges.

III. SUMMARY OF AIRCRAFT CRASH IMPACT HAZARD ASSESSMENT

A. Aviation Activity in the Vicinity of the PFSF in Skull Valley

13. The PFSF site is located in Skull Valley, Utah, approximately 50 miles southwest of Salt Lake City. Aviation activity in the vicinity of the site consists of mili-

[1] A Class A mishap is one in which there is a fatality, the aircraft is destroyed, or the aircraft suffers $1 million in damage or more.

tary operations, associated with the UTTR and Michael Army Airfield, and civilian commercial and potentially general aviation. The UTTR is an Air Force training and testing range. The airspace over the UTTR extends somewhat beyond the range's land boundaries and is divided into restricted areas, over which the airspace is restricted to military operations, and military operating areas (MOAs). The MOAs on the UTTR are located on the edges of the range, adjacent to the restricted areas. A MOA constitutes airspace of defined dimensions allocated to the military to separate or segregate certain military activities from other flight operations.

14. The UTTR airspace is shown on the map attached as Exhibit 5. It is divided into a North Area, located on the western shore of the Great Salt Lake, north of Interstate 80, and a South Area, located to the west of the Stansbury Mountains, south of Interstate 80. The area covered by the airspace of the UTTR South Area is roughly 148 miles long (at its longest point) by 102 miles wide (at its widest point). The PFSF site is located over 18 statute miles east of the eastern land boundary of the UTTR South Area and 8.5 statute miles northeast of the northeastern boundary of Dugway Proving Ground. The site lies within the Sevier B MOA, two statute miles to the east of the edge of UTTR restricted airspace. As shown on Exhibit 5, the area covered by the airspace of the Sevier B MOA is roughly 145 miles long and, in the vicinity of the PFSF site, is roughly 12 miles wide.

15. Military air operations in the vicinity of Skull Valley consist of the following:

- U.S. Air Force F-16 fighter aircraft transiting Skull Valley en route from Hill AFB to the UTTR South Area. Some F-16 flights carry military ordnance.
- F-16s from Hill and other military aircraft of various types conducting training exercises on the UTTR.
- F-16s from Hill occasionally returning from the UTTR South Area to Hill via the Moser Recovery Route, which runs to the northeast, 2-3 miles north of the PFSF site.

- Military aircraft, comprising mostly large transport aircraft, flying on military airway IR-420, to and from Michael Army Airfield, located on DPG, about 17 miles southwest of the PFSF.

Aircraft Report at 1.

16. Civilian aircraft flying in the vicinity of Skull Valley consist of the following:

- Aircraft flying on Federal airway J-56, which runs east-northeast and west-southwest about 12 miles north of the PFSF site.[2]
- Aircraft flying on airway V-257, which runs north and south about 20 miles east of the site.
- General aviation activity, which has not been reported but conceivably may occur in the area.

Aircraft Report at 1.

17. We have grouped the aircraft flying in and around Skull Valley that could potentially pose a hazard to the PFSF in the event of an accident as above. We have calculated the annual crash impact probabilities for the PFSF for each group of aircraft and the probability that ordnance carried on a military aircraft (separate from the aircraft itself) would impact the PFSF. The annual crash impact probability that we have calculated is less than 1 E-6/year.

B. F-16 Aircraft Transiting Skull Valley

1. Aircraft Crash Hazard

18. F-16 fighter aircraft fly north to south down Skull Valley, within Sevier B MOA, en route from Hill AFB to the UTTR South Area. The F-16s use the eastern side of Skull Valley as their predominant route of travel and typically pass approximately five miles to the east of the PFSF site. The U.S. Air Force has indicated that the F-16s typi-

[2] Commercial air traffic to and from Salt Lake City International Airport, including business jets, flying through the region around the PFSF is included in the traffic on J-56 and V-257.

cally fly between 3,000 and 4,000 ft. above ground level (AGL), with a minimum altitude of 1,000 ft AGL at approximately 350 to 400 knots indicated airspeed (KIAS). In Fiscal Year 1998, 3,871 such flights passed through Skull Valley. Aircraft Report at 5-6.

19. It is not credible that a crashing F-16 would impact the PFSF. F-16s use the airspace above Skull Valley primarily as a transition corridor to the UTTR. Typically F-16s will start a descent into the low altitude arena (below 5,000 ft. above ground level (AGL)) and spread out in a tactical formation which may be 2-3 nautical miles across. Formations vary depending on the number of aircraft in the flight, meteorological conditions, mission objectives, etc. In addition, the F-16s may accelerate to above 400 KIAS and perform two 90° G-awareness turns. Typical maneuvering in Skull Valley is in the administrative and routine categories, both of which are low risk phases of flight (compared to aggressive maneuvering in restricted areas, which is higher risk) . Furthermore, by far the most likely cause of an accident in Skull Valley would be an engine failure, which would leave the pilot in control of the aircraft. Air Force pilots are instructed to avoid ground facilities in the event of a mishap in which the pilot retains control of the direction of the aircraft. Thus, the pilot of an F-16 that had suffered an engine failure would be able to direct the aircraft away from the PFSF before ejecting. Nevertheless, we calculated the probability that an F-16 transiting Skull Valley would crash and impact the PFSF.

20. We calculated the probability that an F-16 transiting Skull Valley would crash and impact the PFSF using the following equation:

$P = C \times N \times A / w$, where

P = probability per year of an aircraft crashing into the PFSF
C = in-flight crash rate per mile
N = number of flights per year along the airway
A = effective area of the PFSF in square miles
w = width of airway in miles

Aircraft Crash Report at 6-8.

21. To calculate the F-16 impact probability, the Sevier B MOA airspace in the vicinity of the PFSF was treated as an airway with a width of 10 statute miles. Id. at 16. Given the flight characteristics of the F-16, the region within PFSF where the storage casks are located has an effective area of 0.1337 sq. mi., assuming a facility at full capacity with 4,000 spent fuel storage casks on site. Id. at 13-16. The number of normal flights through the valley was taken to be 3,871 per year. Id. at 8. The crash rate for the F-16 flight was calculated from Air Force data to be 2.736 E-8 per mile. Id. at 8-13. We also determined, from an extensive review of Air Force F-16 accident investigation reports over a 10-year period, that over 90 percent of the F-16 crashes that would result from accident-initiating events that could occur in Skull Valley would leave the pilot in control of the aircraft after the event. Id. at 16-18, Tab H.

22. Furthermore, because of the training Air Force pilots receive in responding to such in-flight events, the flight characteristics of the F-16, the absence of other built up areas in Skull Valley, and the small effort required for the pilot to avoid the PFSF site in the event of a crash caused by an accident-initiating event leaving him in control of the aircraft, the pilot would be able to direct the aircraft away from the PFSF at least 95 percent of the time in which such an event caused a crash in Skull Valley. Id. at 18-23. Review of the F-16 accident reports showed a number of instances in which pilots maneuvered their aircraft to avoid sites on the ground after an accident-initiating event. The accident reports showed no cases, however, in which the pilot had control of the aircraft and time but failed to guide his aircraft so as to minimize damage to a facility or populated area on the ground. Therefore, based on this data, the assumption that pilots would fail to avoid the PFSF 5 percent of the time is a very conservative upper bound; the data would support assigning a percentage of near zero. Id. Tab H at 28 n.22.

23. Accordingly, conservatively, 85.5 percent (90% x 95%) of the crashing F-16s would be able to avoid the PFSF. Hence the calculated crash impact hazard to the PFSF would be reduced by this fraction. See id. at 23a-24.

24. Based on the above, the annual crash impact probability for F-16s transiting Skull Valley (assuming a fully loaded facility) was calculated in the Aircraft Report to be 2.05 E-7 based on the 3,871 flights F-16 in Fiscal Year 1998. Id. at 24-25. PFS, however, recently requested and has just received data from Hill AFB on the number of F-16s transiting Skull Valley en route to the south part of the UTTR for Fiscal Years 1999 and 2000. For Fiscal Year 1999, 4,250 F-16s transited Skull Valley and for Fiscal Year 2000, 5,757 F-16s transited Skull Valley.

25. The change in the number of F-16 sorties represents in part normal fluctuations in the number of sorties flown annually as well as certain changes in Air Force operations. In 1998, the Air Force announced a new policy for overseas and other deployments of Air Force units away from their home bases, implemented through the Air Expeditionary Force (AEF) concept. Under the AEF concept, portions of various Air Force squadrons are assigned to an AEF on a regular basis for overseas or other deployment as needed. Under the AEF concept, units are on call for deployment for 90 days over a 15-month period. The purpose is to make more equal and regular the deployment of Air Force units from their home base of operations. The goal is to provide a more stable and predictable operating cycle and control and reduce the amount of time spent away from the home base of operations.

26. Therefore, based on this new data it is appropriate to increase the number of F-16 sorties transiting Skull Valley on an annual basis. The three year average for Fiscal Years 1998-2000 is 4,626 sorties per year. This number may, however, understate the ongoing impact of the AEF concept, introduced in 1998. By the same token, it would not be appropriate to use the Fiscal Year 2000 number by itself. As stated, the AEF is on a 15-month rotation so there will be fluctuations from year to year on this basis alone. Overseas deployments would reduce sortie rates, as fewer aircraft would be at Hill AFB. For example, in 1999 the Air Force deployed a significant number of aircraft to the conflict in Kosovo. In addition, even if the 388th Fighter Wing were not deployed overseas, some of its aircraft might be temporarily deployed to other locations in the United States

to replace units that were sent overseas. The United States was not involved in an international crisis like the Kosovo conflict in FY2000. UTTR sortie rates in future years, in which there was such a crisis, would therefore be expected to be lower than those in FY2000. In these circumstances, we believe that taking into account the recent increases in sorties, an appropriate and reasonable number of F-16 sorties to assume on an annual basis transiting Skull Valley would be an average of the FY1999 and FY2000 numbers, or approximately 5,000.[3]

27. In addition to the F-16s at Hill AFB flying more sorties, in its recent discovery responses, the State claimed that additional F-16s are to be stationed at Hill. The number of authorized F-16s for the 388th Fighter Wing at Hill AFB has been 54 and we have been advised that this number is scheduled to increase by 12 to 66. Further, the 419th reserve wing consisting of 15 authorized F-16s are still stationed, as previously, at Hill AFB. It would be reasonable to assume a proportional increase in the number of sorties resulting from the additional authorization. The total number of authorized aircraft at the base will increase from 69 (54 + 15) to 81 (66 + 15), which is a 17.4% increase.

28. Therefore, the annual number of sorties would increase by 17.4%, from 5,000 to 5,870 to account for the increase in the number of F-16s stationed at Hill AFB. Accordingly "N" in the equation set forth in paragraph 20 above would become 5,870 instead of 3,871. This in turn would increase the annual crash impact probability for F-16s transiting Skull Valley (assuming a fully loaded 4,000 cask facility) to 3.11 E-7. While F-16 sortie rates were higher in FY1999 and FY2000 than they were in FY1998 and FY1999, the Federal Aviation Administration has projected that the number of military flights in the United States overall would not increase in the period from 1998 to

[3] This includes the last year in which there was a significant military operation overseas and the most recent year without one.

2025.[4] Therefore, we would not expect the sortie rate at Hill AFB or on the UTTR to increase significantly beyond the FY1999 and FY2000 rate.[5]

2. Jettisoned Ordnance Hazard

a. Direct Impact

29. The U.S. Air Force has specifically stated that "no aircraft flying over Skull Valley are allowed to have their armament switches in a release capable mode. All switches are "SAFE" until inside DOD land boundaries." Aircraft Report at 77. The Air Force has also stated that "the UTTR has not experienced an unanticipated munitions release outside of designated launch/drop/shoot boxes" Id. During FY 1998 there were 13,367 total sorties in the UTTR with 5,083 in the North and 8,284 in the South; in earlier years, during the Cold War, the sortie rate was higher; e.g., 27,000 sorties were flown on the UTTR in FY1988. Id. All were accomplished with obviously no inadvertent munitions releases outside of designated launch/drop/shoot boxes. Consequently, the likelihood or probability of an inadvertent weapons release from F-16s flying over Skull Valley impacting or affecting the PFSF is as a practical matter zero.

30. We did calculate, however, a probability for ordnance jettisoned from a crashing F-16 in Skull Valley that could potentially impact the PFSF. Aircraft Report at 79-83. Some of the F-16 flights through Skull Valley carry ordnance (live or inert). In the event of an incident leading to a crash in which the pilot would have time to respond before ejecting from the aircraft (e.g., an engine failure), one of the pilot's first actions would be to jettison any ordnance carried by the aircraft. Id. at 79. We used an approach

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[4] Federal Aviation Administration, Office of Aviation Policy and Plans, FAA Long-Range Forecasts, Fiscal Years 2015, 2020, and 2025, FAA-APO-99-5 (June 1999).

[5] As an excursion, PFShas examined the use of the FY2000 count of 5757 F-16 sorties in Skull Valley as the norm and adjusted it upward by 17.4% to 6759 sorties as the new steady state rate. While we do not believe this rate is likely to be the steady state rate, using it increases the Skull Valley F-16 impact probability from 3.11×10^{-7} to 3.58×10^{-7}, and the Jettisoned Military Ordnance probability from 1.49×10^{-7} to 1.71×10^{-7}. Adjusting the Moser Recovery probability by its same factor brings it upfront 2.00×10^{-8} to 2.30×10^{-8}. This is not significant in the total calculation.

similar to the approach described above for calculating the aircraft impact probability to calculate the probability that jettisoned ordnance would impact the PFSF. See id. at 79-82. Specifically, we calculated the probability, P, that the ordnance would impact the PFSF using the equation $P = N \times C \times e \times A/w$, as described in the paragraph below. Id.

31. The fraction of the 3,871 F-16s transiting Skull Valley per year that would be carrying ordnance that could be jettisoned was determined from data provided by Hill AFB to be 11.8 percent. Id. at 82. Thus the number of aircraft carrying live or inert ordnance through Skull Valley per year, N in the equation above, would be 457. See id. The crash rate for the F-16s, C, was taken to be 2.736 E-8 per mile, as above. Id. Nonetheless, the pilot was assumed to jettison ordnance in only 90 percent of all crashes, the fraction of the crashes, e, assumed to be attributable to engine failure or some other event leaving him in control of the aircraft (in crashes attributable to other causes it was assumed that the pilot would eject quickly and would not jettison ordnance). Id. Skull Valley was treated as an airway with a width, w, of 10 statute miles.

32. As with the calculation for F-16s transiting Skull Valley, we conservatively assumed that the F-16s are uniformly distributed across the 10 miles, despite the fact that their predominant route of flight is down the eastern side of the valley. The area of the PFSF, from the perspective of ordnance jettisoned from an aircraft flying from north to south over the site, A, was taken to be the product of the width and the depth of the cask storage area (assuming a full facility with 4,000 casks) plus the product of the width and depth of the canister transfer building, in that pieces of ordnance are small relative to an aircraft and impact the ground at a steep angle. Id. at 80 & n.82, 82. Thus, the area of the PFSF was calculated to be 0.08763 sq. mi. Id. at 82. Therefore, using the equation $P = N \times C \times e \times A/w$, the probability that jettisoned ordnance would impact the PFSF is calculated as follows:

$$P = 457 \times 2.736\text{ E-8} \times 0.90 \times 0.08763 / 10 = 9.85\text{ E-8}$$

Id. at 82-83.

33. If we assume that the number of sorties carrying ordnance through Skull Valley would increase in proportion to the total increase in sorties due to greater usage of the UTTR and an increase in the number of aircraft at Hill AFB, then this probability would increase by a factor of 5,870/3,871, or 1.516. Therefore, the new probability would be 1.49 E-7.

b. Near Impact and Explosion

34. In addition to the potential hazard posed by direct impacts of crashing aircraft and jettisoned ordnance, we also calculated the hazard to the PFSF posed by jettisoned live ordnance that might land near the facility and explode on impact, as well as the hazard posed by a potential explosion of live ordnance carried aboard a crashing aircraft that might impact the ground near the PFSF. Aircraft Report at 83a-83l. At the outset, as stated above, Air Force pilots do not arm the live ordnance they are carrying while transiting Skull Valley near the PFSF. Id. at 83a. Furthermore, the U.S. Air Force has indicated that the likelihood that unarmed live ordnance would explode when impacting the ground after being jettisoned is "remote" and the Air Force has no records of such incidents in the last 10 years. Id. at 83b, Tab Q. Thus, it is highly unlikely that jettisoned live ordnance or live ordnance carried aboard a crashing aircraft that did not directly impact the PFSF would damage the facility.

35. Nevertheless, to calculate a numerical hazard to the facility, we assumed that such ordnance would have a 1 percent chance of exploding and assessed that damage to the PFSF that would result if an explosion occurred close enough so that the blast overpressure would damage a storage cask or the Canister Transfer Building, without hitting either one. Id. at 83g-83i. The explosive overpressure limit for a storage cask was taken to be 10 psi. Id. at 83b-83c. The limit for the Canister Transfer Building was taken to be 1.5 psi. Id. at 83c. We assumed that the ordnance in question was a 2,000 lb. bomb, the largest single piece of ordnance carried by the F-16s that transit Skull Valley. Id. at 81, 83j. Based on information provided by Hill AFB, approximately 193 F-16s transited Skull Valley in 1998 with live ordnance. Id. at 83h. We calculated the prob-

ability that an F-16 carrying live ordnance would jettison the ordnance so as to impact near the PFSF, or crash near the PFSF without jettisoning the ordnance, following the same method we used to calculate the probability that an F-16 would crash and impact the facility. The results of our final calculation showed that the annual probability that a storage cask or the Canister Transfer Building would be damaged by an explosion of live ordnance jettisoned from a crashing aircraft or carried aboard a crashing aircraft that impacted the ground near the PFSF was equal to 2.43 E-10. Id. at 83k-83l. This is exceedingly low and is insignificant relative to the other aircraft crash and jettisoned ordnance impact hazards calculated for the PFSF. Even if the probability is increased to reflect additional sorties transiting Skull Valley, it remains negligible.

C. Aircraft Conducting Training on the UTTR

36. According to the Air Force, 8,284 sorties were flown over the UTTR South Area in 1998. Aircraft Report at 28. Those aircraft conducted a variety of activities, including air-to-air combat training, air-to-ground attack training, air-refueling training, and transportation to and from Michael Army Airfield (which is located beneath UTTR airspace). Id. at 29. Hazards posed by aircraft flying to and from Michael Army Airfield on Dugway are addressed separately below.

1. Potential Aircraft Impacts

37. Aircraft conducting air-to-ground attack training do so over targets that are located more than 20 miles from the PFSF site and aircraft conducting air refueling training do so on the far western side of the UTTR, over 50 miles from the site. Id. at 29-32. Thus, by virtue of their distance from the PFSF, such aircraft do not pose a crash impact hazard to the facility. Id. Fighter aircraft conducting air to air combat training conduct their aggressive, higher risk maneuvering toward the center of the restricted areas on the UTTR, well over 10 miles from the PFSF. Thus, as a practical matter, those aircraft also do not pose a crash impact hazard to the facility. Nevertheless, we calculated a conservative upper bound probability that fighter aircraft conducting air to air combat training on the UTTR would crash and impact the PFSF.

38. The Air Force indicated 6,360 fighter sorties were flown on the UTTR South Area in 1998 and one-third, or approximately 2,120, involved fighter aircraft conducting air-to-air training. Aircraft Report at 34.

39. The crash impact probability for fighter aircraft conducting air-to-air training on the UTTR was calculated as follows:

$P = C_a \times A_c \times A/A_p \times R$, where

P = annual crash impact probability
C_a = total air-to-air training crash rate per square mile on the UTTR
A_c = the area of the UTTR from which aircraft could credibly impact the PFSF in the event of a crash
A = effective area of the PFSF in square miles
A_p = the footprint area, in which a disabled aircraft could possibly hit the ground in the event of a crash
R = the probability that the pilot of a crashing aircraft would be able to take action to avoid hitting the PFSF

Aircraft Report at 32-33.

40. The total air-to-air training crash rate per square mile on the UTTR, C_a, was calculated from the total number of hours flown in air-to-air training on the UTTR South Area (2,468), the crash rate per hour for fighter aircraft (the F-16) in combat training (3.96 E-5), the distribution of air operations over the sectors of the UTTR nearest the PFSF, and the ground areas of those sectors. Aircraft Report at 34a-37d. As with the F-16s transiting Skull Valley, 95 percent of the crashes on the UTTR attributable to engine failure or some other cause leaving the pilot in control of the aircraft were determined not to pose a hazard to the PFSF, in that the pilot would retain control of the aircraft and would be able to avoid the site. Id. at 42-43. Based on Air Force data, 45 percent of all F-16 crashes occurring during combat training are attributable to engine failure; thus the factor R in the equation above was calculated to be 1-(45% x 95%), or 0.573. Id.

41. The area from which an aircraft could credibly impact the PFSF in the event of a crash, A_c, was taken to be the portion of the UTTR within 10 miles of the PFSF and outside a three-mile buffer zone assumed to exist on the edge of the UTTR restricted

areas. Id. at 37d-39c. A crashing aircraft more than 10 miles from the PFSF would have to be under control of the pilot in order to glide and reach the site, and the pilot would guide any such aircraft away from the site, which is outside the land boundaries and the restricted airspace of the UTTR. Id. at 37d-39. The buffer zone represents the fact that aircraft rarely fly within three miles of the edges of the restricted areas while conducting training on the UTTR. Id. at 37c-37d, 39. For the purposes of calculation, potential aircraft crashes during air to air combat training were assumed to be evenly distributed over the restricted areas in which the training takes place, outside the buffer zone. This is conservative, in that the aggressive maneuvering, that leads to most mishaps and by far the most mishaps in which the pilot does not retain control of the aircraft, occurs toward the center of the restricted areas, not toward the edges. Hence, most UTTR accidents that would theoretically pose an impact hazard to the PFSF would actually occur too far away for the aircraft to reach the facility. See id. Tab Y.

42. The site effective area, A, was determined as above for a facility at a full capacity of 4,000 storage casks. Id. at 40. The footprint area, A_p, was calculated by assuming that a crashing aircraft could glide in any direction up to a distance equal to the product of its starting altitude above ground and its glide ratio. Id. Accordingly, the aircraft conducting air-to-air training over the UTTR were divided into altitude bands and an impact probability calculated for each band. Id. at 39-42. Aircraft too low to glide to the PFSF in the event of a mishap were calculated not to contribute to the crash impact hazard, in that they would have no chance of reaching the site. Id. at 39a-39b.

43. The maximum annual air crash impact probability for aircraft conducting air-to-air training on the UTTR South Area was calculated from the sum of impact probabilities of the altitude bands to be 7.35 E-8. Id. at 43-43a. If we assume that the total number of fighter sorties on the UTTR would increase in proportion to the increase in F-16 sorties flown from Hill AFB (which is conservative, since not all fighter aircraft that fly on the UTTR are F-16s based at Hill), then this probability would increase by a factor of 1.516, to a probability of 1.11 E-7.

44. Nevertheless, as discussed above, this result is highly conservative, in that the crashes on the UTTR that would leave the pilot without control of the aircraft and the ability to avoid the PFSF would occur toward the center of the restricted area ranges, far from the site. Moreover, while it might be possible for an aircraft to glide 10 miles after an in-flight mishap, it is highly unlikely that a pilot experiencing such a mishap that far from the PFSF would fail to turn his aircraft away from it before ejecting. As the Aircraft Report shows, if it is assumed that a crashing aircraft from the UTTR would glide no more than five miles toward the PFSF, then the hazard posed to the PFSF by UTTR operations would be zero. Id. at 44. Therefore, as a practical matter, the risk to the PFSF from aircraft conducting training on the UTTR is negligible. Indeed, State of Utah witness Lt. Col. Horstman agreed that "if an airplane has a problem up there [on the UTTR], it's not going to make it to Skull Valley, it's going to go to Michael [Army Airfield] or it's going to crash before it gets there, it's that simple." Horstman Dep. at 218.[6]

2. Weapons Use on the UTTR

45. Military aircraft conduct air-to-ground attack training and weapons testing using air-delivered ordnance on the UTTR South Area. Nevertheless, the use of air-delivered ordnance on the UTTR does not pose a potential hazard to the PFSF. See Aircraft Report at 30-32, 76-77. The PFSF site is located to the east of the easternmost land boundary of the range and over 20 miles from the nearest target for air-delivered ordnance on the UTTR. Id. at 28, 30. Weapons use on the UTTR is strictly controlled and, as stated above, the UTTR has never experienced an unanticipated munitions release outside of designated launch/release areas. Id. at 77. Master Arm switches are not actually armed until the aircraft are on the ranges within the UTTR where the bombs are to be dropped. Id. All armament switches are on "safe" until the aircraft are inside DOD land boundaries. Id. Furthermore, the targets on the UTTR are all over 20 miles from the PFSF site and there are no run-in headings for weapons delivery over the Skull Valley

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[6] Lt. Col. Hugh Horstman, USAF (Ret.) was named by the State as an expert witness on Contention Utah K.

area. Id. at 30, 76-77. Therefore, weapons use on the UTTR does not pose a hazard to the PFSF.

D. Aircraft Flying on the Moser Recovery

46. Most of the F-16s returning to Hill AFB from the UTTR South Area exit the northern edge of the range (away from the PFSF) in coordination with air traffic control. However, some aircraft returning to Hill from the UTTR South Area may use the Moser recovery route, which runs from the southwest to the northeast, approximately two miles from the PFSF site. Aircraft Report at 48. The Moser route is only used during marginal weather conditions or at night under specific wind conditions which require the use of Runway 32 at Hill AFB. Id. at 48-48a. Based on information from local air traffic controllers, conservatively estimated, the Moser recovery is used by less than five percent of the aircraft returning to Hill. Id. at 48a-49. Indeed, Lt. Col. Horstman stated that Moser was not used at all in 1998. Horstman Dep. at 189-90. He knew of only four flights that used Moser in 1999. Id. at 189. According to the Air Force, 5,726 F-16 sorties were flown on the UTTR South Area in FY98, almost all of which flew from Hill AFB (not all aircraft transit Skull Valley en route to the South Area). Thus, at the very most, fewer than 286 aircraft per year (5% x 5,726) would use the Moser recovery on their return flights. Id. at 49.

47. The average annual crash impact probability for aircraft flying the Moser recovery was calculated using the same method used for calculating the hazard from F-16 flights through Skull Valley. Aircraft Report at 49. The Moser recovery is defined as an airway with a width, *w*, of 10 nautical miles (11.5 statute miles) (equal to the width of military airway IR-420). Id. The number of aircraft, *N*, is very conservatively taken to be 286; the crash probability, *C*, is equal to 2.736 E-8 per mile; the effective area of the site is 0.1337 mi^2; and it is calculated that 85.5 percent of all crashes would be attributable to events leaving the pilot in control of the aircraft, in which the pilot could direct the aircraft away from the PFSF. Id. at 49-49b. Thus, the annual crash impact probability is conservatively estimated to be 1.32 E-8. Id. at 49. If this probability is increased to

reflect the additional sorties flown by F-16s from Hill AFB, it would increase by a factor of 1.516 to 2.00 E-8. But as discussed, PFS's estimate of the number of flights on the Moser recovery was very conservative to begin with.

E. Aircraft Flying to and from Michael AAF on IR-420

48. Michael Army Airfield is located on Dugway Proving Ground, 17 statute miles south-southwest of the PFSF. Aircraft Report at 56. This military airfield has a 13,125 foot runway, and can accommodate all operative aircraft in the Department of Defense inventory, although the majority of the aircraft flying to and from Michael AAF are large cargo aircraft such as the C-5, C-17, and C-141. Id. at 51. The airspace over the Dugway Proving Ground is restricted. Military airway IR-420 terminates north of the PFSF site; aircraft using IR-420 and flying to and from Michael AAF pass in proximity to the site. Id. at 51. The same method used to calculate the hazard to the PFSF from F-16s transiting Skull Valley was used to estimate the probability of an aircraft impacting the PFSF from this airway. Id.

49. NUREG-0800 provides an in-flight crash rate of 4 E-10 per mile for large commercial aircraft, which is appropriate to apply to the types of aircraft flying to and from Michael AAF. Aircraft Report at 51-53. Information provided to PFS by Dugway Proving Ground in 1997 stated that there are approximately 414 flights annually at this airfield. Id. at 55. The effective area of the PFSF is 0.2116 mi^2, calculated for the types of aircraft flying to and from Michael AAF, using the same method as was used to calculate the effective area of the PFSF for an F-16 above. Id. at 53a-54. The width of the airway is 10 nautical miles (nm), or 11.5 statute miles. Id. at 55. The probability of an aircraft impacting the PFSF is therefore 3.0 E-9 per year. Id. Takeoff and landing operations at Michael AAF would pose a negligible hazard to the PFSF because the airfield is over 17 miles from the PFSF. Id. at 56-60. This probability would not increase because of the additional F-16 sorties from Hill AFB, in that the aircraft flying to and from Michael in the direction of IR-420 are not F-16s from Hill.

F. Civilian Aircraft on Airways J-56 and V-257 Including Aircraft Flying to and from Salt Lake City International Airport

50. Airway J-56 runs west-southwest and east-northeast 11.5 statute miles north of the PFSF. Aircraft Report at 62. Airway V-257 runs north and south 19.5 statue miles east of the PFSF. Id. at 66. Traffic on J-56 and V-257 consists of commercial airliners and private business jets, including the traffic to and from Salt Lake City International Airport. Id. at 62, 66. The same method used to calculate the hazard to the PFSF from F-16s transiting Skull Valley was used to estimate the probability of an aircraft impacting the PFSF from both of these airways. Id. at 62, 66.

51. NUREG-0800 provides an in-flight crash rate of 4 E-10 per mile for large commercial aircraft, which is appropriate to apply to the types of aircraft flying on the airways. Aircraft Report at 65. Regional air traffic controllers have stated that fewer than 12 aircraft per day transit each airway. Id. at 62, 66. The effective area of the PFSF is 0.2116 mi^2, calculated for large commercial airliners, using the same method as was used to calculate the effective area of the PFSF for an F-16 above. Id. at 62-65. J-56 is eight nautical miles wide; V-257 is 12 nautical miles wide. Id. at 62, 66. The total probability that an aircraft flying on J-56 or V-257 would crash and impact the PFSF is therefore 3.1 E-8 per year. Id. at 65-66.

52. Takeoff and landing operations at Salt Lake City airport, which is approximately 50 miles from the PFSF, would pose no hazard to the facility. First, takeoff and landing hazards at a commercial airport generally extend out to no more than 10 miles from the end of the runway in question. See Aircraft Report at 56-60 (similar analysis for Michael Army Airfield). Second, using the method of NUREG-0800 to determine the magnitude of takeoff and landing hazards on the basis of distance from the airport and the annual number of operations there, we have shown that the risk to the PFSF is negligible. The risk posed by takeoffs and landings at an airport is insignificant and need not be considered if the number of takeoffs and landings per year is less than 1,000 x D^2, where D is the distance from the airport to the facility in question in miles.

NUREG-0800 § 3.5.1.6. In 1998, there were 365,000 takeoffs and landings at Salt Lake City airport.[7] To pose a significant hazard to the PFSF, there would have to be 2,500,000 takeoffs and landings at Salt Lake City (1,000 x 50^2). Therefore, the hazard to the PFSF posed by takeoffs and landings at Salt Lake City is insignificant. Furthermore, the FAA anticipates that the annual number of takeoffs and landings at Salt Lake City will increase by 53.1 percent, to 558,500, from fiscal year 1999 to fiscal year 2013.[8] If that is extrapolated for another 14 years, to FY2027, beyond the 20-year license term of the PFSF, the number of takeoffs and landings at Salt Lake City would be 855,000, still far less than 2,500,000. Thus, the hazard to the PFSF would remain insignificant.

G. General Aviation

53. The general aviation traffic over Skull Valley is negligible and thus general aviation would not pose a significant hazard to the PFSF. Aircraft Report at 67-73. There are no civilian airports within 25 miles of the PFSF. Id. at 70. The PFSF is located in a sparsely populated area, inside a military operating area (MOA) in which IFR flight by civilian aircraft is restricted while the MOA is being used by the Air Force (and which is avoided by general aviation pilots because of the military operations being conducted within the MOA). Id. at 67. Thus, the general aviation traffic over Skull Valley is negligible; in fact F-16 pilots who have flown from Hill AFB through Skull Valley, including Col. Fly, indicate never having seen general aviation traffic there. Id. at 67-68. Indeed, State of Utah witness Lt. Col. Hugh Horstman, who also flew F-16s over Skull Valley agreed that the general aviation traffic there was "minimal." Horstman Dep. at 220-21.[9] Therefore, it is highly unlikely that a general aviation aircraft would crash into the PFSF.

54. Nevertheless, we calculated a highly conservative upper bound on the crash impact probability for general aviation aircraft using National Transportation Safety

[7] Federal Aviation Administration, FAA Administrator's Handbook (Mar. 1999) at 12.

[8] Federal Aviation Administration, 1999 Aviation Capacity Enhancement Plan (2000) at A-8.

[9] Deposition of Lt. Col. Hugh Horstman (Dec. 11, 2000) ("Horstman Dep.").

Board (NTSB) crash data and the population of general aviation aircraft in the state of Utah. See Aircraft Report at 69-73. The crash impact probability is equal to C_a x A, where C_a is the crash rate per square mile and A is the effective area of the PFSF. Id. at 70a-71. In 1995, the 182,600 general aviation aircraft in the United States suffered 412 fatal accidents. Id. at 69-70. There are 1,218 general aviation aircraft in the state of Utah, which covers an area of 84,094 mi^2. Id. at 69. FAA crash data indicate, however, that only 15 percent of all general aviation crashes occur during the cruise mode of flight, which, because there are no airports nearby, is the mode in which general aviation aircraft would be flying near the PFSF. Id. at 70. Furthermore, business jets experience 7.85 percent of all general aviation fatal crashes and they can be excluded from this calculation, in that they fly mostly on federal airways. Id. The effective area of the PFSF with respect to general aviation aircraft crashes is 0.1173 mi^2 (assuming a fully loaded facility with 4,000 casks). Id. at 68-69. Accordingly, the average annual crash impact probability for general aviation aircraft is 5.25 E-7. Id. at 71.

55. Despite the calculated impact probability, however, the crash impact hazard to the PFSF from general aviation is, as a practical matter, zero because the spent fuel storage casks would be able to withstand the crash impact of the general aviation aircraft that might be found in Skull Valley. First, fifty-five percent of all general aviation aircraft are single-engine piston types weighing less than 3,500 lbs. Id. at 71. Such aircraft typically fly at speeds under 130 knots (150 mph). During a power off glide during a forced landing, which would be the most likely crash scenario at the PFSF, the airspeed is normally well below 100 knots (114 mph). See id. at 71a-72. Therefore, the impact of such aircraft at the PFSF would be bounded by the design basis tornado missile impact for the PFSF, an automobile weighing 1800 kg (3,968 lbs.) moving at a speed of 126 mph. PFSF SAR at 8.2-17. Thus, the impact of such light general aviation aircraft would not cause a radioactive release from a storage cask. Therefore, the calculated general aviation crash impact hazard to the PFSF can be reduced by 55 percent to 2.36 E-7. Id. at 72. As stated above, however, even this probability is highly conservative given PFS's

use of a state-wide average crash rate when the level of general aviation traffic in Skull Valley is negligible.

56. Second, a more detailed assessment of the ability of a crashing general aviation aircraft to penetrate the storage casks that would be used at the PFSF shows that such aircraft would not penetrate the casks and thus would not cause a release of radioactive material from the PFSF. See Declaration of Jeffrey R. Johns (Dec. 27, 2000). In that calculation, PFS shows that a crash of a general aviation aircraft with a weight of 12,500 lbs. or less (which would be those aircraft other than jets, which as noted above, would fly on federal airways rather than through the Sevier B MOA and Skull Valley) would not penetrate a storage cask. The calculation is based on the penetration capability of the aircraft engine with the greatest kinetic energy at impact. The calculation conservatively assumes, moreover, that an engine weighing 800 lbs. (the heaviest engine) could have a diameter as small as 12 inches. In fact, based on discussions with the General Aviation Manufacturers Association, a general aviation aircraft engine weighing 800 lbs. would have a rough diameter of approximately 35 inches. Thus, the penetration calculation is very conservative. Because the calculation shows that a crashing general aviation aircraft would not penetrate a storage cask at the PFSF (in addition to the traffic level being negligible), the hazard to the PFSF from general aviation aircraft accidents may be taken to be zero.[10]

H. Cumulative Hazard to the PFSF from Aircraft Accidents

57. Summing the aircraft impact probabilities from the potential aviation accidents assessed above, including potential impacts of jettisoned ordnance, the cumulative hazard to the PFSF is 6.25 E-7/year, which is below the applicable risk standard. Therefore, potential aircraft accidents do not pose an unacceptable hazard to the PFSF.

58. The results of our assessment are tabulated below.

[10] This calculation was performed after the publication of the Aircraft Report and this was not included in it.

Calculated Aircraft Crash Impact Probabilities	
Aircraft	**Annual Probability**
Skull Valley F-16s	3.11×10^{-7}
UTTR Aircraft	1.11×10^{-7}
Aircraft Using the Moser Recovery	2.00×10^{-8}
Aircraft on Airway IR-420	3.0×10^{-9}
Aircraft on Airway J-56	1.9×10^{-8}
Aircraft on Airway V-257	1.2×10^{-8}
General Aviation Aircraft	0
Cumulative Crash Probability	4.76×10^{-7}
Jettisoned Military Ordnance	1.49×10^{-7}
Cumulative Hazard	6.25×10^{-7}

IV. RESPONSES TO CRITICISMS OF THE STATE OF UTAH

59. In recent responses to PFS discovery requests, the State of Utah asserted that PFS's assessment of the probability that an aircraft would crash and impact the PFSF was deficient in some respects.[11] Specifically, the State claimed that first, additional F-16 aircraft will be stationed at Hill AFB and hence the number of sorties flown over Skull Valley and on the UTTR will be higher than what PFS assumed. Second, PFS assertedly used a crash rate that was too low for Skull Valley and UTTR military flight operations, in that 1) the F-16 will begin to experience a higher crash rate in the future as it gets older, due to an asserted "bathtub effect" in aircraft crash rates and 2) the F-16 will be replaced by a new aircraft sometime in the next 40 years and new aircraft typically have high crash rates. Third, the State claims that PFS incorrectly assumes a random distribu-

[11] State of Utah's Supplemental Response to Applicant's First Set of Discovery Requests for Contention Utah K (Dec. 5, 2000); see also Memorandum from Matt Lamb and Marvin Resnikoff to Hugh Horstman (Dec. 5, 2000) ("Lamb/Resnikoff Memo"), attached as Exhibit 9.

tion of flights through Skull Valley, in that if the PFSF is built, F-16 pilots will aim at the facility in order to calibrate their instruments before entering the restricted areas on the UTTR. Fourth, the State asserts that PFS overestimates a pilot's ability to avoid the PFSF in the event of a mishap leaving the pilot in control of the aircraft, in that 1) PFS does not account for variations in pilot experience and 2) bad weather may obscure the PFSF from the view of the pilot and hence impede his ability to guide his aircraft away from the site before ejecting. PFS responds to all of the State's claims here.

A. Additional F-16 Aircraft and Sorties

60. PFS has addressed the additional aircraft that will be stationed at Hill AFB above, in the section in which PFS describes its calculation of the aircraft crash hazard to the PFSF. PFS has also addressed the additional sorties that the F-16s currently stationed at Hill flew in FY99 and FY00. PFS assumed that the total sorties (adjusted to reflect FY99 and FY00 operational levels) would increase proportionally to the increase in the number of F-16s at the base. The effect of this are included in 58 above.

B. Skull Valley and UTTR Crash Rates

1. F-16 Crash Rates and the "Bathtub Effect"

61. The State of Utah asserts that a "bathtub effect" is exhibited by aircraft accident statistics that show that in the life cycle of an aircraft model (e.g., F-16), high accident rates are seen as the aircraft is introduced. Horstman Dep. at 75-77. As pilot and maintenance experience are gained and problems are fixed, the accident rate decreases for most of the life of the aircraft model, then increases again as the aircraft reaches the end of its life cycle because of mechanical fatigue and aging. This argument is allegedly buttressed by the observation that the F-16 accident rate for FY-99 increased. Purportedly, this presages increased accident rates in the future for the F-16.

62. This assertion, insofar at least as the F-16 is concerned, is without basis for the following reasons. First, the F-16 Class A mishap accident rate for FY-2000 has

actually decreased to 2.63 per 100,000 flight hours[12] compared to a rate of 5.11 per 100,000 hours for FY-99. It is also significantly (28%) below the FY-99 10 year average rate of 3.67 per 100,000 hours.[13] Therefore, taking the one-year FY-99 numbers as a trend would be seriously misleading. The best way to understand these accident statistics is to take a multi-year average. Three-year, 5-year and 10-year averages progressively dampen single year fluctuations. The shorter the average, the more variability there is and the more likely one is to mistake a short term aberration for a trend. As discussed in the Aircraft Crash Report (p. 11), a 5 or 10-year rate is most useful. Both the 5-year and 10-year averages show a level or steadily decreasing accident rate over the life of the F-16, even with the FY-99 figures. A graph of those averages is attached as Exhibit 8. Adding the FY-00 numbers would bring the averages down more.

63. Second, accident rates are decreasing for the total Air Force aircraft inventory as well as for the F-16 because of better maintenance, parts control, improved inspections, built-in tests and fault reporting, better pilot training and other improvements. Air Force commanders are focused on safety and will routinely reallocate resources to reduce and manage risk. According to the Air Force Chief of Safety, the Air Force experienced its lowest accident rate ever in FY2000.[14] The broad trend is illustrated by Figure 2 in the Aircraft Crash Report (behind p. 9), which shows that accident rates for Air Force single engine fighter aircraft have decreased greatly over the past 50 years. There is no reason to believe that the trend will not continue into the future.

64. Third, a study of aircraft accident rates on other fighter aircraft that have been phased out of the inventory within the last 20 years does not show a rise at the end of their lives. There are some anomalies in rates towards the very end of the life cycle of

[12] Curt Lewis, American Airlines Flight Safety, www.aasafety.com. Flight Safety Information (03NOV00-254), attached as Exhibit 6. American Airlines distributes articles in the press concerning aviation safety to the aviation industry.

[13] Air Force Safety Center F-16 statistics, as of January 10, 2000. Exhibit 7.

[14] Secretary of the Air Force, Public Affairs, News Release (Oct. 3, 2000).

some aircraft, where a single Class A mishap causes a large spike in the rate. This is because the number of flying hours has decreased drastically from the norm because of the sharply decreased number of aircraft remaining in the inventory. This causes a large rate change based on a single accident. This does not mean that aircraft are falling out of the sky everywhere. It only means that there are only a few aircraft of that model still flying. The risk to a facility on the ground is actually decreasing since the total number of aircraft flying, the number of sorties, the number of flight hours and the number of accidents are all decreasing.

65. The aircraft that have been phased out of the active inventory most recently are the F-111 (FY98); the F-106 (FY97); and the F-4. The F-4 is still flying a small number of hours (4,306 in FY99) but is essentially phased out. All of these aircraft exhibit the trends of decreasing or level accident rates relative to the mid-life rates except when flying hours are very low. The F-106 (Exhibit 10) is a good example of the effect of an accident when there are only a few aircraft flying and flying hours are low. The F-106 began phase-out in 1984 and most were gone by 1988. Rates (but not accidents) for that aircraft skyrocketed in its last years after 1990, but it was flying less than 100 hours in each of those years. In several cases for the F-106, e.g., in FY1992 and FY1995, the rolling average rates rose even when there were no accidents, because of the fewer number of hours being added to the denominator of the moving average equation to replace larger numbers from earlier years. Exhibits 9 through 11 show the number of flight hours and the 5-year and 10-year average crash rates for the F-111, the F-106, and the F-4, respectively.

66. Looking specifically at flying hour and accident statistics for the F-16A model, the first model of the F-16 introduced to the Air Force and therefore the oldest of the F-16s, it is apparent that most of them have been retired. As may be seen on the charts attached as Exhibit 12, flying hours were at a peak of about 170,000 hours per year in the FY 1984 to FY 1988 time frame, then have steadily decreased to about 20,000 hours in FY 1999. This indicates about a 90% decrease in the inventory of F-16A aircraft

as they are being phased out. Despite this, the accident rate has steadily gone down. Therefore, there is no reason to expect F-16 accident rates to increase in the future.

67. This observation is confirmed by statistics for the F-15A, which was also the first model of the F-15. It is the oldest of the F-15s and like the F-16A, is being phased out of the inventory. As shown in the charts attached as Exhibit 13, the F-15A flew in the neighborhood of 65,000 to 75,000 hours per year between 1980 and 1992, but it has now dropped to about 20,000 hours per year for the last 5 years, indicating about a 70% drop in the inventory of F-15A aircraft. Despite this, the number of destroyed aircraft has been 0 or 1 each year since 1987, and the accident rates show a commensurate decrease from the earlier mid-life years. (Again, the 5 year rate is showing a gradual increase, even in years when there were no accidents, because of the small number phenomenon explained in Para 65 above. The 10 year rate continued its general decrease or leveling off from the mid-life rates.)

68. For all of the above reasons, the 10-year average accurately represents what one should expect the rates to be in the future. Therefore, PFS does not need to change the accident rates for the F-16 used in its assessment.

2. Replacement of the F-16

69. The State of Utah also asserts that the introduction of a new fighter aircraft is always accompanied by a high accident rate as the aircraft comes into the inventory and is only decreased as the bugs are worked out of the system and the pilots learn its characteristics. State Dec. 5 Disc. at 4; Lamb/Resnikoff Memo at 2. Thus, the State claims that the new F-22 will be a greater hazard to the PFSF than the F-16 if it is assigned to Hill AFB as a replacement for the F-16 in the future.

70. Relatively higher fighter accident rates upon introduction to initial service were the case in the past, even with the F-16, which was first delivered to the active inventory in 1978. However, it should be emphasized that the actual initial accident rates have been generally declining. As demonstrated by Figure 2 in the Aircraft Crash Re-

port, behind page 9, initial accident rates (first spikes) have decreased significantly since the F-86 was introduced in 1950. Other aircraft introduced into the inventory in the last 30 years are the F-15 (FY74) and the A-10 (FY75). If plotted on the same Figure 2, the F-15 rate would be 10.14 and the A-10 rate would be 9.27, both below the initial F-16 rate. All of these aircraft were introduced over 20 years ago, with design technology which is now 25 to 30 years old. A further reduction in introduction accident rates is to be expected due to increased skill in designing aircraft with computer modeling and to large scale use of high fidelity simulator training for pilots so that they already know the characteristics of the aircraft before they fly. As well, the aircraft control systems and instrumentation have also improved markedly over the recent years with advances in electronics and computer power. (The F-117 stealth fighter was introduced into the inventory in 1982 but accident data on its early years is still classified and unavailable).

71. There is therefore no reason to expect that the newest computer designed aircraft, the F-22, would not be safer than the F-16 during its introduction and throughout its total life cycle, continuing a trend in fighter aircraft. Moreover, the F-22 is a twin-engine aircraft. As such, because engine failure is a significant cause of aircraft accidents, the F-22 accident rate will likely be even lower than what would be suggested by the use of modern technology in its design and construction, discussed above. Indeed, a comparison of F-16 (single engine) and F-15 (twin engine) accident rates shows that over the last 10 years, the F-15 rate has been only 50.3 percent of the F-16 rate. See Horstman Dep. at 85.

72. Finally, it is unclear that the F-22 would be a replacement for the F-16 or that it would be stationed at Hill AFB. The F-22 is specifically intended to be an air superiority fighter that would replace the F-15 and there are no F-15s stationed at Hill AFB. Horstman Dep. at 84. Moreover, the Air Force has not yet decided how many F-

22's to buy nor where to station them.[15] One informed source (Air Force Magazine, Journal of the Air Force Association, May 2000) states that Langley AFB, Virginia is the preferred F-22 unit location. The October 2000 issue states that the Air Force F-22 training will be accomplished at Tyndall AFB, Florida with 2 F-22 squadrons. So any argument about the F-22, or some other future aircraft (e.g., the Joint Strike Fighter) coming to Hill AFB and experiencing higher crash rates is highly speculative at this point.[16]

C. Distribution of F-16 Flights in Skull Valley

73. The State has raised an attractive nuisance argument concerning the proposed PFS facility. The State argues that F-16 pilots transiting Skull Valley will all point at the PFSF site sometime during their transit through the valley to update their sensors,[17] use it as a navigation turn point or maintain their prescribed position relative to other aircraft in their flight[18]. Because the F-16 pilots will point at the PFSF at some point in time, the State claims, the risk to the facility from a crash will increase. The State essentially asserts that if the facility is built, the predominant flight paths and activities which currently take place in Skull Valley will be fundamentally changed and therefore the PFS analysis no longer accurately reflects the potential risk proposed by military aviation.

74. The State fails to recognize key points in the PFS analysis. First, although the Air Force has indicated that the predominate route used by F-16 pilots favors the eastern portion of Skull Valley[19], the analysis assumed a random, even distribution of F-

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[15] See, e.g., Greg Schneider and Thomas E. Ricks, Fighter Jet Faces New Scrutiny, Budget Crunch, Changing World Threaten $200 Billion Project, Wash. Post, December 28, 2000 at E1 (the Joint Strike Fighter, a potential replacement for the F-16, may be cancelled to pay for higher priority defense projects).

[16] Ibid.

[17] Resnikoff, paragraph 4. Decreased Effective Flight Area in Skull Valley.

[18] Horstman Dep. at 229-230.

[19] Aircraft Crash Report at 5.

16 flights over Skull Valley,[20] thereby effectively overstating the risk associated with current F-16 operations. This risk is certainly overstated when considering the proposed location for the PFS site, its proximity to restricted airspace to the west and to the south, and the routes of flight available to the pilots which will reasonably keep the pilots within the lateral confines of the MOA.[21] The geometry of the MOA induces a natural funneling effect on flights proceeding south through the narrow "neck" of the MOA east of Dugway Village, which makes the eastern side of Skull Valley (away from the proposed site) the preferred route of flight.

75. Pilots routinely perform a number of administrative tasks while transiting Skull Valley. These include: operations (ops) checks, where pilots will check the operating status of the airplane, fuel quantity and distribution, and oxygen system operation; G-awareness maneuvers where the pilot accelerates and then performs two 90° turns to check his ability to withstand G-forces and proper operation of the anti-G suit; and a "fence" check where the pilot positions certain cockpit switches as though he were preparing to cross into hostile territory. There is no prescribed order in which to do these different series of checks and pilots have different habit patterns regarding when and how they accomplish the checks. It is reasonable to assume that pilots will continue to do these routine tasks while transiting Skull Valley whether or not the PFS facility is built.

76. The State infers that pilots will use the proposed PFS site as the primary navigation point in Skull Valley.[22] Nevertheless, the State fails to give adequate consideration to the prominent mountain ranges on both sides of Skull Valley that provide excellent visual references for maintaining positional awareness and that obviate the need for a specific turn point while performing the other tasks pilots routinely perform during this phase of flight. In addition, there are other cultural features, such as ranches that can

[20] Id., at 6.

[21] Id., Tab A.

[22] Horstman Dep. at 121, 124, 126.

be used for turn points if desired. Many of these are located east of the proposed PFS site which will allow pilots to fly more directly toward the narrow "neck" of the MOA at the southern end of Skull Valley.

77. The State contends that the proposed PFS site will become a magnet for pilots and result in a significant redistribution of F-16 flights through Skull Valley.[23] The State's argument is based in part upon the lack of significant sensor signal returns from cultural (i.e., man-made) objects upon which to align the aircraft sensors, as well as for navigation as previously discussed. The State admits, however, that there are no requirements to update the sensors or to update them on any particular point,[24] that pilots update their sensors at different times,[25] and that even if a pilot chooses to update his sensors he may turn anywhere from 10 miles short of the navigation point on which he updates his sensors to where he is directly above the navigation point.[26]

78. We understand that the proposed site will be a prominent feature in Skull Valley and that some pilots may use it as a reference point for navigation, sensor alignment, or both. However, the State overestimates the impact of building the proposed facility and we do not agree that it will result in a significant change to the flight distribution pattern described in the original report.

79. First, as noted previously, the current practice is for F-16s to fly toward the eastern side of the MOA for airspace considerations and to practice terrain masking. The PFS site is located toward the western side of the MOA away from the narrow "neck" at the southern portion of Skull Valley. Pilots must still contend with the airspace limitations regardless of whether or not the PFS facility is built.

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[23] Id. at 229-230.

[24] Id. at 159.

[25] Id. at 123, 160.

[26] Id. at 229-230.

80. Second, pilots will still be required to do those routine functions and checks discussed previously in 75. Skull Valley will remain a good location to complete these checks.

81. Third, there are other points more favorably aligned with the narrow "neck" of the MOA that can be used for navigation and sensor alignment if desired. The PFS access road which will connect the proposed facility with Skull Valley Road approximately two miles to the east will be an additional such point that can be used although it will lack the vertical build up of the PFS facilities.

82. Fourth, the State assumes a pilot must be pointed directly at the facility to update the sensors; this is not necessarily required. While as a practical matter most pilots will have the object fairly close to the nose of the airplane, to update using references on the pilot's Head Up Display (HUD), the point only needs to be within the HUD field of view (approximately 20° either side of the aircraft nose and not more than approximately 10° below the horizon). To update using the radar, a 15° angle minimum away from the nose of the aircraft provides a much more precise radar picture for the pilot. To align the targeting pod on the F-16, pilots are normally at medium altitude (15,000 to 17,000 ft MSL for Skull Valley, although they could be higher if airspace restrictions were not a factor), since the targeting pod is normally employed in the medium altitude environment. To align the targeting pod, the reference point should be within the HUD field of view, which would put the airplane at least 11.3 miles at 15,000 MSL (10,500 AGL with a 10° look down angle) away from the sensor point. This represents the closest distance at which the pilot would be able to align the targeting pod with the HUD.

83. Fifth, the State is in essence stipulating that the proposed PFS facility will be well known to all pilots since they will use it regularly as a primary visual reference point. This makes the conservative allowances built into the original PFS calculations regarding a pilot's ability to see and avoid the PFSF in the event of a mishap unnecessary, which decrease the original probabilities calculated. As discussed elsewhere, PFS

assumed that 5 percent of the time a pilot would fail to avoid the PFSF in the event of a mishap that left him in control of the aircraft, even though PFS's review of F-16 mishap reports over the last 10 years revealed no case where a pilot failed to avoid a site on the ground when he had the time and opportunity to see and avoid it.

84. The State seeks to find a higher risk to the PFSF site by changing the distribution of the flights within the Sevier B MOA based on the visibility of the site to the pilot without taking into account concomitant changes to the other parameters of the risk equation, namely the percentage of pilots who could now avoid crashing into the site because of their perfect situational awareness of its location and the elimination of any weather effect from site obscuration.

85. Finally, the State is using a specific observation that the site will be plainly visible and speculating that it will significantly change overall F-16 flight patterns without providing any supporting analysis that addresses the airspace limitations and other factors, discussed above, which impact and help shape the current operations and flight distribution pattern.

86. The conservative assumptions used in the original calculations adequately allow for any redistribution of F-16 flight operations should they occur as a result of building the proposed PFS facility. As noted, the State's argument is speculative in nature and not supported by empirical data or analysis.

D. Avoidance of the PFSF in the Event of a Mishap

1. Pilot Experience

87. During his December 11, 2000 deposition, State witness Lt. Col. Horstman asserted that when PFS determined that an F-16 pilot would be able to guide his aircraft away from the PFSF in 95 percent of the mishaps in which the pilot was left in control of the aircraft, PFS did not account for variations in pilot experience. Horstman Dep. at 173. Lt. Col. Horstman agreed that all pilots in such circumstances would intend to avoid the PFSF. Horstman Dep. at 172-73. He stated that the probability that a pilot

would succeed would be higher for more experienced pilots. Id. at 173. He then stated that only 60 percent of the Air Force's F-16 pilots are "experienced" in terms of the number of flying hours they have in the aircraft. Id. at 173-77. Lt. Col. Horstman then asserted his belief that PFS's assumption that pilots would be able to avoid the PFSF 95 percent of the time was too high because of the potential for inexperienced pilots to be involved in mishaps, but he did not know what the actual percentage should be. Id. at 175-77, 181, 185.

88. In assessing the Lt. Col. Horstman's assertion, it is important to note that during Lt. Col. Horstman's deposition and the December 12, 2000 deposition of Col. Fly,[27] the word "experienced" was used in two different contexts as it relates to pilots. The first context is commonly understood and is relevant to a pilot's ability to avoid the PFSF; the second context stems from an Air Force management tool used to maintain a balance between more junior and senior pilots it its fighter wings. Col. Horstman's reference to 60 percent of F-16 pilots being "experienced" is concerned with the latter, and not the former. See Horstman Dep. at 173-74.

89. One usage of the term "experienced" is the commonly understood noun "practical knowledge, skill, or practice derived from direct observation of or participation in events or in a particular activity[28]". In this context, a typical pilot who completes pilot training, initial F-16 training, and is then assigned to an operational fighter wing, would be considered "experienced" in terms of practical knowledge, skill or practice derived from direct participation in a particular activity, flying an F-16. Admittedly, a pilot who has been flying the F-16 for ten years is more experienced than one who has been flying it for two years. However, the basic purpose of pilot training, F-16 initial training and the mission ready training after arriving at the operational wing is to provide a sufficient level of experience to proficiently operate the F-16 under routine and emergency condi-

[27] Deposition of Col. Ronald Fly (Dec. 12, 2000) ("Fly Dep.").

[28] Merriam-Webster Collegiate Dictionary, electronic on-line version definition 2.a.

tions at home station and successfully conduct combat sorties when deployed for contingency operations.

90. The other usage of the term "experienced" is a management tool used by the Air Force related to specific pilot flying time. It is a quantitative definition used to distinguish those pilots with more flying hours in the F-16 ("experienced" pilots) from those with fewer hours ("inexperienced" pilots). There is no qualitative assessment of an individual pilot associated with this quantitative categorization. A typical pilot who completes pilot training, initial F-16 training and is then assigned to an operational fighter wing, is considered "experienced" only after he has 500 hours of flying time in the F-16.[29] This reclassification is automatic when the pilot completes the requisite number of hours. There is no prescribed level of performance or any specific evaluation associated with a pilot moving from the "inexperienced" into the "experienced" category. It is worth noting that many "inexperienced" pilots fully participated in the Persian Gulf War and combat operations in Bosnia and Kosovo.

91. Rather, the Air Force uses the "inexperienced" and "experienced" categories primarily as a management tool. The general guidelines are to have a 40/60 split of inexperienced/experienced pilots in an operational fighter wing. This ensures there is adequate intake of new pilots into the force structure to maintain a viable fighter force over time. The AF must ensure there are adequate accessions to provide a pool of individuals available to meet the demands for "experienced" fighter pilots to fill positions such as: undergraduate pilot training instructors, non-flying headquarters staff positions, etc., as well as those needed to fly the F-16. In addition, there is constant movement out of the AF by "experienced" pilots who either retire or elect to transition to civilian life prior to retirement.

[29] Pilots with different backgrounds who have transitioned into the F-16 after flying some other USAF aircraft do not require 500 hours in the F-16. If they have flown another fighter, they may be "experienced" with as few as 100 hours in the F-16.

92. During our review of the 126 F-16 accident reports, there was nothing to indicate, in those cases in which a pilot took actions following an engine failure or other emergency in which he was able to control the airplane, that the pilot's limited experience would have caused him to fail to turn to avoid an inhabited area. As explained above and stated in the report (Aircraft Crash Report, Tab H at 28 n.22), in all of those cases where inhabited areas were indicated as a consideration, pilots did in fact turn to avoid them. This is in accordance with the standard training provided to new pilots. Aircraft Report at 19-19a.

93. Further, there are three factors that mitigate any concerns of pilot experience raised by the State. First, those accidents that were assessed as accidents which could have happened in Skull Valley were randomly distributed across the pilot population. As stated in the original report, mechanical engine failures constituted the vast majority of these accidents. These engine failures would be independent of pilot experience. Therefore, in assessing the ten years of accident reports, there was a reasonable distribution of these events over the spectrum of pilot experience. As a result, the initial report indirectly considered pilot experience in its analysis. Second, the report used a lower bound limit of 90% for the fraction of Skull Valley type accidents that would leave the pilot in a position from which he could maintain control of the aircraft after the initiating event for the emergency, as opposed to the 97% that is supported by consideration of the data in the F-16 mishap reports (see Aircraft Crash Report, Tab H at 13-20). Use of the lower bound 90% fraction increases the calculated probability that an F-16 experiencing a mishap in Skull Valley would not be able to avoid the PFSF. Third, in determining the fraction of pilots with control of their aircraft after a mishap who would fail to avoid the PFSF, PFS used a 5% allowance factor as a conservatism even though the analysis did not indicate such a conservatism was warranted. As discussed above, the F-16 mishap data support an assumption that in 100% of the cases in which a pilot remained in control of his aircraft after a mishap he would be able to avoid a site on the ground like the PFSF (i.e., according to the data, PFS's allowance factor for the failure to avoid the PFSF could be set at zero).

94. Therefore, adequate allowance was made for pilot experience in PFS's original assessment. No change in PFS's assumption that pilots would be able to avoid the PFSF in 95 percent of the mishaps that left the pilot in control of the aircraft is warranted.

2. **Weather Effects**

95. The State of Utah asserts that cloud cover in Skull Valley will increase the risk of an F-16 impacting the proposed PFS site. The state claims that Skull Valley has at least 5/10 (five-tenths) cloud cover 46.3 percent of the time in a given year and further asserts that consequently 46.3 percent of the time, F-16 pilots would be unable to see and avoid the PFSF in the event of an engine failure or other emergency. Lamb/Resnikoff Memo at 1, 3-4.

96. The State of Utah incorrectly interprets its cloud data and therefore incorrectly applies the effect of cloud cover on the probability of an F-16 impacting the proposed PFS site. In a memorandum to Hugh Horstman dated December 5, 2000, Matt Lamb and Marvin Resnikoff assert that cloud cover will prevent a pilot in control of a crashing aircraft (e.g. after an engine failure) from directing the aircraft away from the Private Fuel Storage Facility (PFSF) 45% of the time. Id. The basis for their assumption was assertedly a statement by Lt. Col. Horstman that 45% of the time annually, clouds obscure 50% of the sky at elevations below 10,000 ft (note: AGL or MSL unspecified). In his deposition on December 11, 2000, Lt. Col. Horstman stated that the basis for the statement he made to Mr. Lamb and Dr. Resnikoff was the International Station Meteorological Climate Summary for Dugway Proving Ground ("Climate Summary").[30] Horstman Dep. at 131-32.

97. The Climate Summary, submitted by the State, indicates there is cloud coverage greater than 5/10 (five tenths) 46.3% of the time on an annual basis. The State

[30] The Climate Summary is available at https://www.airfield-ops.hill.af.mil/osw/climo/kdpg.htm.

further claims this data is the sum of the cumulative cloud coverage up to an altitude of 12,000' Above Ground Level (AGL). See id. This is incorrect and results from the erroneous assumption that the chart is based on data collected by the Automated Surface Observing System (ASOS) which has a maximum cloud measurement capability of 12,000' AGL. The Climate Survey provided by the State is based upon the compilation of manual weather observations indicated on the report as "HOURLY OBS FOR: 6005-7012, 7301-7606, 8401-9004"[31]. This corresponds to May 1960 - December 1970, January 1973 – June 1976 and January 1984 – April 1990, all of which predates the use of ASOS in 1992. These sky cover observations were made on the basis of total sky coverage (expressed in tenths) without respect to cloud altitude. Thus all that can be determined is that cumulative sky coverage was observed to be greater than 5/10 (five tenths) 46.3% of the time with no basis for determining the altitude of the sky cover. Two tenths of cloud coverage at 1,000' AGL would be reported the same as two tenths at 30,000'. The Climate Summary, therefore, does not provide any useful data on the altitude of the various cloud layers nor of a pilot's ability to operate under visual flight rules (VFR), see the ground, or maintain general positional awareness using outside references. To have a better appreciation of the potential impact on flight operations in Skull Valley, it is necessary to have more information concerning the actual weather[32] and how it could affect the pilots actions. Specifically, as shown below the Climate Summary does not mean that the PFSF would be invisible to F-16 pilots transiting Skull Valley 46% of the time.

98. For example, there could be a solid deck of clouds at 11,000 ft. AGL with nothing below that. The Climate Summary reports at least 5/10 coverage. However, it would be possible for the pilot to operate VFR under the cloud deck without any restric-

[31] Telephone call between Mr. Steve Vigeant, Certified Consulting Meteorologist, and Mr. Al Wallis of the National Climatic Data Center, Asheville, NC.

[32] A more detailed weather database is attached. See also Declaration of Stephen Vigeant (Dec. 28, 2000). Portions of the historic ceiling and visibility conditions are summarized in Tables 1, 2 and 3. They will be discussed below.

tions. This would include all of the Sevier B airspace and approximately 6,000 ft. above it. If the pilot elected to operate VFR over the clouds, he would not be able to see the ground or any other features. In this situation, the pilot would use his Inertial Navigation System (INS) aided by the Global Positioning System (GPS) for navigation and positional awareness. Due to the narrowing of the Sevier B MOA near the area to the east of Michael Army Air Field, it would be reasonable for pilots to select a ground track that pointed them toward the center of the "neck" where the MOA narrows. This ground track would keep pilots away from the eastern boundary of the UTTR restricted airspace that slants toward the southeast in the southern portion of Skull Valley. This ground track would also tend to keep pilots away from the proposed PFS location as well. Pilots maintain their positional awareness by monitoring their bearing and distance to their selected INS steer point and cross referencing their map.

99. In a second example, the total cloud coverage could be reported as 5/10 by the Climate Summary, with a 1/10 layer at 3,000 AGL, a 2/10 layer at 5,000 AGL, and a 2/10 layer at 7,000 AGL. The sum of these is 5/10 cloud coverage. When looking at the distribution of the coverage however, it is reasonable to assume that F-16's could fly VFR at any altitude up to 12,000' AGL, the maximum altitude for cloud coverage contained in the Climate Survey. If they choose to fly at 3,000'AGL, 5,000'AGL or 7,000'AGL, they might have to adjust portions of their route of flight depending on where the actual clouds were, but they could operate at any of those altitudes. If the pilots elected to fly above the highest layer of clouds, it is reasonable to assume that they could maintain their positional awareness with ground references such as mountain ranges, major roads, cultural features, etc. Because of the cumulative cloud coverage however, there will be specific points or features that might not be visible. The pilot would still have awareness of the general location of those points and features.

100. In a third example, the area could be 8/10 covered by low altitude clouds at 1,000 ft. AGL. This would preclude VFR operations below the weather. In addition, it would preclude direct identification of most ground features in the relatively flat plain

areas in and around Skull Valley. However, pilots could easily operate VFR over the clouds. In Skull Valley they would be able to maintain positional awareness using the portions of the Stansbury and Cedar Mountains that rise above the clouds and that portion of the ground which is still visible. In addition, their INS would assist them with navigation as well.

101. There are innumerable variations to this theme, but they can conclusively show that in many possible circumstances where there is cloud coverage a pilot flying through Skull Valley would still be able to see the PFSF and his ability to avoid the site in case of an in-flight mishap would not be compromised by the clouds.

102. A more detailed investigation of the cloud cover in Skull Valley below, shows that the original, conservative analysis adequately allows for the effects of cloud cover and that no further adjustments to the probability of an F-16 impacting the proposed PFS site are required.

Michael Army Air Field

Local Standard Time	Ceiling > 2,500' & Visibility > 3NM[1]	Ceiling > 6,000' & Visibility > 3NM	Ceiling > 10,000' & Visibility > 3NM
1600	353.6[2]	313.3	276.0
2200	354.5	324.3	290.7
0400	352.6	320.2	300.3
1000	350.3	321.4	294.0
Average	352.8	319.8	290.3

Table 1

[1] Based upon a 13 year average of data collected by the National Weather Service.

[2] Average number of days per year the observed weather was greater than ceiling and visibility stated at the top of the column.

Salt Lake City Airport

Local Standard Time	Ceiling > 2,500' & Visibility > 3NM	Ceiling > 6,000' & Visibility > 3NM	Ceiling > 10,000 & Visibility > 3NM
1700	346.5	323.0	283.0
2300	344.3	317.4	280.2
0500	339.3	310.6	271.7
1100	338.2	309.4	274.1
Average	342.1	315.1	277.3

Table 2

Hill AFB

Local Standard Time	Ceiling > 2,500' & Visibility > 3NM	Ceiling > 6,000' & Visibility > 3NM	Ceiling > 10,000 & Visibility > 3NM
1700	343.7	305.4	267.7
2300	345.0	312.0	274.0
0500	344.3	307.6	269.0
1100	339.8	298.3	266.8
Average	343.2	305.8	269.4

Table 3

103. Tables 1, 2, and 3 show a more detailed breakout of actual ceiling[33] and visibility for Michael Army Air Field, Salt Lake City Airport, and Hill AFB respectively. Although they do not give a detailed breakout of cloud coverage in 1,000' increments, they do provide 3 different ceilings that might affect the pilots ability to fly VFR in Skull Valley and maintain positional awareness using visual references. The data for Michael Army Air Field (AAF) is considered the most like that in Skull Valley due to its proxim-

[33] A ceiling is cumulative cloud coverage of 6/10 (six tenths) or greater.

ity and location. This is supported by the Salt Lake City Airport data which is similar in elevation but closer to the Rocky Mountains to the east.

104. First, as shown in Table 1, Column 2 an average of approximately 353 days a year (96.6%) Michael AAF has a ceiling greater than 2,500 ft. and visibility greater than 3 miles. This is supported by the Air Force brochure describing the UTTR attached as Exhibit 13. The brochure states that the range has weather of at least a 3,000 ft. ceiling and 3 miles visibility 96% of the time. Further, on page 5 it states that the visibility is 10 miles or greater 95% of the time. With a 3000 ft. ceiling, an F-16 pilot can easily and safely transit Skull Valley at 2000 ft. AGL, i.e., 1000 ft. below the clouds, and maintain situational and positional awareness with respect to the location of the PFS site, particularly when the visibility is 10 miles greater. Thus pilots can operate in Skull Valley at low altitude with little to no impact from the weather. Maintaining positional awareness using outside references would not be a problem under these circumstances. Thus, a pilot would be able to avoid the PFSF in the event of an in-flight mishap.

105. Second, the 6,000 ft. ceiling listed in Table 1, Column 3 (Ceiling > 6,000' & Visibility > 3 Mi) includes all the vertical airspace in the Sevier B MOA.[34] It clearly indicates that pilots could fly through Skull Valley and the entire Sevier B MOA, using visual reference to the ground, mountains and cultural features approximately 88% of the time (320 days per year). By comparing the data in Table 1, Columns 2 and 3, it can be seen that only 7% of the time (95%-88%) would there be a ceiling between 2,500' and 6,000' in Skull Valley.

106. Although cumulative cloud coverage could mask some specific points or features, the pilots would still have a general awareness of their location. In addition, Deseret Peak at 11,031 ft. MSL provides an excellent and very specific reference for F-16's transiting Skull Valley.

[34] Sevier B MOA extends up to 9,500 ft. MSL or approximately 5,300 ft. AGL.

107. Third, as indicated in Table 1 Column 3, the ceiling is higher than 10,000 ft. AGL (14,200 ft. MSL) approximately 79% of the time (290 days per year). The 10,000 ft. AGL airspace includes all the airspace in the Sevier B MOA, 5,500' above the MOA and approximately 71% of all the airspace above Skull Valley below the Positive Control Airspace (PCA[35]). Thus pilots could maintain positional awareness at least 79% of the time in 71% of the VFR airspace over Skull Valley, including all of the Sevier B MOA. As discussed above, in most of the remaining time a pilot could fly VFR by staying beneath the cloud ceiling in Sevier B MOA if clouds above 10,000' were a factor.

108. In the event that an F-16 pilot transits Skull Valley above a ceiling or cloud deck high enough to obscure the Stansbury Mountains (which would be at least 6,500 ft. AGL), situational and positional awareness with respect to the proposed PFS site can be readily maintained using navigation systems such as GPS and INS. Ground references, such as major roads and cultural features, when visible through breaks in the undercast, are also helpful in checking position.

109. For example, there could be a solid deck of clouds from 8,000' to 10,000' AGL. In this situation, the pilot flying above this deck would use his Inertial Navigation System (INS) aided by the Global Positioning System (GPS) for navigation and positional awareness. Due to the narrowing of the Sevier B MOA near the area to the east of Michael Army Air Field, it would be reasonable for pilots to select a ground track that pointed them toward the center of the "neck" where the MOA narrows. This ground track would tend to keep pilots away from the eastern boundary of the UTTR restricted airspace that slants toward the southeast in the southern portion of Skull Valley. This ground track would also tend to keep pilots away from the proposed PFSF location as well. Pilots maintain their positional awareness by monitoring their bearing and distance to their selected INS steer point and cross referencing their map

[35] The PCA starts at 18,000 ft. MSL. To operate in the PCA, pilots must have an approved instrument flight plan and follow Air Traffic Control instructions. VFR flights are not allowed in the PCA. Pilots do not normally fly in the PCA airspace en route from Hill AFB to the UTTR.

110. In the event that a major weather system with extensive cloud cover moves into the area and makes the UTTR unworkable for combat training due to cloud coverage and visibility, the 388th Fighter Wing would cancel or reduce their sorties because of the weather. They would also cancel their sorties if Hill AFB weather went below takeoff and landing minimums. In either or both cases, there would be no F-16s in Skull Valley. Such cases would include part or all of the time that Skull Valley experienced weather that would result in ceilings below 3,000 ft. and/or visibility less than 3 miles.

111. In summary, the more detailed USAF Air Weather Service data demonstrates that the weather in Skull Valley clearly supports VFR flight operations. Further, the weather data shows that when cloud coverage is a factor, pilots will normally be able to conduct their training below the clouds rather than above them. The 46.3% cloud coverage greater than 5/10 relied on by the State is clearly not an accurate representation of the amount of time a pilot will be able to maintain positional awareness using visual references. In addition, it does not account for pilots' general positional awareness using navigation systems when operating above an undercast that completely obscures the ground. Also, it does not allow for probable ground tracks pilots would select to keep them from violating restricted airspace when operating over an undercast or the fact that those ground tracks would tend to keep pilots away from the proposed PFS site. Finally, it does not account for the cancellation of flight operations in Skull Valley due to poor weather.

112. In addition to the weather analysis above, PFS conducted a detailed analysis of every F-16 Class A Flight mishap from FY 1989 through FY 1998. In its Report, PFS gives particular attention to aircraft destroyed (actual ground impact/crashes), engine failures, and ability to avoid a structure like the PFSF in the event of an engine failure or other emergency. One hundred and twenty-six Class A Flight mishaps were examined.

113. PFS re-examined all 126 F-16 Class A Flight mishaps and specifically assessed the impact and effect of weather and cloud conditions at the time of each mishap.

Focus was placed on determining if the weather and cloud conditions influenced the pilot's behavior and performance in a way that would have prevented avoiding a structure like the PFSF. PFS identified only eight mishaps where the weather and cloud conditions could have affected the actions taken by the pilot during the emergency and which might have impeded the ability to avoid a structure like the PFSF in a setting similar to Skull Valley. Notably, in only one instance did the pilot eject above an undercast, the scenario envisioned by the State that would cause a pilot to be unable to avoid the PFSF. This occurred in Europe where the pilot had been operating above an undercast at low altitude and zoomed higher after experiencing engine problems, but could not see the ground. In two other accidents in which pilots experienced engine failures above or in weather that prevented them from seeing the ground, the pilots specifically asked for vectors from ground controllers to avoid inhabited areas. In another case, the pilot descended below the clouds to clear the area before ejecting. In one other accident occurring below a low overcast, the pilot elected to reduce his zoom and stay below the clouds. This enabled him to keep sight of the ground and avoid hitting ground structures.

114. In summary, the 5/10 cloud coverage 46.3 percent of the time during the year presumed by the State neither accurately depicts the operational or meteorological environment for F-16's transiting Skull Valley nor realistically influences the potential risk to a proposed PFSF site. The reality of at least 3,000 ft. ceilings with at least 3 miles visibility 96 percent of the time does not pose a hazard regarding the ability to avoid the proposed PFS site, particularly when the visibility is 10 miles or greater 95 percent of the time. Moreover, even if a pilot were to experience a mishap while transiting Skull Valley above an undercast, actual mishap data shows that it would still be possible for the pilot to avoid a site on the ground like the PFSF. The real weather and cloud conditions, coupled with the detailed examination of ten years worth of F-16 Class A Flight mishaps indicate that neither the weather nor the clouds would have any significant effect on the risk to the PFSF.

115. Based upon the detailed data provided, the subsequent analysis, and the conservatisms built into the analysis, the PFS Aircraft Crash Impact Hazard adequately considers the impact of weather on the probability of an F-16 impacting the proposed PFS site. No adjustments to the analysis are required because of weather.

E. Miscellaneous

116. The State of Utah claims that aircraft jettisoning multiple pieces of ordnance would increase the effective area of the PFSF, in that there would be a slight delay between the release of the first piece and the release of the second. The State asserts that the distance the aircraft travels during the delay should be added to both ends of the effective area of the facility, north to south.

117. The 1/3-second delay at 471.8 miles per hour is equivalent to 231 feet. This would be added to the front of the area only in calculating effective area. On the back side, if the first weapon released hit the very back edge of the facility, it would not matter for the probability calculation that another hit 231 feet beyond the site. Since the depth of the cask storage area is 1,590 ft., the effect of the delay would be to increase the site area by 231/1590 or 14.5 percent.

F. Conservatism Remaining in PFS's Assessment

118. Even if the State's challenges to PFS's assessment had some merit, PFS's calculated hazard to the PFSF retains sufficient conservatism to render the State's claims immaterial. First, with respect to the F-16s transiting Skull Valley and flying on the Moser recovery, PFS used a crash rate that included not only destroyed aircraft, but also Class A and B mishaps in which no aircraft was destroyed. Aircraft Report at 25; id. Tab H at 4 n.8. Since in the 10 years of FY-89 to FY-98, there were 162 Class A and Class B mishaps but only 139 destroyed aircraft, the crash rate is overstated by 16.5%, which probably applies to both the Normal and Special Operations accident rates used in the analysis. In other terms, for this conservatism alone, the correct calculated Impact Probabilities in Paragraph 58 above are about 86% of those shown.

119. Second, and more significantly, PFS assumed that any crashing F-16 that impacted the site could potentially cause a release of radioactive material. In fact, those F-16s that impacted the site after a mishap that left the pilot in control of the aircraft would hit at a velocity of roughly 170 to 210 knots. Aircraft Report at 21. This would be low enough not to penetrate a spent fuel storage cask. Id. Chap. XI. PFS has determined that at least 90 percent of all mishaps that would otherwise result in an impact at the PFSF would leave the pilot in control, and in no more than 5 percent of those the pilot would fail to avoid the PFSF. Accordingly, in .90 x .05 = .045 or 4.5% of the total accidents, the plane could impact the site at these relatively low speeds. The other 10 percent of the mishaps would not leave the pilot in control and could simply result in an impact at higher speeds, depending on the location of the aircraft when the mishap took place. Thus, at least approximately 30 percent of all potential impacts (.045 / (0.45 + .10)) would hit at a velocity insufficient to penetrate a cask and hence the F-16 crash hazard to the PFSF from Skull Valley transits and the Moser recovery could be reduced by 30 percent.

120. In addition, as we discussed above, crashing aircraft on the UTTR would simply be too far away, as a practical matter, to fly to and impact the PFSF. PFS's calculation conservatively assumed that a crashing aircraft could glide 10 miles before impacting the site. If potential aircraft impact locations are considered more realistically, then, as even the State of Utah's witness agrees, the hazard from the UTTR can be taken to be zero. See ¶ 44, supra.

121. PFS's calculated hazard from jettisoned ordnance is also conservative in a number of respects. First, the calculation does not take into account the fact that over half of cask storage area at the PFSF will consist of open space where ordnance could impact and do no damage. Aircraft Report at 83. Second, the State of Utah has recently produced discovery in the form of a letter from the Air Force stating that none of the inert

munitions tested would penetrate the lid of a storage cask if they struck it.[36] Those weapons tested included the Mark 82, Mark 84 and CBU-87 which make up most of the jettisonable ordnance carried by F-16s on the UTTR. Most of these are inert. Aircraft Report at 81. The Mark 84 (2000 lb. bomb) could penetrate the outside wall of the structure, but it is unclear from the Col. Bauer letter if it would then penetrate the inner shell or fuel canister shell. Since Mark 84s make up only 13% of the jettisonable ordnance, in any event the actual risk from jettisoned ordnance is probably well below the figure of 1.49×10^{-7} given in the table in Paragraph 58, and is probably on the order of 2.0×10^{-8}.

122. Finally, all of PFS's calculations assume a fully loaded site with 4,000 spent fuel storage casks. In fact, the PFSF would contain 4,000 casks for only one year during its lifetime. If PFS considered a time-weighted average size for the cask storage area, the effective area of the site would be only 55 percent of the area of the site at full capacity. Thus, the average aircraft crash impact hazard for the PFSF is only 55 percent of the peak hazard. Aircraft Report at 25-27. Since effective area is integral to all calculations of risk, the total risk could likely be reduced by a factor of approximately 45% for an average risk value.

V. CONCLUSION REGARDING THE HAZARDS OF AIRCRAFT CRASHES AND AIR-DELIVERED WEAPONS USE

123. The calculated aircraft crash impact risk to the PFSF as a whole, assuming a fully loaded facility with 4,000 storage casks, is 4.87×10^{-7} per year. If the probability of jettisoned military ordnance impacting the PFSF is added to that total, the cumulative probability of an air crash or military ordnance impact at the PFSF is 6.25×10^{-7}. Be-

[36] Letter from Col. Lee Bauer, USAF, Deputy Associate Director for Ranges and Airspace, to Connie Nakahara, Utah Department of Environmental Quality (Dec. 28, 2000).

cause of the distance from the PFSF site at which weapons use on the UTTR takes place, the likelihood that a weapon used on the UTTR would impact the PFSF is insignificant. Therefore, the cumulative hazard to the PFSF from aircraft crashes and air-delivered ordnance is insignificant.

We declare under penalties of perjury that, to the best of our knowledge, the foregoing is true and correct.

Executed on December 30, 2000.

James L. Cole, Jr.

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Wayne O. Jefferson, Jr.

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NUCLEAR REGULATORY COMMISSION

Docket No. ______ Official Exh. No. STATE 39

In the matter of ______

Staff ______ IDENTIFIED ✓

Applicant ______ RECEIVED ✓

Intervenor ✓ REJECTED ______

Other ______ WITHDRAWN ______

DATE 4/12/02 Witness ______

Clerk pal