

**NUCLEAR REGULATORY COMMISSION
ISSUANCES**

**OPINIONS AND DECISIONS OF THE
NUCLEAR REGULATORY COMMISSION
WITH SELECTED ORDERS**

January 1, 2003 — June 30, 2003

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PREFACE

This is the fifty-seventh volume of issuances (1 – 617) of the Nuclear Regulatory Commission and its Atomic Safety and Licensing Boards, Administrative Law Judges, and Office Directors. It covers the period from January 1, 2003, to June 30, 2003.

Atomic Safety and Licensing Boards are authorized by Section 191 of the Atomic Energy Act of 1954. These Boards, comprised of three members conduct adjudicatory hearings on applications to construct and operate nuclear power plants and related facilities and issue initial decisions which, subject to internal review and appellate procedures, become the final Commission action with respect to those applications. Boards are drawn from the Atomic Safety and Licensing Board Panel, comprised of lawyers, nuclear physicists and engineers, environmentalists, chemists, and economists. The Atomic Energy Commission first established Licensing Boards in 1962 and the Panel in 1967.

Between 1969 and 1990, the AEC authorized Atomic Safety and Licensing Appeal Boards to exercise the authority and perform the review functions which would otherwise have been exercised and performed by the Commission in facility licensing proceedings. In 1972, that Commission created an Appeal Panel, from which are drawn the Appeal Boards assigned to each licensing proceeding. The functions performed by both Appeal Boards and Licensing Boards were transferred from the AEC to the Nuclear Regulatory Commission by the Energy Reorganization Act of 1974. Appeal Boards represented the final level in the administrative adjudicatory process to which parties could appeal. Parties, however, were permitted to seek discretionary Commission review of certain board rulings. The Commission also could decide to review, on its own motion, various decisions or actions of Appeal Boards.

On June 29, 1990, however, the Commission voted to abolish the Atomic Safety and Licensing Appeal Panel, and the Panel ceased to exist as of June 30, 1991. Since then, the Commission itself reviews Licensing Board and other adjudicatory decisions, as a matter of discretion. *See* 56 Fed. 29 & 403 (1991).

The Commission also has Administrative Law Judges appointed pursuant to the Administrative Procedure Act, who preside over proceedings as directed by the Commission.

The hardbound edition of the Nuclear Regulatory Commission Issuances is a final compilation of the monthly issuances. It includes all of the legal precedents for the agency within a six-month period. Any opinions, decisions, denials, memoranda and orders of the Commission inadvertently omitted from the monthly softbounds and any corrections submitted by the NRC legal staff to the printed softbound issuances are contained in the hardbound edition. Cross references in the text and indexes are to the NRCI page numbers which are the same as the page numbers in this publication.

Issuances are referred to as follows: Commission—CLI, Atomic Safety and Licensing Boards—LBP, Administrative Law Judges—ALJ, Directors' Decisions—DD, and Decisions on Petitions for Rulemaking—DPRM.

The summaries and headnotes preceding the opinions reported herein are not to be deemed a part of those opinions or to have any independent legal significance.

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

COMMISSIONERS:

Richard A. Meserve, Chairman
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Nils J. Diaz
Edward McGaffigan, Jr.
Jeffrey S. Merrifield

In the Matter of

Docket No. 72-26-ISFSI

**PACIFIC GAS AND ELECTRIC
COMPANY
(Diablo Canyon Power Plant
Independent Spent Fuel Storage
Installation)**

January 23, 2003

In this proceeding to authorize construction of a dry cask independent spent fuel storage installation at the site of the Diablo Canyon Nuclear Power Plant, the Commission accepts the Licensing Board referral of its decision to reject terrorism contentions and affirms the Board's rejection of the contentions.

TERRORISM

NEPA

We recently decided similar issues in four other cases in four different contexts: *Private Fuel Storage* (a dry cask independent spent fuel storage installation), *Savannah River* (a mixed oxide fuel fabrication facility), *Millstone* (expansion of the spent fuel storage pool capacity at a commercial reactor site), and *McGuire/Catawba* (license renewal for four commercial reactors). See *Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), CLI-02-25, 56 NRC 340 (2002); *Duke Cogema Stone & Webster* (Savannah River Mixed Oxide Fuel Fabrication Facility), CLI-02-24, 56 NRC 335 (2002); *Dominion*

Nuclear Connecticut, Inc. (Millstone Nuclear Power Station, Unit 3), CLI-02-27, 56 NRC 367 (2002); and *Duke Energy Corp.* (McGuire Nuclear Station, Units 1 and 2; Catawba Nuclear Station, Units 1 and 2), CLI-02-26, 56 NRC 358 (2002). In each of these settings, we considered whether NEPA requires the NRC, in rendering licensing decisions, to consider the impacts of terrorism. We held that NEPA does not require a terrorism review, and that an environmental impact statement is not the appropriate format in which to address the challenges of terrorism.

TERRORISM

NEPA

In the lead *Private Fuel Storage* case, involving a large away-from-reactor ISFSI, we detailed four principal reasons for our holding. First, the “possibility of a terrorist attack . . . is speculative and simply too far removed from the natural or expected consequences of agency action to require a study under NEPA,” which is confined to “manageable” inquiries. See *Private Fuel Storage*, CLI-02-25, 56 NRC at 349 & n.33, citing *Metropolitan Edison Co. v. People Against Nuclear Energy*, 460 U.S. 766, 776 (1983). Second, the risk of a terrorist attack at a nuclear facility cannot be adequately determined. See CLI-02-25, 56 NRC at 350-51, and references cited therein. As a practical matter, attempts to evaluate that risk even in qualitative terms are likely to be meaningless and consequently of no use in the agency’s decisionmaking. Third, NEPA does not require a “worst-case” analysis, which “creates a distorted picture of a project’s impacts and wastes agency resources.” See *id.* at 352; see generally *id.* at 351-54, and references cited therein. Lastly, NEPA’s public process is not an appropriate forum for considering sensitive security issues. In this regard we noted, “NEPA does not override [our] concern for making sure that sensitive security-related information ends up in as few hands as practicable.” *Id.* at 355; see *id.* at 354-57 and references cited therein. For the same reasons, we affirm the Board’s rejection of SLOMFP’s contention EC-1, the terrorism-related portions of contentions EC-2 and EC-3, and the County’s environmental issue.

NUCLEAR WASTE POLICY ACT

Our conclusion comports with the practical realities of spent fuel storage and the congressional policy to encourage utilities to provide for spent fuel storage at reactor sites pending construction of a permanent repository. See *Nuclear Waste Policy Act*, 42 U.S.C. §§ 10131 *et seq.*; *Millstone*, CLI-02-27, 56 NRC at 371.

MEMORANDUM AND ORDER

The Licensing Board, in a recent ruling on standing, admissibility of contentions, and admission of interested governmental entities in this independent spent fuel storage installation (“ISFSI”) licensing proceeding, referred its decision on one environmental contention and portions of three other contentions to the Commission.¹ We accept the Board’s referral and affirm its rejection of the contentions.

I. BACKGROUND

Pacific Gas & Electric Company (“PG&E”) filed an application on December 21, 2001, for a materials license authorizing construction and operation of a dry storage cask ISFSI to be located at its Diablo Canyon Nuclear Power Plant (“DCPP”) site. In response to a notice of opportunity for hearing, the Secretary of the Commission received petitions to intervene from numerous petitioners.² The San Luis Obispo Mothers for Peace, acting as Lead Petitioner, submitted five technical and three environmental contentions. The County of San Luis Obispo (“County”), previously granted governmental participant status, submitted one environmental and two technical issues.³ The Board heard oral argument on the issues of standing of the Petitioners and admissibility of their contentions on September 10-11, 2002. In addition to the Lead Petitioner, the Board found that the Santa Lucia Chapter of the Sierra Club, San Luis Obispo Cancer Action Now, Peg Pinard, the Avila Valley Advisory Council, and the Central Coast Peace and Environmental Council have standing.⁴ We shall refer to the admitted Interveners collectively as “SLOMFP.” The Board granted governmental participant status to the California Energy Commission and the Avila Beach Community Services District, but denied the request of the Diablo Canyon Independent Safety Committee.

¹ See LBP-02-23, 56 NRC 413 (2002).

² In addition, five entities sought leave to participate as interested governmental entities pursuant to 10 C.F.R. § 2.715(c): “The presiding officer will afford representatives of an interested State, county, municipality, Federally-recognized Indian Tribe, and/or agencies thereof, a reasonable opportunity to participate and to introduce evidence, interrogate witnesses, and advise the Commission without requiring the representative to take a position with respect to the issue.” Of the five requests, only that of the County of San Luis Obispo is relevant to today’s decision.

³ See unpublished Memorandum and Order (Establishing Schedule for Identification of Issues by Interested Governmental Entities; Limited Appearance Participation) (Aug. 7, 2002). The Board also granted governmental participant status to the Port San Luis Harbor District. *See id.*

⁴ The Board also determined that the following groups had not demonstrated standing: the Environmental Center of San Luis Obispo, Cambria Legal Defense Fund, Santa Margarita Area Residents Together, San Luis Obispo Chapter of Grandmothers for Peace International, Nuclear Age Peace Foundation, and the Ventura County Chapter of the Surfrider Foundation.

The Board admitted one of SLOMFP's five technical contentions for litigation in this proceeding and rejected SLOMFP's three environmental contentions. In accordance with 10 C.F.R. § 2.730(f), the Board referred its rulings regarding the sabotage and terrorism aspects of SLOMFP's three environmental contentions and San Luis Obispo County's environmental issue to the Commission for further consideration and action as appropriate.⁵ We accept the Board's referral and affirm the Board's denial of admission of the contentions, albeit for different reasons than those the Board expressed.

II. DISCUSSION

A. The Referred Terrorism Issues⁶

SLOMFP's three environmental contentions address, at varying levels of prominence, the threat of terrorism. Contention EC-1, the primary terrorism contention, states: "The Environmental Report's discussion of environmental impacts is inadequate because it does not include the consequences of destructive acts of malice or insanity against the proposed ISFSI."⁷ SLOMFP believes that PG&E's environmental report should evaluate a range of alternatives to the proposed ISFSI, including dispersal of casks, protection of casks by berms or bunkers, and use of more robust storage casks.

The Board found the contention inadmissible because it "directly challenge[s] the Commission's rules regarding destructive acts of malice or insanity by enemies of the United States. . . . [C]ontentions that question existing NRC regulations are inadmissible as a matter of law."⁸ Thus, the Board relied in part on 10 C.F.R. § 2.758(a), which prohibits adjudicatory challenges to NRC rules,⁹ and in part on 10 C.F.R. § 50.13, which provides that an applicant for a license to construct and operate a production or utilization facility "is not required to provide for design features or other measures for the specific purpose of protection against the effects of . . . attacks and destructive acts, including sabotage, directed against

⁵ See LBP-02-23, 56 NRC at 462. See also 10 C.F.R. § 2.730(f): "When in the judgment of the presiding officer prompt decision is necessary to prevent detriment to the public interest or unusual delay or expense, the presiding officer may refer the ruling promptly to the Commission"

⁶ We recently denied the direct request of the San Luis Obispo Mothers for Peace and several other petitioners to suspend this proceeding pending completion of the Commission's comprehensive review of measures to protect against terrorist attack. See CLI-02-23, 56 NRC 230 (2002).

⁷ "Supplemental Request for Hearing and Petition To Intervene by [SLOMFP]" at 24 (July 18, 2002).

⁸ LBP-02-23, 56 NRC at 448.

⁹ "[A]ny rule or regulation of the Commission, or any provision thereof . . . is not subject to attack by way of discovery, proof, argument, or other means in any adjudicatory proceeding involving initial or renewal licensing" 10 C.F.R. § 2.758(a).

the facility by an enemy of the United States, whether a foreign government or other person.”¹⁰

Because EC-1 is an environmental contention based on the National Environmental Policy Act (“NEPA”)¹¹ rather than a safety contention, SLOMFP argued that 10 C.F.R. § 2.758 is not applicable. The Board, however, reasoned that “the rationale for 10 C.F.R. § 50.13 [is] as applicable to the Commission’s NEPA responsibilities as it is to its health and safety responsibilities.”¹² The Board thus found contention EC-1 inadmissible, but referred its ruling to the Commission.¹³

Contention EC-2 asserts that PG&E has failed to fully describe the purposes of the proposed ISFSI or to evaluate all reasonably associated environmental impacts and alternatives. SLOMFP’s focus in this contention is its allegation that PG&E might have an unstated purpose for the proposed ISFSI; i.e., to provide spent fuel storage capacity during a license renewal term for the Diablo Canyon units. The Board found the contention inadmissible, but noted that, in several of the contention’s bases, SLOMFP repeated arguments concerning acts of destruction or sabotage that were discussed in support of EC-1. Therefore, the Board referred its ruling on admissibility of contention EC-2 to the Commission “to the extent destruction and sabotage matters are proffered in support of admission.”¹⁴

¹⁰ 10 C.F.R. § 50.13. Although section 50.13 does not, on its face, apply to an ISFSI, an applicant for an ISFSI must describe physical security protection plans, which must meet the requirements set forth in 10 C.F.R. § 73.51. Adopting section 73.51 in 1998, the Commission specifically rejected a requirement that ISFSIs be protected against malevolent attacks by land-based or airborne vehicles. See Final Rule: “Physical Protection for Spent Nuclear Fuel and High-Level Radioactive Waste,” 63 Fed. Reg. 26,955, 26,956 (May 15, 1998).

¹¹ See 42 U.S.C. §§ 4321 *et seq.*

¹² LBP-02-23, 56 NRC at 448, quoting *Long Island Lighting Co.* (Shoreham Nuclear Power Station), ALAB-156, 6 AEC 831, 851 (1973) and citing *Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), LBP-01-37, 54 NRC 476, 487 (2001), *referral accepted*, CLI-02-3, 55 NRC 155 (2002).

¹³ See LBP-02-23, 56 NRC at 448. In making the referral, the Board alluded to the Commission’s ongoing comprehensive review of NRC’s safeguards and physical security programs in the wake of the Sept. 11, 2001 terrorist attacks. Moreover, the Commission, at the time of the Board’s referral, was considering terrorism contentions we had agreed to review in four other cases. See *Private Fuel Storage*, LBP-01-37, 54 NRC 476 (denying admission of terrorism contention and referring issue to the Commission), *referral accepted*, CLI-02-3, 55 NRC 155; *Duke Energy Corp.* (McGuire Nuclear Station, Units 1 and 2; Catawba Nuclear Station Units 1 and 2), LBP-02-4, 55 NRC 49 (2002) (certifying terrorism issue to the Commission), *certification accepted*, CLI-02-6, 55 NRC 164 (2002); *Duke Cogema Stone & Webster* (Savannah River Mixed Oxide Fuel Fabrication Facility), LBP-01-35, 54 NRC 403 (2001), *reconsideration denied*, unpublished Memorandum and Order (Jan. 16, 2002), *petition for Commission review granted in part*, CLI-02-4, 55 NRC 158 (2002); and *Dominion Nuclear Connecticut, Inc.* (Millstone Nuclear Power Station, Unit 3), LBP-02-5, 55 NRC 131 (2002) (denying admission of terrorism contention and referring contention to the Commission), *referral accepted*, CLI-02-5, 55 NRC 161 (2002).

¹⁴ LBP-02-23, 56 NRC at 451.

In Contention EC-3, SLOMFP asserts that PG&E has failed to evaluate the environmental impacts of transporting fuel away from the proposed ISFSI at the end of its license term. SLOMFP claims that the ER must consider impacts of such transportation, including sabotage and terrorist attacks against transportation casks. The Board rejected contention EC-3 but, as with EC-2, referred its ruling to the Commission “to the extent terrorism and sabotage matters are proffered in support of its admission.”¹⁵

Similar to SLOMFP’s EC-1, the County’s environmental issue asserted that the environmental report does not contain an adequate analysis of alternatives. Specifically, in its subissue regarding alternative sites and associated security measures, the County argues that PG&E did not consider vulnerability to offshore attacks when it selected the site for the proposed ISFSI. Because this subissue “appears to challenge the Commission’s rules regarding acts of destruction and sabotage,” the Board denied it as a matter of law, but made the terrorism aspects of the issue part of its referral to the Commission.¹⁶

B. The Commission’s Ruling

We accept the Board’s referral of the terrorism issues in SLOMFP’s three environmental contentions and the County’s environmental subissue and affirm the result the Board reached.

We recently decided similar issues in four other cases in four different contexts: *Private Fuel Storage* (a dry cask independent spent fuel storage installation), *Savannah River* (a mixed oxide fuel fabrication facility), *Millstone* (expansion of the spent fuel storage pool capacity at a commercial reactor site), and *McGuire/Catawba* (license renewal for four commercial reactors).¹⁷ In each of these settings, we considered whether NEPA requires the NRC, in rendering licensing decisions, to consider the impacts of terrorism. We held that NEPA does not require a terrorism review, and that an environmental impact statement is not the appropriate format in which to address the challenges of terrorism.

In the lead *Private Fuel Storage* case, involving a large away-from-reactor ISFSI, we detailed four principal reasons for our holding. First, the “possibility of a terrorist attack . . . is speculative and simply too far removed from the natural or expected consequences of agency action to require a study under NEPA,” which

¹⁵ *Id.* at 453.

¹⁶ *See id.* at 460.

¹⁷ *See Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), CLI-02-25, 56 NRC 340 (2002); *Duke Cogema Stone & Webster* (Savannah River Mixed Oxide Fuel Fabrication Facility), CLI-02-24, 56 NRC 335 (2002); *Dominion Nuclear Connecticut, Inc.* (Millstone Nuclear Power Station, Unit 3), CLI-02-27, 56 NRC 367 (2002); and *Duke Energy Corp.* (McGuire Nuclear Station, Units 1 and 2; Catawba Nuclear Station, Units 1 and 2), CLI-02-26, 56 NRC 358 (2002).

is confined to “manageable” inquiries.¹⁸ Second, the risk of a terrorist attack at a nuclear facility cannot be adequately determined.¹⁹ As a practical matter, attempts to evaluate that risk even in qualitative terms are likely to be meaningless and consequently of no use in the agency’s decisionmaking. Third, NEPA does not require a “worst-case” analysis, which “creates a distorted picture of a project’s impacts and wastes agency resources.”²⁰ Lastly, NEPA’s public process is not an appropriate forum for considering sensitive security issues. In this regard we noted, “NEPA does not override [our] concern for making sure that sensitive security-related information ends up in as few hands as practicable.”²¹ For the same reasons, we affirm the Board’s rejection of SLOMFP’s contention EC-1, the terrorism-related portions of contentions EC-2 and EC-3, and the County’s environmental issue.²²

Our decision today rests entirely on our understanding of NEPA and of what means are best suited to dealing with terrorism. Nonetheless, our conclusion comports with the practical realities of spent fuel storage and the congressional policy to encourage utilities to provide for spent fuel storage at reactor sites pending construction of a permanent repository.²³ Storage of spent fuel at commercial reactor sites offers no unusual technological challenges. Indeed, it has been occurring at Diablo Canyon for many years and will continue whether or not we license the proposed ISFSI.²⁴

¹⁸ See *Private Fuel Storage*, CLI-02-25, 56 NRC at 349 & n.33, citing *Metropolitan Edison Co. v. People Against Nuclear Energy*, 460 U.S. 766, 776 (1983).

¹⁹ See *Private Fuel Storage*, CLI-02-25, 56 NRC at 350-51, and references cited therein.

²⁰ See *id.* at 352; see generally *id.* at 351-54, and references cited therein.

²¹ *Id.* at 355; see *id.* at 354-57, and references cited therein.

²² We need not decide the applicability of the rationale for 10 C.F.R. § 50.13 to the Commission’s NEPA responsibilities. We note that “[t]he provision grew out of a policy judgment by the Atomic Energy Commission that it was our nation’s ‘settled tradition’ to ‘look[] to the military’ for defense against enemy attacks, and that it was ‘impracticable’ to expect a ‘civilian industry’ to provide the necessary defense.” *Millstone*, CLI-02-27, 56 NRC at 369 n.7 (quoting *Siegel v. AEC*, 400 F.2d 778, 782 (D.C. Cir. 1968)). As in *Private Fuel Storage*, *Savannah River*, *Millstone*, and *McGuire/Catawba*, our decision today “rest[s] on general principles regarding the scope of NEPA, [and] we do not reach the application of section 50.13 as applied to the terrorism contentions that are raised in [this] case.” *Millstone* at 369, n.7.

²³ See Nuclear Waste Policy Act, 42 U.S.C. §§ 10131 *et seq.*; *Millstone*, CLI-02-27, 56 NRC at 371.

²⁴ See *Millstone*, CLI-02-27, 56 NRC at 371. Cf. *McGuire/Catawba*, CLI-02-26, 56 NRC at 365 (“Particularly in the case of a license renewal application, where reactor operation will continue for many years regardless of the Commission’s ultimate decision, it is sensible not to devote resources to the likely impact of terrorism during the license renewal period, but instead to concentrate on how to prevent a terrorist attack in the near term at the already licensed facilities”); *Pacific Gas and Electric Co.* (Diablo Canyon Nuclear Power Plant, Units 1 and 2), CLI-02-16, 55 NRC 317, 343 (2002) (terrorist attacks are neither caused by nor result from the proposed license transfers).

Although we decline to consider terrorism in the context of NEPA, the Commission is devoting substantial time and agency resources to combating the potential for terrorism involving nuclear facilities and materials. The NRC Staff is conducting a comprehensive review of our security and safeguards measures, including measures concerning interim spent fuel storage at power reactor sites. We have also instituted interim upgrades in security requirements for our licensees, and we are working with numerous other government agencies to meet and minimize the threat of terrorism.

III. CONCLUSION

We *accept* the Board's referral of the terrorism aspects of four environmental contentions and issues and *affirm* the Board's decision to reject consideration of the terrorism issues presented in this proceeding.

IT IS SO ORDERED.

For the Commission²⁵

ANNETTE L. VIETTI-COOK
Secretary of the Commission

Dated at Rockville, Maryland,
this 23d day of January 2003.

²⁵ Commissioner Dicus was not present for the affirmation of this Order. If she had been present, she would have approved it.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:

Alan S. Rosenthal, Presiding Officer
Dr. Richard F. Cole, Special Assistant

In the Matter of

Docket No. 70-143-MLA
(ASLBP No. 02-803-04-MLA)

NUCLEAR FUEL SERVICES, INC.
(Erwin, Tennessee)

January 31, 2003

MEMORANDUM

**(Further Explanation of the Basis for the
January 21, 2003 Order Holding Proceeding in Abeyance)**

On January 21, 2003, I entered an order (attached hereto) holding further proceedings in this matter in abeyance pending certain forthcoming events. Because there appeared to be good reason to make that action known before there was time to prepare a fuller explanation of the basis for it, the January 21 order stated that one would be supplied at a later date. The purpose of this Memorandum is to provide that explanation.

I. BACKGROUND

1. On February 28, 2002, Nuclear Fuel Services, Inc. (Licensee) filed an application for an amendment to its Special Nuclear Materials License (SNM-124) that would authorize the storage of low-enriched uranium-bearing materials in the Uranyl Nitrate Building located at Licensee's Erwin, Tennessee site. That proposed amendment is associated with the portion of the Blended Low-Enriched

Uranium (BLEU) Project that is to be conducted at that site. On July 9, 2002, the NRC Staff published in the *Federal Register* a notice in connection with the proposed amendment. 67 Fed. Reg. 45,555. The notice described the BLEU Project as being a part of a Department of Energy program to reduce stockpiles of surplus high-enriched uranium through reuse or disposal as radioactive waste. In addition, it noted that the license amendment addressed in the application at hand was but the first of three amendments that the Licensee would seek in connection with aspects of the project. Specific reference was made in this regard to the construction and operation of an Oxide Conversion Building; the construction and operation of a new Effluent Processing Building; and the relocation of downblending operations in a BLEU Preparation Facility.

Despite the fact that only a portion of the overall BLEU project was covered by the amendment application then before the NRC Staff, the July 9 notice pointed out that, to avoid segmentation of the environmental review, the Licensee had submitted environmental documentation for all three amendments. Accordingly, the Staff had embarked upon an environmental assessment (EA) of the entire project. The notice stressed, however, that that assessment did not serve as authorization for any proposed activities and that, as each amendment application was submitted, the Staff would perform a separate safety evaluation. It added:

As part of the safety evaluation, the NRC will perform an environmental review. If the review indicates that this EA appropriately and adequately assesses the environmental effects of the proposed action, then no further assessment will be performed. However, if the environmental review indicated that this EA does not evaluate fully the environmental effects, another EA [or environmental impact statement (EIS)] will be prepared in accordance with the National Environmental Policy Act (NEPA).

Following this introduction, the July 9 notice went on to summarize the content of the EA, which had produced the conclusion that “the environmental impacts associated with the proposed action would not be significant and do not warrant the preparation of an Environmental Impact Statement.” Accordingly, the Staff had determined that a Finding of No Significant Impact (FONSI) was appropriate. *Id.* at 45,556-58.

Finally, the July 9 notice provided an opportunity for a hearing on the proposed license amendment then in hand. *Id.* at 45,558. Nowhere in the notice, however, was there to be found either the date upon which the application for the amendment had been filed or any information as to how the content of the application might be located.

2. Several hearing requests were filed in response to the July 9 notice and opposed by the Licensee on the ground that none of them satisfied the requirements imposed by Subpart L of the Commission’s Rules of Practice, which sets forth

the informal hearing procedures applicable to materials license proceedings such as this one. See 10 C.F.R. § 2.1205(e) and (h). One of the requests pointed specifically to the omissions in the notice pertaining to the application. That led to the issuance of an unpublished order on September 11 calling upon the NRC Staff to address the question of the adequacy of the notice.

The Staff's September 19 response acknowledged that the July 9 notice was defective and that, as a consequence, a revised notice providing a fresh opportunity for hearing would be published in the *Federal Register*. Such a notice surfaced on October 30 (67 Fed. Reg. 66,172) and received a minor correction on November 12 (67 Fed. Reg. 68,699). In response to that notice, some (but not all) of the prior requestors filed new hearing requests and, in addition, a hearing request was received from someone who had not responded to the July notice.

3. In the wake of the publication of the October 30 revised notice, but before the receipt of the new hearing requests in response thereto, the Licensee filed on November 12 a motion in which it sought a ruling that that notice required the then-existing hearing requestors and those additional ones taking advantage of the notice to address the entire EA. According to the Licensee, the requestors should be precluded from raising concerns regarding the EA when, at some later point, the second and third license amendment applications were to come before the NRC Staff for its consideration.

In a solicited November 18 response, the Staff took the position that the scope of the hearing was necessarily limited to areas of concern related to the February 2002 license amendment application then before me and could not extend to areas of concern that related to future license amendment applications. In that connection, the Staff noted that, given that it did not notice the entire BLEU project or either the second or third license amendment, the October 30 *Federal Register* publication could not serve to bar the future assertion of environmental issues by persons having an interest in the project but not in the first license amendment. Thus, the Staff observed, requiring the current hearing requestors to raise all of their areas of concern related to the EA in advance of the submission of the second and third license amendment applications would not accomplish the Licensee's desire to avoid repetitious litigation. In a November 19 order (unpublished), I found this analysis persuasive and determined (at 3) "that the scope of the proceeding is limited to those safety and environmental areas of concern that directly relate to the February 2002 license amendment application."

4. One of the hearing requests in response to the October 30 revised *Federal Register* notice was filed on November 27 on behalf of Friends of the Nolichucky River Valley and three other organizations (hereafter collectively FNRV). It was accompanied by a motion to hold the proceeding in abeyance pending the submission of the additional license amendment applications. According to the motion, among other things a hearing at this time on any NEPA issues associated with the BLEU project would be premature as well as wasteful of the parties'

resources. In addition, the motion insisted that the safety issues that had been raised in the hearing request would be better considered in the context of the entire project.

In its December 13 response, the Licensee insisted that, given that it had not as yet been admitted to the proceeding, FNRV was not entitled to seek a postponement of further adjudicatory consideration. Additionally, the response took issue with the reasons assigned by those hearing requestors in support of a postponement.

For its part, in a December 6 letter reiterating its intention not to participate in the proceeding, the NRC Staff had noted in passing its agreement with FNRV, *et al.* that it would be more expeditious to postpone the proceeding pending the submission of all the related license amendment applications. In a December 17 order, I requested the Staff to advise Judge Cole and me whether it adhered to that view notwithstanding the Licensee's opposition. In a January 6 letter, the Staff took a different position. As the Staff then saw it, "the three amendments are each distinct and independent undertakings that may be analyzed and acted upon separately. There is no requirement that this proceeding be held in abeyance pending the receipt and analysis of the remaining amendments."

II. DISCUSSION

Upon a preliminary examination of the papers in hand with regard to the motion to hold the proceeding in abeyance, this much seemed quite clear. Irrespective of whether, as the Licensee maintained, the motion was 'unripe' because FNRV has not as yet been admitted as a party to the proceeding, nothing stood in the way of my providing the requested relief if that course appeared warranted in the totality of circumstances. The authority of the presiding officer in Subpart L proceedings is set forth in 10 C.F.R. § 2.1209 and is quite broad. That authority includes the power to "[r]egulate the course of the hearing . . . [d]ispose of procedural requests or similar matters . . . and [t]ake any other action consistent with the [Atomic Energy] Act and this chapter."

That being so, there appeared to be no present necessity to pass upon the validity of the Licensee's claim that the FNRV motion could not be entertained because the movants had not as yet achieved party status. Rather, what needed to be determined was whether, as a matter of sensible case management, there was compelling reason for the three license amendments to be considered together rather than piecemeal.

Because the papers on file did not appear to address that question adequately, Judge Cole and I decided to conduct a telephone conference with the parties and the NRC Staff on January 17. As the January 13 order scheduling the conference stated, the participants were to focus on two possible options.

The first would have Judge Cole and me move forward to pass upon the viability of the hearing requests now in hand with respect to the first license amendment application. If one or more of those requests were found to meet the requirements imposed by 10 C.F.R. § 2.1205(e) and (h), and without waiting for the outcome of any hearing requests filed with respect to the second and third proposed amendments, we would then address the merits of the viable challenges to the first amendment. The second option would have all hearing requests addressed to one or another of the three license amendments considered collectively after the expiration of the time for the filing of requests directed to the third amendment. Under that option, all viable challenges to aspects of the BLEU project would be jointly determined.

What was not said by the participants during the January 17 telephone conference was just as significant as what was said. For his part, Licensee's counsel stressed that the three license amendments were independent in the sense that they involved different buildings and different processes (Tr. 34). At no point during the conference, however, did he offer any practical reason why it would be more expeditious to adjudicate the challenges to the BLEU project piecemeal, rather than as an entity once the third license amendment application was filed in the projected May-June 2003 time frame.¹ In this connection, the Licensee did not appear to take issue with the assertion of FNRV (Tr. 7-8) that those challenges involved global environmental and safety issues. On that score, FNRV counsel referred specifically to concerns regarding the Licensee's past operating history insofar as environmental protection was concerned, as well as to safety concerns in the area of financial assurance and management capabilities.

For its part, the Staff clarified the seeming inconsistency between the position on deferral taken in its December 6 letter and that later advanced in its January 6 filing. According to its counsel, the Staff was of the view that the adoption of either option was acceptable and therefore it was not specifically pressing for the acceptance of one or the other. As summarized by counsel (Tr. 19):

It is the staff's position now — and we have always maintained — there could be some efficiency in holding this proceeding in abeyance for the simple reason that one proceeding, as opposed to three, would likely be a little more efficient.

¹ Counsel hypothesized that a hearing request might be filed with regard to the second amendment application by someone with an interest restricted to the activities covered by that application (Tr. 14-15). If that requestor had a sufficient reason not to wish the consideration of its request deferred until the receipt of the third license amendment application, it would be free to bring that fact to my attention.

However, it is also our position, both then and now, that the projects are independent, such that they could be dealt with in separate proceedings.²

Apart from the fact that neither the Licensee nor the Staff provided any good practical reason to conduct a piecemeal adjudication of the challenges to the overall BLEU project — and the Staff perceived some advantage in unitary adjudication — both counsel also professed a lack of awareness of any prior instance of a single project being segmented in this fashion (Tr. 16, 21).³ Nor is either Judge Cole or this presiding officer aware of such an instance. That is not to say, however, that a like attempt at segmentation might not have been possible in other material license proceedings.

I made reference during the conference (Tr. 21-22) to the case that Judge Cole and I recently had before us involving receipt at the International Uranium (USA) Corporation's White Mesa Mill in Utah of alternate feed material originating at a site in California. See *International Uranium (USA) Corp. (White Mesa Uranium Mill)*, LBP-02-19, 56 NRC 113 (2002). The sought license amendment contemplated that the Licensee would, among other things, process the received material to extract its uranium content and then store the residue in onsite tailing cells. Although a single license amendment application was filed that covered the entire project, no apparent reason exists why, as transpired here, the Licensee could not have instead elected to file separate applications, each addressed to a different phase of the project. Had it done so, however, it is scarcely likely that any serious thought would have been given to adjudicating separately the various phases. This would have been so even though there were independent concerns advanced by the intervenors with regard to the receipt and residue disposition portions of the overall undertaking.

In sum, following the telephone conference it seemed manifest to Judge Cole and to me that, although nothing would preclude moving forward on the first license amendment at this time, on balance the better course was the deferral

² Staff counsel did acknowledge that, although independent, the projects were interrelated (Tr. 18).

³ Although the Licensee maintained that the segmentation here was at the Staff's suggestion, Staff counsel responded that such was not the case (Tr. 16, 17).

directed in my January 21 order in the exercise of the authority conferred upon me by 10 C.F.R. § 2.1209.⁴

BY THE PRESIDING OFFICER⁵

Alan S. Rosenthal
ADMINISTRATIVE JUDGE

Rockville, Maryland
January 31, 2003

⁴ As at least implicitly acknowledged in my January 21 issuance, there is the possibility that, acting pursuant to 10 C.F.R. § 2.1207(a), the Commission or the Chief Administrative Judge might assign hearing requests addressed to either or both the second and third license amendment applications to a different presiding officer for adjudication. In that event, a motion to reconsider the deferral action taken by me might well be in order.

⁵ Copies of this Memorandum were sent this date by e-mail transmission to the counsel or other representative of each of the participants in the proceeding, as well as to counsel for the NRC Staff.

ATTACHMENT

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:

Alan S. Rosenthal, Presiding Officer
Dr. Richard F. Cole, Special Assistant

In the Matter of

Docket No. 70-143-MLA
(ASLBP No. 02-803-04-MLA)

NUCLEAR FUEL SERVICES, INC.
(Erwin, Tennessee)

January 21, 2003

ORDER

(Directing the Holding of the Proceeding in Abeyance)

This license amendment proceeding being conducted under Subpart L of the Commission's Rules of Practice, 10 C.F.R. § 2.1201 *et seq.*, involves the portion of the Blended Low-Enriched Uranium (BLEU) project that is to be performed on the Nuclear Fuel Services, Inc. (Licensee) site in Erwin, Tennessee. Rather than cover all activities associated with the project in a single comprehensive license amendment application, the Licensee has chosen to address them in three separate amendment applications.

The first application was submitted early last year but not properly noticed in the *Federal Register* until the end of October (*see* 67 Fed. Reg. 66,172 (Oct. 30, 2002)). It led to the filing of several hearing requests, all of which are opposed by the Licensee. The second amendment application, submitted in October, received its *Federal Register* notice of opportunity for hearing earlier this month and the deadline for filing hearing requests in response to that notice is February 6, 2003. *See* 68 Fed. Reg. 796 (Jan. 7, 2003). The third application apparently will not be submitted to the NRC Staff for several additional months.

At current issue is whether all further adjudicatory action should now be held in abeyance until the third license amendment has been submitted to the Staff and the time established in a *Federal Register* notice for the filing of hearing requests with regard thereto has expired.¹ Stated otherwise, Judge Cole and I are called upon to decide whether the three proposed license amendments and the challenges to them should be adjudicated piecemeal or, instead, collectively once all are in hand.

We have given full consideration to the arguments advanced in favor of and in opposition to each option, as those arguments were presented in written submissions as well as at a telephone conference held with the parties and the NRC Staff on January 17, 2003. On the basis of that consideration, it is hereby directed *sua sponte* in the exercise of the authority conferred upon the Presiding Officer by 10 C.F.R. § 2.1209:

1. All further action with regard to the hearing requests now on file pertaining to the first license amendment shall abide the event of the filing of the third license amendment application and the expiration of the period set forth in the *Federal Register* notice of opportunity for hearing pertaining to that proposed amendment.
2. Assuming that any hearing requests filed in response to the now-pending second license amendment application are assigned to this presiding officer, the consideration of those requests similarly shall be held in abeyance.
3. Hearing requests addressed to the second or third license amendment application may incorporate by reference all or a part of any hearing request previously filed by that hearing requestor.

Because, as above noted, the deadline for the filing of hearing requests addressed to the second proposed amendment rapidly approaches, it seems advisable to announce this determination without further delay. A memorandum setting forth in greater detail the basis for the determination will issue later. It suffices for present purposes to note that Judge Cole and I are convinced that, in the totality of circumstances, it makes good sense from a case management standpoint to consider all aspects of the BLEU project as an entity.

¹ Although that issue surfaced in the form of a motion on the part of one group of hearing requestors, Judge Cole and I deemed it worthy in any event of consideration on our own initiative.

IT IS SO ORDERED

BY THE PRESIDING OFFICER²

Alan S. Rosenthal
ADMINISTRATIVE JUDGE

Rockville, Maryland,
January 21, 2003

² Copies of this Order were sent this date by e-mail transmission to the counsel or other representative of each of the participants in the proceeding, as well as to counsel for the NRC Staff.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

COMMISSIONERS:

Richard A. Meserve, Chairman
Greta Joy Dicus
Nils J. Diaz
Edward McGaffigan, Jr.
Jeffrey S. Merrifield

In the Matter of

Docket Nos. 50-275-LT
50-323-LT

PACIFIC GAS AND ELECTRIC
COMPANY
(Diablo Canyon Nuclear Power Plant,
Units 1 and 2)

February 14, 2003

The Commission rejects Petitioners' technical, financial, and antitrust claims and terminates this license transfer proceeding.

RULES OF PRACTICE: INTERVENTION (STANDING)

LICENSE TRANSFER

To demonstrate standing in a Subpart M license transfer proceeding, the petitioner must (1) identify an interest in the proceeding by (a) alleging a concrete and particularized injury (actual or threatened) that (b) is fairly traceable to, and may be affected by, the challenged action (here, the grant of a license transfer application), and (c) is likely to be redressed by a favorable decision, and (d) lies arguably within the "zone of interests" protected by the governing statute(s) (here, the AEA); (2) specify the facts pertaining to that interest.

**RULES OF PRACTICE: CONTENTIONS (ADMISSIBILITY);
INTERVENTION (ADMISSIBILITY OF ISSUES)**

LICENSE TRANSFER

Our procedural rules require petitioners to articulate at least one detailed threshold issue in order to qualify for an agency hearing. We will not consider vague, unparticularized issues. To demonstrate that issues are admissible in a Subpart M proceeding, a petitioner must: (1) set forth the issues (factual and/or legal) that petitioner seeks to raise; (2) demonstrate that those issues fall within the scope of the proceeding; (3) demonstrate that those issues are relevant to the findings necessary to a grant of the license transfer application; (4) show that a genuine dispute exists with the applicant regarding the issues; and (5) provide a concise statement of the alleged facts or expert opinions supporting the petitioner's position on such issues, together with references to the sources and documents on which petitioner intends to rely.

RULES OF PRACTICE: LATE-FILED PLEADINGS

Despite the fact that a pleading is unauthorized under our procedural rules, we find that it contains information that assists us in our determination of the antitrust issues in this proceeding, and we therefore grant the party's request for permission to file that pleading.

**RULES OF PRACTICE: CONTENTIONS (ADMISSIBILITY);
INTERVENTION (ADMISSIBILITY OF CONTENTIONS)**

Overly general issues violate our prescription against petitioners submitting vague, unparticularized issues. As we have stated repeatedly, NRC practice demands detailed explanation and support for initial issues or contentions; "notice pleading" does not suffice. Our jurisprudence makes it clear that parties must support their arguments with facts, policy discussion, or legal authority.

ENFORCEMENT

We have long declined to assume that licensees will refuse to meet their obligations under their licenses or our regulations. This includes their obligations regarding technical qualifications. If, however, the Commission finds that "a licensee's staff reductions or other cost-cutting decisions result in its being out of compliance with NRC regulations, then . . . the agency can and will take the necessary enforcement action to ensure the public health and safety." *GPU*

Nuclear Inc. (Oyster Creek Nuclear Generating Station), CLI-00-6, 51 NRC 193, 209 (2000).

RULES OF PRACTICE: ABEYANCE OF PROCEEDING

LICENSE TRANSFER: ABEYANCE OF PROCEEDING

“[I]t would be productive of little more than untoward delay were each regulatory agency to stay its hand simply because of the contingency that one of the others might eventually choose to withhold a necessary permit or approval.” See *Pacific Gas and Electric Co.* (Diablo Canyon Nuclear Power Plant, Units 1 and 2), CLI-02-16, 55 NRC 317, 334 (2002) (footnote and internal quotation marks omitted), *petition for judicial review pending*, No. 02-72735 (9th Cir.). Also, such a delay would contravene our more general policy of expediting license transfer proceedings. *Id.* at 343; Final Rule, “Streamlined Hearing Process for NRC Approval of License Transfers,” 63 Fed. Reg. 66,721 (Dec. 3, 1998); *Statement of Policy on Conduct of Adjudicatory Proceedings*, CLI-98-12, 48 NRC 18, 24 (1998).

ANTITRUST

**RULES OF PRACTICE: CONTENTIONS (ADMISSIBILITY);
INTERVENTION (ADMISSIBILITY OF CONTENTIONS)**

LICENSE TRANSFER

A careful reading of Atomic Energy Act sections 105c(5) and 105c(6) shows that Congress linked NRC’s antitrust authority to the specific license under antitrust review — and to *that license only*. The first of these sections provides that the Commission “shall make a finding as to whether *the activities under the license* would create or maintain a situation inconsistent with the antitrust laws” 42 U.S.C. § 2135(c)(5) (emphasis added). Once we have made the finding required under section 105(c)(5), we have the authority under section 105(c)(6) to take certain specified licensing actions — i.e., “to issue or continue *a license as applied for*, to refuse to issue a license, to rescind a license or amend it, and to issue a license with such conditions as [the NRC] deems appropriate.” 42 U.S.C. § 2135(c)(6) (emphasis added).

As for the antitrust conditions at issue in the instant proceeding, the “license as applied for” was the construction permit for PG&E’s proposed Stanislaus facility, and the “activities” that triggered the Diablo Canyon Power Plant (“DCPP”) antitrust conditions, via a settlement, were PG&E’s potential activities under the Stanislaus license. In the end, however, we never issued a license for the proposed Stanislaus plant — as PG&E eventually abandoned the project. See

Pacific Gas and Electric Co. (Stanislaus Nuclear Project, Unit 1), LBP-83-2, 17 NRC 45 (1983) (granting PG&E’s motion to withdraw the Stanislaus application). In the absence of a Stanislaus license, either actual or proposed, we now lack the statutorily referenced license for which the AEA authorizes “such [antitrust] conditions as [we] deem appropriate.”

The AEA gives the NRC no separate authority, independent of the Stanislaus proceeding, to impose antitrust license conditions on PG&E with respect to DCP. This is because DCP was licensed pursuant to section 104 of the AEA — a section excluding license applicants for “research and development” plants, such as DCP, from antitrust review (except under circumstances not present here). See AEA § 105(c)(3), 42 U.S.C. § 2135(c)(3). The Commission’s initial authority to impose antitrust conditions on PG&E came from the now-defunct Stanislaus proceeding (a license review based on an application submitted under section 103). Now that it is clear that the section 103 Stanislaus proceeding will not be reopened, we lack an antitrust “hold” on PG&E.

We see no legal underpinning for transferring the Stanislaus-triggered DCP antitrust conditions to new entities to be created under the proposed PG&E reorganization plan. This legal conclusion is particularly compelling in light of our obligation to respect our congressional grant of authority. *Adams Fruit Co. v. Barrett*, 494 U.S. 638, 650 (1990), quoting *Federal Maritime Commission v. Seatrain Line, Inc.*, 411 U.S. 726, 745 (1973). See also *Pratt & Whitney Aircraft v. Donovan*, 715 F.2d 57, 62 (2d Cir. 1983); *Office of Consumers’ Counsel v. Federal Energy Regulatory Commission*, 655 F.2d 1132, 1142 (D.C. Cir. 1980); *Utz v. Cullinane*, 520 F.2d 467, 490 (D.C. Cir. 1975).

As we indicated at length in *Wolf Creek*, sound policy reasons argue against taking an expansive view of our antitrust authority. Here, were we to transfer DCP’s current antitrust conditions to new independent PG&E spinoffs, we would be placed in the position of enforcing antitrust conditions against at least one company with no connection at all to the nuclear power plant. We simply lack the resources and expertise necessary to handle antitrust matters that do not fall squarely within our jurisdiction. By contrast, FERC and the Federal Trade Commission (as economic regulatory bodies) — together with the Department of Justice and the federal courts — have the resources and mission (the NRC is primarily a safety regulator) to deal with antitrust issues such as those that concern Petitioners.

As we stated in *Wolf Creek*: “Once a nuclear facility is licensed to operate, traditional antitrust forums — the federal courts and governmental agencies with longstanding antitrust expertise — are better equipped than the Commission to resolve and remedy antitrust violations by NRC licensees.” *Kansas Gas & Electric Co.* (Wolf Creek Generating Station, Unit 1), CLI-99-19, 49 NRC 441, 452 (1999). “For this Commission to use its scarce resources needed more to fulfill our primary statutory mandate to protect the public health and safety and

the common defense and security than to duplicate other antitrust reviews and authorities makes no sense and only impedes nationwide efforts to streamline and make more efficient the federal government.” *Id.* at 465. *See also id.* at 463; *Houston Lighting and Power Co.* (South Texas Project, Units 1 and 2), CLI-77-13, 5 NRC 1303, 1316-17 (1977); Final Rule, “Nuclear Power Plant License Renewal,” 56 Fed. Reg. 64,943, 64,971 (Dec. 13, 1991).

The age of the DCPD conditions and recent developments in the law (in particular, those providing for nondiscriminatory open access to transmission, *see New York v. Federal Energy Regulatory Commission*, 535 U.S. 1 (2002) (upholding FERC’s open access requirements)) are practical factors cutting against the carryover of the original PG&E conditions to the new situation created by the PG&E reorganization plan (presuming that it gains approval). Hence, we decline to reenact the DCPD antitrust conditions as part of the DCPD license transfer, and we instruct our Staff not to include those conditions if it otherwise approves the PG&E transfer application.

Our ruling today does not preclude Petitioners from enforcing their antitrust-related rights under the Stanislaus Commitments. As beneficiaries of the Stanislaus settlement contracts, they can enforce those contracts quite apart from any NRC license conditions. No participant in this proceeding has given us any reason to doubt the enforceability of the Stanislaus Commitments either in federal court or before the FERC. Indeed, both a federal district court and FERC have described the Commitments as a contract, and each considers the Commitments enforceable in its own forum. *See United States v. Pacific Gas and Electric Co.*, 714 F. Supp. 1039, 1047 n.13, 1050-51, 1054 (N.D. Cal. 1989), *appeals dismissed per stipulation*, No. 91-16011 (9th Cir. Mar. 20, 1992); *Pacific Gas and Electric Co.*, 49 FERC ¶61,116, 1989 WL 262814 at text associated with n.14 (no WL pagination available) (FERC) (Commission 1989).

MEMORANDUM AND ORDER

Today, in this license transfer proceeding, we reject on their merits the antitrust-based portions of the petitions to intervene and requests for hearing filed by the Northern California Power Agency (“NCPA”) and the following group of entities: the Transmission Agency of Northern California, M-S-R Public Power Agency, Modesto Irrigation District, the California Cities of Santa Clara, Redding, and Palo Alto, and the Trinity Public Utility District (collectively, “TANC”). We find that legal and policy considerations preclude transfer of antitrust conditions originally imposed in 1978 on the licenses for Diablo Canyon Nuclear Power Plant, Units 1 and 2 (collectively, “DCPD”). Further, we find inadmissible TANC’s challenges to the transferees’ technical and financial qualifications to

operate DCP. Our decision on the TANC and NCPA petitions completes our consideration of adjudicatory issues in this case.¹ We accordingly terminate the proceeding.

I. BACKGROUND

This proceeding involves an application seeking the Commission's authorization for Pacific Gas and Electric Company ("PG&E") to transfer its licenses for DCP² in connection with a comprehensive Plan of Reorganization which PG&E filed under Chapter 11 of the United States Bankruptcy Code. Under the restructuring plan that PG&E submitted to the Bankruptcy Court, the licenses would be transferred to a new generating company named Electric Generation LLC ("Gen"), which would operate DCP, and to a new wholly owned subsidiary of Gen named Diablo Canyon LLC ("Diablo Nuclear"), which would hold title to DCP and lease it to Gen. Other components of the restructuring include the transfer of both the majority of PG&E's electric transmission business to ETrans LLC ("ETrans") and the majority of its gas transmission assets and liabilities to GTrans LLC ("GTrans")³ — both newly created companies.

The application proposes that, solely for antitrust purposes, the NRC licensees would be Gen, ETrans, PG&E, and Diablo Nuclear. The first three of these would be jointly and severally responsible for compliance with certain antitrust conditions (described in Section III.C, *infra*) in the current DCP licenses.⁴ The NRC Staff, however, in its *Federal Register* notice of the DCP application,⁵

¹ We previously denied all other petitions to intervene. See *Pacific Gas and Electric Co.* (Diablo Canyon Nuclear Power Plant, Units 1 and 2), CLI-02-16, 55 NRC 317 (2002), *petition for judicial review pending*, No. 02-72735 (9th Cir.).

² See 42 U.S.C. § 2234; 10 C.F.R. § 50.80.

³ Both ETrans and GTrans would also become indirect wholly owned subsidiaries of PG&E Corporation (the current parent of, and not to be confused with, PG&E), which will change its name. PG&E would retain most of the remaining assets and liabilities and would continue to conduct local electric and gas distribution operations and related customer services. After disaggregation of the businesses, PG&E Corporation would declare a dividend and distribute the common stock of PG&E to its public shareholders, thus separating PG&E from PG&E Corporation. PG&E expects that the value realized will provide cash and increased debt capacity to enable it to repay creditors, restructure existing debt, and emerge from the bankruptcy. See CLI-02-16, 55 NRC at 332 n.2.

⁴ PG&E's Brief in Response to Commission Memorandum and Order CLI-02-12, dated May 10, 2002, at 3-4, 15. The antitrust conditions themselves are appended to that Brief as Attachment B at 1 ("Antitrust Conditions: Facility Operating License No. DPR-80").

⁵ We refer throughout this Memorandum and Order to "[t]he NRC Staff['s] . . . *Federal Register* notice" or "the NRC Staff's proposal" because it was drafted and signed by a member of the agency's staff, albeit "[f]or the Nuclear Regulatory Commission." See 67 Fed. Reg. 2455, 2456 (Jan. 17, 2002).

indicated that it might transfer the antitrust conditions to only Diablo Nuclear and Gen because they would be the only entities with authority to possess or operate DCP. ⁶

In response to the published notice of the DCP application, the Commission received five petitions to intervene and requests for hearing. The Petitioners were the Official Committee of Unsecured Creditors of PG&E (“Committee”), the California Public Utilities Commission (“CPUC”), the County of San Luis Obispo (“County”), NCPA, and TANC. The Committee expressed interest in the financial qualifications of the future licensees but supported PG&E’s proposed reorganization plan. CPUC opposed the transfer of the two licenses to the extent that the transfer would proceed according to PG&E’s proposed plan. The County was concerned about the technical and financial qualifications of the transferees and ETrans. Neither CPUC, the Committee, nor the County raised any antitrust issues. TANC and NCPA, however, expressed concerns primarily about the NRC Staff’s proposal to grant licensee status to only Gen and Diablo Nuclear. TANC and NCPA believe that this proposed approach would have the effect of eliminating the antitrust conditions in the current licenses. TANC also raised issues involving the transferees’ financial and technical qualifications. Pursuant to 10 C.F.R. § 2.1316, the NRC Staff is not a party to this proceeding.

On June 25, 2002, we issued an order (CLI-02-16, *supra* note 1) denying the intervention petitions of CPUC, the Committee, and the County, but granting CPUC and the County “governmental participant” status (entitling them to participate in the proceeding if, but only if, we were subsequently to grant a hearing to another petitioner).⁷ But we deferred ruling on the intervention petitions of NCPA and TANC. Today we address their petitions.

To intervene as of right in a license transfer proceeding, a petitioner must demonstrate standing, i.e., that its “interest may be affected by the proceeding,”⁸ and must raise at least one admissible issue.⁹ We conclude that NCPA and TANC have each demonstrated standing and raised an admissible antitrust issue. We therefore grant their petitions to intervene. We find, however, that as their antitrust issues are ones of law rather than fact, we can resolve them on the basis of the current record. We therefore deny NCPA’s and TANC’s requests for hearing.

⁶ *See id.*

⁷ CLI-02-16, 55 NRC at 345, 349 (permitting participation analogous to that authorized under 10 C.F.R. § 2.715(c)).

⁸ AEA § 189a, 42 U.S.C. § 2239(a); *Diablo Canyon*, CLI-02-16, 55 NRC at 335 & n.17.

⁹ 10 C.F.R. § 2.1306; *Diablo Canyon*, CLI-02-16, 55 NRC at 335 & n.18.

II. STANDING

To demonstrate standing in a Subpart M license transfer proceeding, the petitioner must

- (1) identify an interest in the proceeding by
 - (a) alleging a concrete and particularized injury (actual or threatened) that
 - (b) is fairly traceable to, and may be affected by, the challenged action ([here,] the grant of [a license transfer] application), and
 - (c) is likely to be redressed by a favorable decision, and
 - (d) lies arguably within the “zone of interests” protected by the governing statute(s) [here, the AEA].
- (2) specify the facts pertaining to that interest.¹⁰

NCPA rests its claim of standing on its status as a third-party beneficiary of the Stanislaus Commitments (a 1976 antitrust agreement between PG&E and the United States Department of Justice which the Commission incorporated into DCP’s license conditions 2 1/2 years later) which protect the economic interests of NCPA’s members.¹¹ PG&E acknowledges that NCPA has an interest in raising antitrust issues in this proceeding¹² and no other party opposes NCPA’s claim of standing. We likewise conclude that NCPA has standing as a beneficiary of antitrust license conditions at issue in this proceeding.

TANC uses PG&E’s scheduling, generation, and transmission services¹³ and claims standing based on, *inter alia*, antitrust interests quite similar to those of NCPA.¹⁴ PG&E acknowledges that TANC, like NCPA, has an interest in raising

¹⁰ See 10 C.F.R. §§ 2.1306, 2.1308; *Diablo Canyon*, CLI-02-16, 55 NRC at 336; *GPU Nuclear, Inc.* (Oyster Creek Nuclear Generating Station), CLI-00-6, 51 NRC 193, 202 (2000), and references cited therein.

¹¹ NCPA’s Petition To Intervene, dated Feb. 6, 2002, at 3-5. The Stanislaus Commitments and their incorporation into the DCP licenses are described in greater detail both at pages 30 *et seq.*, *infra*, and in DD-90-3, 31 NRC 595, 597 (1990), and were published in “Receipt of Attorney General’s Advice and Time for Filing of Petitions To Intervene on Antitrust Matters,” 41 Fed. Reg. 20,225, 20,226-28 (May 17, 1976). The Commitments were supplemented by a 1991 settlement agreement between PG&E and NCPA in an NRC proceeding. The settlement extended the contract’s term until at least January 1, 2050. See TANC’s Additional Comments, dated Sept. 23, 2002, at 4 n.2, 5, 7. TANC’s Sept. 23d pleading, despite being unauthorized under our procedural rules, contains information that assists us in our determination of the antitrust issues in this proceeding, and we therefore grant TANC’s request for permission to file that pleading, *id.* at 1-2.

¹² PG&E’s Answer to NCPA’s Conditional Request for Hearing, dated Feb. 15, 2002, at 9.

¹³ TANC’s Petition To Intervene, dated Feb. 6, 2002, at 6-10, 12.

¹⁴ *Id.* at 12, 13.

antitrust issues¹⁵ and no other party challenges TANC's claim of standing. We agree that TANC has standing.

III. SUBSTANTIVE ISSUES

A. Standards for Admission of Substantive Issues

Our rules specify that, to demonstrate that issues are admissible in a Subpart M proceeding, a petitioner must

- (1) set forth the issues (factual and/or legal) that petitioner seeks to raise,
- (2) demonstrate that those issues fall within the scope of the proceeding,
- (3) demonstrate that those issues are relevant to the findings necessary to a grant of the license transfer application,
- (4) show that a genuine dispute exists with the applicant regarding the issues, and
- (5) provide a concise statement of the alleged facts or expert opinions supporting the petitioner's position on such issues, together with references to the sources and documents on which petitioner intends to rely.¹⁶

Our procedural rules require petitioners to articulate at least one detailed threshold issue in order to qualify for an agency hearing.¹⁷ We will not consider vague, unparticularized issues.¹⁸ Applying these standards, we now turn to the two categories of issues raised by TANC and/or NCPA.

B. Financial and Technical Qualifications Issues

TANC expresses concern that Gen may be unable to meet its decommissioning obligations or its operating expenses, particularly as the prices it charges for electricity are set by contract for 12 years and are therefore not subject to rate increases which would enable Gen to pass along excess costs to its customers.¹⁹ In a related concern, TANC also worries that Gen may make no contributions

¹⁵ PG&E's Answer to TANC's Petition To Intervene, dated Feb. 15, 2002, at 7.

¹⁶ See 10 C.F.R. § 2.1306; *Diablo Canyon*, CLI-02-16, 55 NRC at 338 & n.32, citing *Consolidated Edison Co. of New York* (Indian Point, Units 1 and 2), CLI-01-19, 54 NRC 109, 133-34 (2001).

¹⁷ *Diablo Canyon*, CLI-02-16, 55 NRC at 338 & n.34, citing *Power Authority of the State of New York* (James A. FitzPatrick Nuclear Power Plant; Indian Point, Unit 3), CLI-00-22, 52 NRC 266, 295 (2000), and *Vermont Yankee Nuclear Power Corp.* (Vermont Yankee Nuclear Power Station), CLI-00-20, 52 NRC 151, 164 (2000).

¹⁸ *Diablo Canyon*, CLI-02-16, 55 NRC at 338 & n.34, citing *FitzPatrick*, CLI-00-22, 52 NRC at 295.

¹⁹ TANC's Petition To Intervene at 13-14, 21.

to the decommissioning trust fund.²⁰ Further, TANC asserts that PG&E may not assign to Gen sufficient personnel with the required technical qualifications to operate the plant in accordance with the licenses' requirements.²¹ Finally, TANC asserts that the review of the Reorganization Plan by multiple forums²² "create[s] a shifting sand foundation on which to make any decision regarding the license [transfer] application."²³

In our view, none of TANC's issues is admissible. All are overly general and therefore do not satisfy our requirement that petitioners not submit vague, unparticularized issues.²⁴ As we have stated repeatedly, NRC practice demands detailed explanation and support for initial issues or contentions; "notice pleading" does not suffice.²⁵ TANC's issues do not meet this standard.

We reject as unsupported the "financial qualifications" portion of TANC's first issue (the possible insufficiency of Gen's rates to cover its operating and decommissioning costs). TANC's arguments are footed in neither facts nor expert opinion, and do not address the relevant portions of PG&E's application.²⁶ Moreover, this portion of TANC's first issue appears merely to be an abbreviated version of the previously resolved "financial qualifications" issue raised by CPUC, i.e., that "Gen's finances are 'highly questionable' and it is 'uncertain that Gen will have the resources to carry out the critical plant maintenance and public safety-related functions that will enable [DCPP] to meet the Commission's rigorous regulatory requirements.'"²⁷ We therefore also reject this portion of TANC's first issue on the same grounds as we rejected the CPUC's similar but far more detailed position.²⁸

We similarly decline to admit the "decommissioning funding" portion of TANC's first issue, as it lacks sufficient factual or expert support. We also rely on the grounds we previously expressed in rejecting CPUC's similar issue — that because "PG&E does not have the legal authority to make this transfer, the proposed licensee will have no decommissioning funding assurance, and, therefore, the Commission cannot approve the requested license transfer."²⁹

²⁰ *Id.* at 21.

²¹ *Id.*

²² Specifically, the Bankruptcy Court, the Federal Energy Regulatory Commission, the Securities and Exchange Commission, CPUC, the Internal Revenue Service, and the NRC.

²³ TANC's Petition To Intervene at 21.

²⁴ See note 18, *supra*, and accompanying text.

²⁵ See *Dominion Nuclear Connecticut, Inc.* (Millstone Nuclear Power Station, Units 2 and 3), CLI-01-24, 54 NRC 349, 363 (2001); *Indian Point*, CLI-01-19, 54 NRC at 134.

²⁶ See Application at 8-10 (operating costs), 10-12 (decommissioning funding).

²⁷ CLI-02-16, 55 NRC at 338.

²⁸ See *id.* at 338-40.

²⁹ See *id.* at 340, 341-42.

Regarding TANC's second issue (that Gen intends not to contribute to the decommissioning trust fund), TANC has not demonstrated that the anticipated level of the decommissioning fund would be insufficient to satisfy the regulatory requirements of 10 C.F.R. § 50.75.³⁰ Nor has TANC provided us any reason (via submission of facts or expert opinion) to believe that Gen, if it becomes a licensee, would fail to meet its decommissioning funding obligations to supplement the current fund to the extent necessary to comply with section 50.75. We have long declined to assume that licensees will refuse to meet their obligations under their licenses or our regulations.³¹

TANC also has provided no factual or expert support for its third argument, that PG&E may not assign to Gen sufficient personnel with the required technical qualifications to operate the plant in accordance with the license requirements.³² Our jurisprudence makes it clear that parties may not submit summary conclusions, but must instead support their arguments with facts, policy discussion, or legal authority.³³ Further, as noted above, we assume that our licensees will comply with this agency's safety regulations — including those involving technical qualifications.³⁴ If the Commission finds that "a licensee's staff reductions or other cost-cutting decisions result in its being out of compliance with NRC regulations, then . . . the agency can and will take the necessary enforcement action to ensure the public health and safety."³⁵

³⁰We previously observed that "PG&E proposes to meet [the decommissioning funding obligations imposed by] section 50.75 by prepaying, by means of existing trust funds, an amount sufficient to cover the decommissioning costs at the expected time of termination of operation. . . . Prepayment is the strongest and most reliable of the funding devices described in 10 C.F.R. § 50.75(e)(1)." *Id.* at 342 n.50 (citations omitted). *See also* PG&E's Answer to TANC's Petition To Intervene, dated Feb. 15, 2002, at 18 ("assuming the present value of the [decommissioning] funds, plus credit for a contribution to the funds in 2002 as already approved through the CPUC ratemaking process, as well as a modest return over the operating license term as allowed by the regulations, the decommissioning trusts are adequately funded to meet the NRC-mandated decommissioning obligations *without further contributions*" (emphasis in original)); Application at 11 and Enclosure 9.

³¹*See, e.g., Oyster Creek*, CLI-00-6, 51 NRC at 207; *Curators of the University of Missouri* (TRUMP-S Project), CLI-95-8, 41 NRC 386, 400 (1995); *Northern Indiana Public Service Co.* (Bailly Generating Station, Nuclear-1), ALAB-207, 7 AEC 957, 958 (1974).

³²By contrast, PG&E has provided significant information indicating that TANC's concerns regarding technical qualifications are unfounded. *See* Application at 2, 4, 7-8; PG&E's Answer to TANC's Petition To Intervene, dated Feb. 15, 2002, at 19-20, *citing* Application at 7.

³³*See, e.g., Oyster Creek*, CLI-00-6, 51 NRC at 208 (petitioner "has offered no tangible information, no experts, no substantive affidavits. Instead, it has provided bare assertions and speculation. This is not enough to trigger an adversary hearing on [transferee's] financial qualifications"). *See also* note 25, *supra*, and accompanying text.

³⁴*See* 10 C.F.R. § 50.54(m).

³⁵*Oyster Creek*, CLI-00-6, 51 NRC at 209.

TANC's fourth ("shifting sand foundation") argument is in essence nothing more than a challenge to our policy of not delaying license transfer proceedings merely because another judicial or administrative forum simultaneously happens to be adjudicating a related matter.³⁶ As we recently reiterated in this very proceeding, "it would be productive of little more than untoward delay were each regulatory agency to stay its hand simply because of the contingency that one of the others might eventually choose to withhold a necessary permit or approval."³⁷ Also, such a delay would contravene our more general policy of expediting license transfer proceedings.³⁸ TANC's cursory argument lacks any factual, legal, or policy support that would convince us to suspend these policies here.

C. Antitrust Issues

1. Background

The antitrust arguments in NCPA's and TANC's petitions are unusual in that they do not challenge PG&E's license transfer application but instead dispute the NRC Staff's suggestion in the *Federal Register* notice that the NRC might reject PG&E's proposed treatment of the antitrust conditions, known as the Stanislaus Commitments, that are currently included in PG&E's DCPD licenses. The Stanislaus Commitments arose out of a 1976 settlement between the United States Department of Justice and PG&E regarding antitrust issues related to PG&E's then-proposed Stanislaus nuclear power plant.³⁹ PG&E had agreed at the time to attach those commitments as license conditions for DCPD if the Stanislaus facility were not licensed and constructed in accordance with PG&E's original plans.⁴⁰ Accordingly, the Stanislaus Commitments became amendments to the DCPD

³⁶ See *Diablo Canyon*, CLI-02-16, 55 NRC at 334; *Consolidated Edison Co. of New York* (Indian Point, Units 1 and 2), CLI-01-8, 53 NRC 225, 229-30 (2001); *FitzPatrick*, CLI-00-22, 52 NRC at 289; *Niagara Mohawk Power Corp.* (Nine Mile Point Nuclear Station, Units 1 and 2), CLI-99-30, 50 NRC 333, 343-44 (1999).

³⁷ *Diablo Canyon*, CLI-02-16, 55 NRC at 334 (footnote and internal quotation marks omitted).

³⁸ *Id.* at 343; Final Rule, "Streamlined Hearing Process for NRC Approval of License Transfers," 63 Fed. Reg. 66,721 (Dec. 3, 1998); *Statement of Policy on Conduct of Adjudicatory Proceedings*, CLI-98-12, 48 NRC 18, 24 (1998).

³⁹ A United States District Court ruled that certain members of the NCPA are third-party beneficiaries to that 1976 settlement. See *United States v. Pacific Gas and Electric Co.*, 714 F. Supp. 1039, 1051 (N.D. Cal. 1989), *appeals dismissed per stipulation*, No. 91-16011 (9th Cir. Mar. 20, 1992).

⁴⁰ See *Pacific Gas and Electric Co.* (Stanislaus Nuclear Project, Unit 1), LBP-83-2, 17 NRC 45, 47 (1983).

construction permits in 1978.⁴¹ These amendments were ultimately incorporated as conditions into the two DCPD operating licenses in 1984 and 1985.⁴²

The current PG&E license transfer application proposes to continue these conditions in effect for Gen, PG&E itself, and ETrans even though the latter two companies would, after the transfer, not own or operate the Diablo Canyon plants or otherwise engage in any activities requiring an NRC license for DCPD. The NRC Staff described in its *Federal Register* notice how PG&E's license transfer application proposed to address these conditions:

With specific regard to the antitrust conditions in the licenses, the application proposes changes such that Gen will be inserted in the conditions and thus become subject to complying with them, and ETrans . . . , a new company that will be affiliated with Gen upon implementation of the [Reorganization P]lan and that will acquire the electric transmission assets of PG&E but not have any interest in Diablo Canyon, will also be inserted in the conditions and thus become subject to complying with them. In addition, the application proposes that PG&E will remain designated in the conditions for the limited purpose of compliance with the conditions, notwithstanding the divesting of its interest in Diablo Canyon, while [Diablo] Nuclear will not be named in the conditions.⁴³

In the next paragraph of the notice, the Staff made the comment to which NCPA and TANC object:

Notwithstanding the proposed changes to the antitrust conditions offered as part of the amendments to conform the licenses to reflect their transfer from PG&E to Gen and [Diablo] Nuclear, the Commission is considering whether to approve either all of the proposed changes to the conditions, or only some, but not all, of the proposed changes as may be appropriate and consistent with the Commission's decision in *Kansas Gas and Electric Co., et al.*, CLI-99-19, 49 NRC 441, 466 (1999). *In particular, the Commission is considering approving only those changes that would accurately reflect Gen and [Diablo] Nuclear as the only proposed entities to operate and own Diablo Canyon.*⁴⁴

Stated differently, the NRC Staff proposed both removing PG&E from the license conditions that had incorporated the Stanislaus Commitments and declining to impose those conditions upon ETrans.

⁴¹ See Issuance of Amendment to Construction Permit, Pacific Gas & Elec. Co. (Diablo Canyon Nuclear Power Plant, Units 1 and 2), 43 Fed. Reg. 59,934 (Dec. 22, 1978).

⁴² See PG&E's License Transfer Application, Enclosure 4 (which includes Appendix C to Operating License for Unit 1) and Enclosure 5 (which includes Appendix C to Operating License for Unit 2).

⁴³ 67 Fed. Reg. at 2455-56.

⁴⁴ *Id.* at 2456 (emphasis added).

In this adjudication, PG&E does not oppose outright the NRC Staff's alternative but instead describes it as "unnecessary."⁴⁵ PG&E points to our ruling in *Wolf Creek* that the Commission "plainly has continuing authority to modify or revoke its own validly imposed conditions"⁴⁶ in a way that would permit inclusion of PG&E and ETrans in the Licenses' antitrust conditions.

TANC, in its hearing request, expresses support for the Stanislaus Commitments. TANC explains that many of its co-petitioners benefit from those commitments because they obligate PG&E to provide essential transmission, scheduling, interconnection, generation, and related services.⁴⁷ TANC is concerned that, "in a post-reorganization world, reorganized PG&E will have neither the generation nor the transmission capabilities to satisfy the Stanislaus Commitments."⁴⁸ TANC therefore supports (though it would prefer to strengthen⁴⁹) PG&E's proposal to retain its obligations under these commitments and to add Gen, Diablo Nuclear, and ETrans as successor licensees who would likewise be bound by those commitments.⁵⁰ Thus, TANC implicitly opposes the NRC Staff's proposed elimination of PG&E and ETrans from the license conditions that incorporate the Stanislaus Commitments.

NCPA takes a similar position, but explicitly opposes the Staff's proposal.⁵¹ Indeed, NCPA questions whether the Commission even has the authority to alter the DCPD antitrust license conditions in the fashion proposed by the NRC

⁴⁵ PG&E's Answer to NCPA's Conditional Request for Hearing, dated Feb. 15, 2002, at 12. *See also* PG&E's Brief in Response to Commission Memorandum and Order CLI-02-12 at 6.

⁴⁶ *Id.* at 13 n.9, citing *Kansas Gas and Electric Co.* (Wolf Creek Generating Station, Unit 1), CLI-99-19, 49 NRC 441, 466 n.23 (1999) ("Wolf Creek") (which in turn cited *Ohio Edison Co.* (Perry Nuclear Power Plant, Unit 1), CLI-92-11, 36 NRC 47, 54-59 (1992) ("Perry"), *petition for review dismissed sub nom. City of Cleveland v. Nuclear Regulatory Commission*, 68 F.3d 1361, 1370 (D.C. Cir. 1995)). *See also* PG&E's Brief in Response to Commission Memorandum and Order CLI-02-12 at 9 n.10 (same); NCPA's Brief on Specific Questions, dated May 10, 2002, at 6 ("The Commission may modify a license for cause . . ." (emphasis omitted)).

⁴⁷ *See* TANC's Petition To Intervene, dated Feb. 6, 2002, at 12.

⁴⁸ *Id.* at 19.

⁴⁹ *Id.* at 19-21. TANC wishes to strengthen the proposal in the following respects: the need for the licenses to specify the existence of joint and several liability amongst Gen, PG&E, and ETrans; certain implied changes to the antitrust obligations; the continued availability of "firm transmission" of electricity after reorganization; and the duration of the antitrust conditions.

⁵⁰ *Id.* at 19-21. *See also id.* at 25 (asking the Commission to "[e]nsure that PG&E's obligations under the Stanislaus Commitments remain fully in force, whether performed by reorganized PG&E and/or PG&E affiliates, and remain unaffected by the proposed reorganization").

⁵¹ NCPA's Petition To Intervene, Conditional Request for Hearing and Suggestion That Proceeding Be Held in Abeyance, dated Feb. 6, 2002. *See particularly id.* at 28 ("request[ing] that the NRC grant [PG&E's] application for transfer of its license[s] in the manner proposed by [PG&E], which is intended to preserve the Stanislaus Commitments as presently in effect").

Staff.⁵² In addition, in a background discussion of the Commission’s antitrust jurisprudence, NCPA addresses the relevance of both sections 103 and 105 of the AEA,⁵³ suggesting that its challenge to the Commission’s authority to change the conditions rests, at least in part, on those statutory sections.

We sought comments from PG&E, Petitioners, governmental participants, and the United States Department of Justice on our statutory authority to retain or impose the antitrust conditions at issue in this proceeding.⁵⁴ TANC, NCPA, and PG&E filed briefs responding to this issue (with TANC also filing “additional comments”), all arguing that the Commission has the necessary authority to retain the antitrust conditions in the Diablo Canyon licenses.

We conclude that TANC’s and NCPA’s antitrust issues are admissible (a conclusion no party or participant contests) but, for the reasons set forth below, that they are without merit.

2. Analysis

A careful reading of AEA sections 105(c)(5) and 105(c)(6) shows that Congress linked NRC’s antitrust authority to the specific license under antitrust review — and to *that license only*. The first of these sections provides that the Commission “shall make a finding as to whether *the activities under the license* would create or maintain a situation inconsistent with the antitrust laws”⁵⁵ Once we have made the finding required under section 105(c)(5), we have the authority under section 105(c)(6) to take certain specified licensing actions — i.e., “to issue or continue *a license as applied for*, to refuse to issue a license, to rescind a license or amend it, and to issue a license with such conditions as [the NRC] deems appropriate.”⁵⁶

As for the antitrust conditions at issue in the instant proceeding, the “license as applied for” was the construction permit for PG&E’s proposed Stanislaus facility, and the “activities” that triggered the DCPD conditions, via a settlement, were PG&E’s potential activities under the Stanislaus license. In the end, however, we never issued a license for the proposed Stanislaus plant — as PG&E eventually

⁵² *Id.* at 26. NCPA also raises a number of equitable arguments against changing the conditions. *Id.* at 26-29.

⁵³ *Id.* at 19-25, citing 42 U.S.C. §§ 2133, 2135.

⁵⁴ See *Pacific Gas and Electric Co.* (Diablo Canyon Power Plant, Units 1 and 2), CLI-02-18, 56 NRC 79, 80 (2002). See also *Pacific Gas and Electric Co.* (Diablo Canyon Nuclear Power Plant, Units 1 and 2), CLI-02-12, 55 NRC 267, 268 (2002).

⁵⁵ 42 U.S.C. § 2135(c)(5) (emphasis added).

⁵⁶ 42 U.S.C. § 2135(c)(6) (emphasis added).

abandoned the project.⁵⁷ In the absence of a Stanislaus license, either actual or proposed, we now lack the statutorily referenced license for which the AEA authorizes “such [antitrust] conditions as [we] deem appropriate.”

The AEA gives the NRC no separate authority, independent of the Stanislaus proceeding, to impose antitrust license conditions on PG&E with respect to DCP. This is because DCP was licensed pursuant to section 104 of the AEA — a section excluding license applicants for “research and development” plants, such as DCP, from antitrust review (except under circumstances not present here).⁵⁸ The Commission’s initial authority to impose antitrust conditions on PG&E came from the now-defunct Stanislaus proceeding (a license review based on an application submitted under section 103). Now that it is clear that the section 103 Stanislaus proceeding will not be reopened, we lack an antitrust “hold” on PG&E. We see no legal underpinning for transferring the Stanislaus-triggered DCP antitrust conditions to new entities to be created under the proposed PG&E reorganization plan. This legal conclusion is particularly compelling in light of our obligation to respect our congressional grant of authority.⁵⁹

Moreover, as we indicated at length in *Wolf Creek*, sound policy reasons argue against taking an expansive view of our antitrust authority. Here, were we to transfer DCP’s current antitrust conditions to new independent PG&E spinoffs, we would be placed in the position of enforcing antitrust conditions against at least one company with no connection at all to the nuclear power plant. We simply lack the resources and expertise necessary to handle antitrust matters that do not fall squarely within our jurisdiction. By contrast, FERC and the Federal Trade Commission (as economic regulatory bodies) — together with the Department of Justice and the federal courts — have the resources and mission (the NRC is primarily a safety regulator) to deal with antitrust issues such as those that concern TANC and NCPA.

⁵⁷ See *Stanislaus*, LBP-83-2, 17 NRC 45 (granting PG&E’s motion to withdraw the Stanislaus application). PG&E withdrew the Stanislaus application in 1983 “without prejudice.” *Id.* at 46. By now, however, it is evident that PG&E has abandoned the Stanislaus project. No filing in this adjudication maintains otherwise.

⁵⁸ See AEA § 105(c)(3), 42 U.S.C. § 2135(c)(3).

⁵⁹ *Adams Fruit Co. v. Barrett*, 494 U.S. 638, 650 (1990), quoting *Federal Maritime Commission v. Seatrain Line, Inc.*, 411 U.S. 726, 745 (1973) (“an agency may not bootstrap itself into an area in which it has no jurisdiction by . . . violating its statutory mandate”). See also *Pratt & Whitney Aircraft v. Donovan*, 715 F.2d 57, 62 (2d Cir. 1983) (“Neither the Secretary by regulation nor the Commission by decision can extend the scope of OSHA beyond the boundaries defined by Congress”); *Office of Consumers’ Counsel v. Federal Energy Regulatory Commission*, 655 F.2d 1132, 1142 (D.C. Cir. 1980) (quoting *Seatrain, supra*); *Utz v. Cullinane*, 520 F.2d 467, 490 (D.C. Cir. 1975) (same).

As we stated in *Wolf Creek*:

Once a nuclear facility is licensed to operate, traditional antitrust forums — the federal courts and governmental agencies with longstanding antitrust expertise — are better equipped than the Commission to resolve and remedy antitrust violations by NRC licensees.⁶⁰

* * * *

For this Commission to use its scarce resources needed more to fulfill our primary statutory mandate to protect the public health and safety and the common defense and security than to duplicate other antitrust reviews and authorities makes no sense and only impedes nationwide efforts to streamline and make more efficient the federal government.⁶¹

The age of the DCPD conditions⁶² and recent developments in the law (in particular, those providing for nondiscriminatory open access to transmission)⁶³ are practical factors cutting against the carryover of the original PG&E conditions to the new situation created by the PG&E reorganization plan (presuming that it gains approval). Hence, we decline to reenact the DCPD antitrust conditions as part of the DCPD license transfer, and we instruct our Staff not to include those conditions if it otherwise approves the PG&E transfer application.

Finally, we note that our ruling today does not preclude TANC and NCPA from enforcing their antitrust-related rights under the Stanislaus Commitments. As beneficiaries of the Stanislaus settlement contracts,⁶⁴ they can enforce those contracts quite apart from any NRC license conditions. No participant in this proceeding has given us any reason to doubt the enforceability of the Stanislaus Commitments either in federal court or before the FERC.⁶⁵ Indeed, both a federal

⁶⁰ CLI-99-19, 49 NRC at 452.

⁶¹ *Id.* at 465. *See also id.* at 463; *Houston Lighting and Power Co.* (South Texas Project, Units 1 and 2), CLI-77-13, 5 NRC 1303, 1316-17 (1977); Final Rule, “Nuclear Power Plant License Renewal,” 56 Fed. Reg. 64,943, 64,971 (Dec. 13, 1991).

⁶² The Department of Justice normally seeks antitrust remedies of a 10-year duration. *See New York v. Microsoft Corp.*, 224 F. Supp. 2d 76, 184 (D.D.C. 2002).

⁶³ *See New York v. Federal Energy Regulatory Commission*, 535 U.S. 1 (2002) (upholding FERC’s open access requirements).

⁶⁴ *See* note 11, *supra*.

⁶⁵ *See, e.g.*, TANC’s Additional Comments at 9-10, 12, 15. In fact, in proceedings before both this Commission and the FERC, PG&E “has repeatedly acknowledged its obligation to provide transmission services under [the Stanislaus] Commitments.” *United States v. Pacific Gas and Electric Co.*, 714 F. Supp. at 1049. The enforceability of the Commitments is further supported by PG&E’s own statement in the instant proceeding that it “would continue to meet any obligations to other parties with respect to the Stanislaus Commitments so long as those obligations may exist under other agreements.” *See* PG&E’s Brief in Response to Commission Memorandum and Order CLI-02-18, dated Aug. 22, 2002, at 11.

district court and the FERC have described the Commitments as a contract, and each considers the Commitments enforceable in its own forum.⁶⁶ The commitments' enforceability in other fora undermines the hyperbolic claims of TANC and NCPA that a parade of horrors⁶⁷ will ensue if we do not retain the DCP antitrust license conditions.

IV. CONCLUSION

For the reasons set forth above, the Commission

1. *grants* TANC's and NCPA's petitions to intervene,
2. *finds* TANC's financial and technical qualifications issues inadmissible,
3. *finds* TANC's and NCPA's antitrust issues lack substantive merit,
4. *denies* TANC's and NCPA's requests for hearing,
5. *terminates* this proceeding, and
6. instructs the NRC Staff not to include the antitrust conditions if it otherwise approves the PG&E transfer application.

⁶⁶ See *United States v. Pacific Gas and Electric Co.*, 714 F. Supp. at 1047 n.13, 1050-51, 1054 (rejecting the argument that the court lacks authority to enforce the Stanislaus Commitments); *Pacific Gas and Electric Co.*, 49 FERC ¶61,116, 1989 WL 262814 at text associated with n.14 (no WL pagination available) (FERC) (Commission 1989) ("We . . . disagree with PG&E that the Stanislaus Commitments are not subject to the [Federal Energy Regulatory] Commission's review . . . [T]o the extent that the Commitments affect or relate to . . . a rate schedule subject to our jurisdiction under the Federal Power Act, they are . . . subject to our review" (footnote 14 omitted)).

⁶⁷ E.g., TANC's Brief, dated Aug. 22, 2002, at 15 ("anti-competitive and predatory trade practices"); TANC's Additional Comments at 11 ("PG&E's obligations . . . to third party beneficiaries of the Stanislaus Commitments [will] be evaded or negated"); NCPA's Brief on Specific Questions at 9 ("If ETrans is no longer a licensee, the Commission could not take action to safeguard the national welfare under section 105(a) of the [AEA] or to enforce its own license conditions"); *id.* at 13 ("The Stanislaus Commitments without all of the NRC mechanisms needed for assuring compliance would be akin to the Molotov-Rippentrop [*sic*, Ribbentrop] Pact, which Nazi Germany could and did breach without a moment's hesitation when it believed it desirable to do so in its own interest").

IT IS SO ORDERED.⁶⁸

For the Commission⁶⁹

ANNETTE L. VIETTI-COOK
Secretary of the Commission

Dated at Rockville, Maryland,
this 14th day of February 2003.

⁶⁸ PG&E, TANC, and NCPA may seek reconsideration of this Order. Petitions for reconsideration must be filed in such a manner that they arrive at the Office of the Secretary no later than 4:15 p.m. on February 24, 2003, and replies to such petitions no later than 4:15 p.m. on March 6, 2003.

⁶⁹ Commissioner Diaz was not present for the affirmation of this Order. If he had been present, he would have approved it.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:

Alan S. Rosenthal, Presiding Officer
Thomas D. Murphy, Special Assistant

In the Matter of

Docket No. 40-8838-MLA
(ASLBP No. 00-776-04-MLA)

U.S. ARMY
(Jefferson Proving Ground Site)

February 6, 2003

MEMORANDUM AND ORDER
(Rulings on Adequacy of Statement of Concerns and
Motion To Hold Proceeding in Abeyance)

I. BACKGROUND

1. This proceeding involves a proposed amendment to the materials license (SUB-1435) held by the U.S. Army (Licensee) in connection with its Jefferson Proving Ground Site (JPG), located in Madison, Indiana. The amendment would permit, in accordance with the provisions of 10 C.F.R. § 20.1403, the restricted release of the site on which there is currently an accumulation of depleted uranium (DU) munitions that had been utilized by the Licensee under the aegis of the license.

The amendment application was submitted to the NRC Staff several years ago and, in response to a December 16, 1999 *Federal Register* notice of opportunity for hearing (64 Fed. Reg. 70,294), a hearing request was filed on January 13, 2000, by Save the Valley, Inc. (Petitioner). On March 23, 2000, in LBP-00-9, 51 NRC 159, the request was granted on a determination that, as required by 10 C.F.R. § 2.1205(e) and (h), the Petitioner had both (1) demonstrated its standing

to challenge the proposed amendment and (2) identified with particularity one or more germane areas of concern regarding the site decommissioning plan that the Licensee had supplied to the Commission in connection with the license amendment application.

In normal circumstances, the grant of the hearing request would have moved the matter forward with some dispatch to a consideration of the merits of the controversy. That, however, did not happen here. Rather, as detailed almost 20 months later in LBP-01-32, 54 NRC 283 (2001), the proceeding took a quite unusual turn.

As explained in LBP-01-32, in the year following the grant of the hearing request all that happened of note was the Licensee's submission of quarterly status reports that reflected, among other things, that it had submitted its decommissioning plan to the Petitioner for its consideration and had received back the latter's comments on it.¹ Then, a seemingly unexpected development took place. On June 27, 2001, the Licensee furnished the NRC Staff with an entirely new plan, which it characterized as a "final decommissioning/license termination plan" (LTP). According to a letter that accompanied the plan, this LTP was being submitted for the purpose of facilitating the termination of the NRC license to which the sought amendment referred.

It turned out that the June 2001 LTP was not well received by the NRC Staff. In a September 27, 2001 letter, the Staff informed the Licensee that the plan had not been accepted for the commencement of a full technical review. According to the letter, the Staff had noted a number of deficiencies in the plan that would require correction before such a review could be initiated. In a subsequent letter, dated October 17, 2001, the Licensee was told by the Staff that the LTP was deemed to have superseded the previously furnished decommissioning plan, with the consequence that the latter would receive no further review.

Even before these Staff pronouncements surfaced, the Petitioner had filed a request on September 13, 2001, to hold the proceeding in further abeyance, the request being based on the fact that the LTP was "very different" from the earlier site decommissioning plan that had prompted Petitioner's decision to seek

¹In LBP-00-9, 51 NRC at 161, I noted that the Licensee's response to the hearing request had pointed to a distinct possibility that the then-current decommissioning plan would receive material revision. Accordingly, the response had explicitly requested that further proceedings be held in abeyance pending the outcome of the Licensee's further interaction with the NRC Staff with regard to the plan. In addition, the Licensee had stated its willingness to work with the Petitioner in an endeavor to resolve its concerns and thus to obviate the need for a hearing. Given the obvious fluidity of the situation and the equally manifest desirability of facilitating an endeavor to achieve a settlement, I saw no good reason to force the parties to move forward with a hearing at that time and therefore acceded to the Licensee's deferral request. The Licensee was, however, required to submit quarterly status reports to enable Judge Murphy and me to monitor, among other things, the progress of the settlement negotiations between the parties.

a hearing. In LBP-01-32, that request was granted with these directions: First, the Licensee was to continue to furnish quarterly status reports and to advise me immediately if it should withdraw or abandon the license amendment application. 54 NRC at 290. Second, should the Commission publish in the *Federal Register* a new notice of opportunity for hearing in connection with the LTP or some successor JPG site decommissioning plan, the Petitioner was to file and to serve within 30 days thereafter a statement specifying its areas of concern, if any, relative to that plan. *Id.*²

2. Nearly a year later, in a solicited October 17, 2002 memorandum, the NRC Staff informed me that it had completed its acceptance review of the LTP (as apparently revised during the course of that review) and the environmental report that the Licensee had submitted in connection with it. The two documents had been accepted for a detailed technical review that was projected for completion by October 2004. A month later, as had been anticipated might occur, the Staff published in the *Federal Register* a notice of opportunity for hearing on the plan. 67 Fed. Reg. 69,049 (Nov. 14, 2002).

As required by LBP-01-32, the Petitioner submitted on December 12, 2002, a statement of its concerns with regard to the version of LTP that had been accepted by the Staff for technical review.³ Simultaneously, it filed a motion seeking to defer a hearing on the plan pending the completion of the Staff's technical review.

In a January 17, 2003 response to the Petitioner's statement of concerns, as supplemented on January 21, the Licensee maintained that none of the advanced concerns was germane to the LTP in hand and therefore the proceeding should be terminated. The January 21 submission added that, should I determine that the Petitioner had set forth at least one germane area of concern in its December 12 filing, the Licensee did not oppose the requested hearing deferral. For its part, in a solicited January 17 filing, the NRC Staff explained why the technical review of the current LTP would require so much time for completion. It then went on to endorse the deferral request.⁴

²I saw no reason to freight the Petitioner with the obligation to rehearse the successful showing it had made in its hearing request on the question of its standing.

³Although the cover page of the filing bears a December 16, 2002 date, the certificate of service reflects that it was actually filed and served on the 12th and therefore was timely.

⁴Having elected pursuant to 10 C.F.R. § 2.1213 not to become a party to the proceeding, the Staff was not called upon by me to address the question of the adequacy of the Petitioner's statement of its areas of concern. I did want, however, the Staff's views on the deferral question, as well as an explanation regarding the apparent need to expend 2 years in the conduct of the technical review.

II. DISCUSSION

As the foregoing reflects, the first issue that must be addressed is whether, contrary to the Licensee's insistence, the Petitioner has specified at least one germane area of concern with respect to the LTP now before the NRC Staff for detailed technical review. If that question is answered in the affirmative, then the hearing deferral request must be confronted.

1. In granting in LBP-00-9 the Petitioner's hearing request submitted in the context of the original site decommissioning plan, I pointed to the fact that that request had identified with particularity several areas of concern with regard to that plan. In that connection, there was reference to "such issues as the extent of the proposed cleanup of the accumulated DU material; future monitoring requirements; and restrictions upon further use of the area in which the DU material has been stored." I added that those issues were "indisputably germane whether or not the Petitioner's articulated concerns are ultimately found to warrant the denial or alteration of the decommissioning plan as now presented." 51 NRC at 160.

If anything, as both Judge Murphy and I see it, having obtained in the meanwhile the assistance of legal counsel, the Petitioner has presented an even more particularized statement of concerns in the filing currently before us. Among other things, the Petitioner assigns five independent reasons why it believes that the LTP under present consideration does not meet the criteria imposed by 10 C.F.R. § 20.1403 with regard to the restricted release of the site that the Licensee desires. *See* Petitioner's December 12, 2002 filing at 10-15. In addition, Petitioner maintains that, for two stated reasons, the Licensee's characterization of the JPG site is flawed, inadequate, and incomplete, making it impossible to verify that the LTP meets the necessary criteria for approval. *Id.* at 15-18.

Not surprisingly, as reflected in its January 17 response, the Licensee does not regard any of the claims to be meritorious. And it might well turn out that, in fact, none of them has substance. But, to reiterate what was said in LBP-00-9, that consideration is entirely irrelevant at this stage of the proceeding. It is enough that a hearing requestor present at least one area of concern that bears upon the matter at hand — here whether the current LTP satisfies all applicable Commission requirements with regard to the restricted release of the JPG site. Judge Murphy concurs in my belief that the Petitioner has met that test, leaving the question of the justification for that concern to the hearing stage.

2. Accordingly, it is now necessary to reach the deferral question presented by the Petitioner. When I learned last October that the NRC Staff's technical review of the revised LTP might not be completed before late in 2004, I advised the parties in the course of an October 24, 2002 order (unpublished) that it was not my then inclination to hold up further proceedings to await the outcome of that review. I recognized, of course, that, although technically the proceeding had

then been pending for almost 3 years, in a real sense its origin was the yet-to-be published new *Federal Register* notice prompted by the Staff's conclusion that there were substantial differences between the original site decommissioning plan and the LTP ultimately accepted for technical review. Nonetheless, I was loathe to put the proceeding into mothballs for such a long additional period.

The October 24 order went on, however, to invite any party who saw the matter differently to express its views once the new *Federal Register* notice was published. And, as we have seen, the Petitioner did precisely that in the form of its deferral request — a request that not only is unopposed by the Licensee but also, perhaps more significantly, enjoys the affirmative support of the NRC Staff.

On that score, the Staff had this to say on the subject in its January 17, 2003 submission (at 3):

The history of this proceeding compellingly indicates that the mere filing of a [decommissioning plan], or even its acceptance for detailed technical review, is not determinative as to whether the Staff will conclude that the Licensee has satisfied the requirements for license termination on a restricted release basis. Thus, we consider that [the Petitioner] has a sound basis for its deferral request. Grant of the requested deferral is also consistent with the time needed to complete the Staff's technical review.

Beyond those observations, the Staff took note (*id.* at 2-3) of the fact that the activities that would be part of (or at least related to) the technical review would include the preparation of an environmental impact statement (EIS). Clearly, even if not deemed entitled to litigate the validity of the conclusions eventually reached by the Staff on safety issues, the Petitioner at some point would have the right to question the Staff's compliance with the National Environmental Policy Act once its environmental findings have been proffered.

In the totality of the present circumstances, and given that no objection has been forthcoming from any quarter, the appropriate course would appear to be a deferral of further proceedings to abide the event of the completion of the technical review of the current LTP. Accordingly, the Petitioner's request for such relief is *granted*. The Licensee shall continue to provide quarterly status reports and the NRC Staff is to notify Judge Murphy and me promptly when it is prepared to disclose the results of the technical review.

It is so ORDERED.

BY THE PRESIDING OFFICER⁵

Alan S. Rosenthal
ADMINISTRATIVE JUDGE

Rockville, Maryland,
February 6, 2003

⁵ Copies of this Memorandum and Order were sent this date by Internet electronic mail transmission to the counsel for the parties and the NRC Staff.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:

**Ann Marshall Young, Chair
Dr. Richard F. Cole
Dr. Thomas S. Elleman**

In the Matter of

**Docket No. 50-336-OLA-2
(ASLBP No. 03-808-02-OLA)**

**DOMINION NUCLEAR CONNECTICUT, INC.
(Millstone Nuclear Power Station,
Unit 2)**

February 14, 2003

In this license amendment proceeding under 10 C.F.R. Part 54, the Licensing Board finds that Petitioner Connecticut Coalition Against Millstone (CCAM) has shown interests sufficient to confer standing to participate in the proceeding, but that Petitioner STAR Foundation has not established standing, and sets certain deadlines for the filing of a supplemented petition and contentions, and responses thereto.

**RULES OF PRACTICE: STANDING TO INTERVENE;
INTERVENTION**

Judicial concepts of standing provide the following guidance in determining whether a petitioner has established the necessary “interest” under 10 C.F.R. § 2.714(d)(1): To qualify for standing a petitioner must allege (1) a concrete and particularized injury that is (2) fairly traceable to the challenged action and (3) likely to be redressed by a favorable decision, criteria commonly referred to, respectively, as “injury in fact,” causality, and redressability. The injury may be either actual or threatened, but must lie arguably within the “zone of interests”

protected by the statutes governing the proceeding — here, either the Atomic Energy Act (AEA) or the National Environmental Policy Act (NEPA).

**RULES OF PRACTICE: STANDING TO INTERVENE;
INTERVENTION**

An organization may meet the injury-in-fact test either (1) by showing an effect upon its organizational interests, or (2) by showing that at least one of its members, who has authorized the organization to represent him or her, would suffer injury as a result of the challenged action, sufficient to confer upon it “derivative” or “representational” standing.

**RULES OF PRACTICE: STANDING TO INTERVENE;
INTERVENTION**

The injury a petitioner must show must be “concrete and particularized” and “actual or imminent,” rather than merely “conjectural or hypothetical”; a petitioner must have a “real stake” in the outcome of the proceeding that, while it need not be “substantial,” must be “actual,” “direct,” or “genuine.” A mere academic interest in the litigation or outcome of a proceeding is insufficient; one must allege some injury that will occur as a result of the action proposed to be taken.

**RULES OF PRACTICE: STANDING TO INTERVENE;
INTERVENTION**

Standing may also be based on a petitioner’s proximity to the facility at issue, and standing may be presumed based on proximity if the petitioner lives within, or otherwise has frequent contacts with, the zone of possible harm from a nuclear reactor or other source of radioactivity; this geographic presumption has generally been applied to petitioners in reactor licensing proceedings who reside within 50 miles of a reactor, and does not apply in other proceedings unless the proposed action quite obviously entails an increased potential for offsite consequences.

**RULES OF PRACTICE: STANDING TO INTERVENE;
INTERVENTION**

A petitioner must be within the potential “zone of harm” of the proposed action, which is determined by examining the significance of the radioactive source in relation to the distance involved and the type of action proposed.

**RULES OF PRACTICE: STANDING TO INTERVENE;
INTERVENTION**

In making a standing determination a presiding officer is to construe the petition in favor of the petitioner, and even minor radiological exposures resulting from a proposed licensee activity can be enough to create the requisite injury in fact.

**RULES OF PRACTICE: STANDING TO INTERVENE;
INTERVENTION**

A petitioner whose member lives 2 miles from the plant and makes claims of adverse health and safety risks from alleged increased radiological emissions, resulting from proposed changes to fuel movement operations that involve leaving open containment penetrations, is found to have standing, because if there were a fuel handling accident involving spent fuel, this would obviously entail an increased potential for offsite consequences, even if only through minor radiological exposures.

**RULES OF PRACTICE: STANDING TO INTERVENE;
INTERVENTION**

A petitioner living 23 miles from a plant was found not to have made sufficient showing to establish standing, given its failure to present any significant argument or scenario showing the impact of the proposed action at such a distance, and the remoteness of any normal releases or releases during a fuel handling accident during reactor shutdown conditions being likely to have any measurable effect at such a distance.

RULES OF PRACTICE: CONTENTIONS

The standards that licensing boards must apply in ruling on the admissibility of contentions are defined at 10 C.F.R. § 2.714(b), (d); the failure of a contention to comply with any of these requirements is grounds for dismissing the contention.

RULES OF PRACTICE: CONTENTIONS

A petitioner must do more than merely make unsupported bald allegations; contentions must specifically state the issue a petitioner wishes to raise and, in addition to providing support in the form of expert opinion, document(s), and/or a fact-based argument, a petitioner must provide reasonably specific and understandable explanation and reasons to support its contentions. If a petitioner

in a contention fails to offer any specific explanation, factual or legal, for why the consequences the petitioner fears will occur, the requirements of the contention rule are not satisfied.

RULES OF PRACTICE: CONTENTIONS

The contention rule does not require a specific allegation or citation of a regulatory violation, but a petitioner is obliged to read pertinent portions of the license application including the Safety Analysis Report and the Environmental Report, state the applicant's position and the petitioner's opposing view, and include in a contention either (1) references to the specific portion of the application that the petitioner disputes and the supporting reasons for each dispute, or (2) if a contention alleges that an application fails to contain information on a relevant matter as required by law, identification of each alleged failure and the supporting reasons for the petitioner's belief.

RULES OF PRACTICE: CONTENTIONS

A contention must establish that a genuine dispute exists between a petitioner and an applicant.

RULES OF PRACTICE: CONTENTIONS

A contention's proponent, not the licensing board, is responsible for formulating the contention and providing the necessary information to satisfy the basis requirement of the rule.

MEMORANDUM AND ORDER
(Ruling on Standing of Petitioners To Proceed and
Setting Deadlines for Supplemented Petition and Contentions)

This proceeding involves a September 26, 2002, application of Dominion Nuclear Connecticut, Inc. (Dominion), to amend the operating license for Millstone Power Station, Unit No. 2, by changing certain technical specifications, based upon a reanalysis of the limiting design basis Fuel Handling Accident (FHA) using an Alternative Source Term in accordance with 10 C.F.R. § 50.67 and NRC Regulatory Guide 1.183. This application was among those included in a November 2002 NRC "Biweekly Notice" regarding "Applications and Amendments to Facility Operating Licenses Involving No Significant Hazards Considerations." 67 Fed. Reg. 68,728, 68,731 (Nov. 12, 2002). On December 12,

2002, in response to this notice and Dominion's application, the Connecticut Coalition Against Millstone (CCAM) and the STAR Foundation (STAR) filed an "Amended Petition To Intervene and Request for Hearing" (hereinafter Petition). For the reasons stated herein, we conclude that Petitioner CCAM has standing to participate in this proceeding, and establish certain deadlines for further pleadings in the proceeding, as set forth below.

I. BACKGROUND

Dominion in its license amendment application requests approval of its "re-analysis of the Millstone Unit No. 2 limiting design basis Fuel Handling Accidents using a selective implementation of the Alternative Source Term methodology in accordance with 10 C.F.R. 50.67 and Regulatory Guide 1.183," and approval of certain changes to the Technical Specifications (TSs) consistent with that reanalysis. Dominion License Amendment Request (Letter, J. Alan Price to U.S. Nuclear Regulatory Comm'n Document Control Desk, B18763, "Millstone Unit No. 2, License Basis Document Change Request (LBDCR) 2-18-02, Selective Implementation of the Alternative Source Term — Fuel Handling Accident Analyses" (Sept. 26, 2002)), at 1 (hereinafter LAR). Specifically, Dominion requests amendments to TS 3.3.3.1, "Monitoring Instrumentation, Radiation Monitoring"; TS 3.3.4, "Instrumentation, Containment Purge Valve Isolation Signal"; TS 3.7.6.1, "Plant Systems, Control Room Emergency Ventilation System"; TS 3.9.4, "Refueling Operations, Containment Penetrations"; TS 3.9.8.1, "Refueling Operations, Shutdown Cooling and Coolant Circulation — High Water Level"; TS 3.9.8.2, "Refueling Operations, Shutdown Cooling and Coolant Circulation — Low Water Level"; and TS 3.9.15, "Refueling Operations, Storage Pool Area Ventilation System." *Id.*

As noted by the Staff, the LAR is based on a 1999 amendment of NRC regulations, permitting nuclear power plant licensees to voluntarily replace the traditional source term used in design basis accident analyses with alternative source terms. Final Rule, "Use of Alternative Source Terms at Operating Reactors," 64 Fed. Reg. 71,990 (Dec. 23, 1999); *see* NRC Staff's Response to Amended Petition To Intervene and Request for Hearing Filed by [CCAM] and [STAR], Jan. 2, 2003, at 2-3 (hereinafter Staff Response). The new "Alternative Source Term" rule, codified at 10 C.F.R. § 50.67, permits utilities with nuclear power plant operating licenses to replace the prior, 1962-era source term in their licenses with a revised one. 64 Fed. Reg. 71,990-92. Under the new rule, at 10 C.F.R. § 50.67(b), dose limits to (1) individuals located at any point on the boundary of the exclusion area for any 2-hour period following the onset of the postulated fission product release, (2) individuals located at any point on the outer boundary of the low population zone exposed to the radioactive cloud resulting

from the release, and (3) persons working in the control room under accident conditions are stated in terms of single total effective dose equivalents (TEDEs). This approach replaces that used in the original design basis for operating reactors, the terms of which provided for two different doses, to the whole body and to the thyroid. *See* 64 Fed. Reg. at 71,992-93; *see also* 10 C.F.R. § 100.3, for definitions of “Exclusion area” and “Low population zone.”

Petitioners challenge proposed changes to technical specifications that would modify requirements regarding containment closure and spent fuel pool area ventilation during movement of irradiated fuel assemblies in containment and in the spent fuel pool area, allow containment penetrations including the equipment door and personnel airlock door to be left open under administrative control, and eliminate requirements for automatic closure of containment purge during Mode 6 fuel movement, as well as the deletion of TSs associated with storage pool area ventilation. Petition at 1-2. Petitioners seek to intervene and request a hearing “because of concerns of adverse health and safety risks to their membership,” alleging various harms, which are summarized below. *Id.* at 3.

II. ANALYSIS

A. Legal Standards

A petitioner’s standing to participate in an NRC licensing proceeding is grounded in section 189a of the Atomic Energy Act (AEA), 42 U.S.C. § 2239(a)(1)(A), which requires the Commission, “[i]n any proceeding under [the Act], for the granting, suspending, revoking, or amending of any license,” to provide a hearing “upon the request of any person whose interest may be affected by the proceeding” The Commission has implemented this requirement in its regulations at 10 C.F.R. § 2.714.

Under section 2.714(a)(2), an intervention petition must set forth with particularity “the interest of the petitioner in the proceeding, how that interest may be affected by the results of the proceeding, including the reasons why petitioner should be permitted to intervene, with particular reference to the factors in paragraph (d)(1),” along with “the specific aspect or aspects of the subject matter of the proceeding as to which petitioner wishes to intervene.” 10 C.F.R. § 2.714(a)(2). Subsection (d)(1) provides in relevant part that the Board shall consider the following three factors when deciding whether to grant standing to a petitioner:

- (i) The nature of the petitioner’s right under the [AEA] to be made a party to the proceeding.
- (ii) The nature and extent of the petitioner’s property, financial, or other interest in the proceeding.

(iii) The possible effect of any order that may be entered in the proceeding on the petitioner's interest.

10 C.F.R. § 2.714(d)(1).

When determining whether a petitioner has established the necessary "interest" under subsection (d)(1), licensing boards are directed by Commission precedent to look for guidance to judicial concepts of standing. *See, e.g., Yankee Atomic Electric Co.* (Yankee Nuclear Power Station), CLI-98-21, 48 NRC 185, 195 (1998); *Quivira Mining Co.* (Ambrosia Lake Facility, Grants, New Mexico), CLI-98-11, 48 NRC 1, 5-6 (1998); *Georgia Institute of Technology* (Georgia Tech Research Reactor, Atlanta, Georgia), CLI-95-12, 42 NRC 111, 115 (1995). According to these concepts, to qualify for standing a petitioner must allege (1) a concrete and particularized injury that is (2) fairly traceable to the challenged action and (3) likely to be redressed by a favorable decision. *See, e.g., Steel Co. v. Citizens for a Better Environment*, 523 U.S. 83, 102-04 (1998); *Kelley v. Selin*, 42 F.3d 1501, 1508 (6th Cir. 1995).

These three criteria are commonly referred to, respectively, as "injury in fact," causality, and redressability. The requisite injury may be either actual or threatened, *Yankee*, CLI-98-21, 48 NRC at 195 (citing, e.g., *Wilderness Society v. Griles*, 824 F.2d 4, 11 (D.C. Cir. 1987)), but must arguably lie within the "zone of interests" protected by the statutes governing the proceeding — here, either the AEA or the National Environmental Policy Act (NEPA). *See Yankee*, CLI-98-21, 48 NRC at 195-96; *Ambrosia Lake Facility*, CLI-98-11, 48 NRC at 6. This showing must be made by both individual petitioners and organizational petitioners such as the petitioners herein. *See Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), CLI-99-10, 49 NRC 318, 323 (1999).

An organization may demonstrate standing in its own right, or claim standing through one or more individual members who have standing. *Georgia Tech*, CLI-95-12, 42 NRC at 115. The alleged injury to a member must fall within the purposes of the organization. *Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), CLI-98-13, 48 NRC 26, 33-34 (1998); *see Curators of the University of Missouri* (TRUMP-S Project), LBP-90-18, 31 NRC 559, 565 (1990). Thus, an organization may meet the injury-in-fact test either (1) by showing an effect upon its organizational interests, or (2) by showing that at least one of its members would suffer injury as a result of the challenged action, sufficient to confer upon it "derivative" or "representational" standing. *Houston Lighting and Power Co.* (South Texas Project, Units 1 and 2), ALAB-549, 9 NRC 644, 646-47 (1979), *aff'd* LBP-79-10, 9 NRC 439, 447-48 (1979). An organization seeking to intervene in its own right must demonstrate a palpable injury in fact to its organizational interests that is within the zone of interests protected by the AEA or NEPA. *Yankee Atomic Electric Co.* (Yankee Nuclear

Power Station), CLI-94-3, 39 NRC 95, 102 n.10 (1994); *Florida Power and Light Co.* (Turkey Point Nuclear Generating Plant, Units 3 and 4), ALAB-952, 33 NRC 521, 528-30 (1991). When an organization relies upon the interests of its members to confer standing, it must show that at least one member who would possess standing in an individual capacity has authorized the organization to represent the member. *Private Fuel Storage*, CLI-98-13, 48 NRC at 31; *Georgia Tech*, CLI-95-12, 42 NRC at 115; *Turkey Point*, ALAB-952, 33 NRC at 530; *Houston Lighting and Power Co.* (Allens Creek Nuclear Generating Station, Unit 1), ALAB-535, 9 NRC 377, 393-94, 396 (1979).

The injury required to be shown by any petitioner has been described as “concrete and particularized” and “actual or imminent,” rather than merely “conjectural or hypothetical.” See *Lujan v. Defenders of Wildlife*, 504 U.S. 555, 560 (1992); see also *International Uranium (USA) Corp.* (White Mesa Uranium Mill), CLI-98-6, 47 NRC 116 (1998); *Ohio Edison Co.* (Perry Nuclear Power Plant, Unit 1), LBP-91-38, 34 NRC 229, 252 (1991), *aff’d in part on other grounds*, CLI-92-11, 36 NRC 47 (1992). A petitioner must have a “real stake” in the outcome of the proceeding to establish injury in fact for standing, and while this stake need not be a “substantial” one, it must be “actual,” “direct,” or “genuine.” *South Texas*, LBP-79-10, 9 NRC at 447-48. A mere academic interest in the outcome of a proceeding or an interest in the litigation is insufficient to confer standing; rather, the requestor must allege some injury that will occur as a result of the action taken. *Puget Sound Power and Light Co.* (Skagit/Hanford Nuclear Power Project, Units 1 and 2), LBP-82-74, 16 NRC 981, 983 (1982), citing *Allied-General Nuclear Services* (Barnwell Fuel Receiving and Storage Station), ALAB-328, 3 NRC 420, 422 (1976); *Puget Sound Power and Light Co.* (Skagit/Hanford Nuclear Power Project, Units 1 and 2), LBP-82-26, 15 NRC 742, 743 (1982).

In addition to the traditional standing requirements, standing may also be based on a petitioner’s proximity to the facility at issue. *Tennessee Valley Authority* (Sequoyah Nuclear Plant, Units 1 and 2; Watts Bar Nuclear Plant, Unit 1), LBP-02-14, 56 NRC 15, 23 (2002). This proximity or geographical presumption “presumes a petitioner has standing to intervene without the need specifically to plead injury, causation, and redressability if the petitioner lives within, or otherwise has frequent contacts with, the zone of possible harm from the nuclear reactor or other source of radioactivity.” *Id.*, citing *Florida Power and Light Co.* (Turkey Point Nuclear Generating Plant, Units 3 and 4), LBP-01-6, 53 NRC 138, 146 (2001), *aff’d on other grounds*, CLI-01-17, 54 NRC 3 (2001). This geographic presumption has generally been applied to petitioners in reactor licensing proceedings who reside within 50 miles of a reactor. *Sequoyah Fuels Corp. and General Atomics* (Gore, Oklahoma Site), CLI-94-12, 40 NRC 64, 75 n.22 (1994). It does not apply in proceedings unless the proposed action “quite obvious[ly] entails an increased potential for offsite

consequences.” *Commonwealth Edison Co.* (Zion Nuclear Power Station, Units 1 and 2), CLI-99-4, 49 NRC 185, 191 (1999), *petition for review denied sub nom. Dienethal v. NRC*, 203 F.3d 52 (D.C. Cir. 2000).

The Commission has articulated the following standard for applying the proximity presumption:

It is true that in the past, we have held that living within a specific distance from the plant is enough to confer standing on an individual or group in proceedings for construction permits, operating licenses, or significant amendments thereto such as the expansion of the capacity of a spent fuel pool. However, those cases involved the construction or operation of the reactor itself, with clear implications for the offsite environment, or major alterations to the facility with a clear potential for offsite consequences. Absent situations involving such obvious potential for offsite consequences, a petitioner must allege some specific “injury in fact” that will result from the action taken

Florida Power and Light Co. (St. Lucie Nuclear Power Plant, Units 1 and 2), CLI-89-21, 30 NRC 325, 329-30 (1989) (citations omitted). In a later case, the Commission indicated that the focus of the proximity presumption is upon whether “the proposed action involves a significant source of radioactivity producing an obvious potential for offsite consequences.” *Georgia Tech*, CLI-95-12, 42 NRC at 116. The next step in the analysis is to determine whether the petitioner’s residence is within the potential “zone of harm” of the proposed action by examining the nature of the proposed action and the significance of the radioactive source. *Sequoyah*, LBP-02-14, 56 NRC at 24, citing *Georgia Tech*, CLI-95-12, 42 NRC at 116-17. This must be determined on a case-by-case basis, by “examining the significance of the radioactive source in relation to the distance involved and the type of action proposed.” *Sequoyah*, LBP-02-14, 56 NRC at 26, citing *Georgia Tech*, CLI-95-12, 42 NRC at 116-17.

Finally, while a petitioner bears the burden of establishing standing, Commission case law provides that in making a standing determination a presiding officer is to “construe the petition in favor of the petitioner,” *Georgia Tech*, CLI-95-12, 42 NRC at 115; *Atlas Corp.* (Moab, Utah Facility), LBP-97-9, 45 NRC 414, 424 (1997); and, “[r]elative to a threshold standing determination, . . . [that] even minor radiological exposures resulting from a proposed licensee activity can be enough to create the requisite injury in fact.” *General Public Utilities Nuclear Corp.* (Oyster Creek Nuclear Generating Station), LBP-96-23, 44 NRC 143, 158 (1996); *Atlas*, LBP-97-9, 45 NRC at 425.

B. Arguments of Parties

1. Petitioners

In challenging various TS changes involved in the LAR, *see* Background section above, the Petitioners assert concerns “of adverse health and safety risks to their membership, as well as the health and safety of Millstone workers and the surrounding community, should the amendment be granted.” Petition at 3. They also raise issues “concerning reduction of protection to workers and the public from unnecessary environmental releases of fission products,” and assert that the amendment application fails “to identify and define administrative measures to be implemented to protect the public health and safety,” and “to address the public health and safety consequences relative to the potential of a terrorism attack upon the Millstone Nuclear Power Station during Unit 2 fuel movements and the likelihood of increasing peril to the community should the amendment be granted.” *Id.*

Petitioners attach to their petition the Declarations of Joseph H. Besade and Christine Guglielmo. Mr. Besade, a member of CCAM and a former employee of Millstone, declares that he lives in Waterford, Connecticut, within 2 miles of Millstone. Ms. Guglielmo declares that she lives in East Hampton, New York, within 23 miles of Millstone, and that she submits her declaration in support of intervention by STAR, although she does not specifically state that she is a member of STAR.¹ Petition at 4, 9. Both declare that the LAR “seeks to eliminate, erode and relax existing standards of radiological protection for workers and the public,” through proposed changes to the Millstone TSs “to modify requirements regarding containment closure and spent fuel pool area ventilation during movement of irradiated fuel assemblies in containment and in the spent fuel pool area,” “to allow containment penetrations, including the equipment door and personnel airlock door, to be maintained open under administrative control,” “to eliminate the requirements for automatic closure of containment purge during Mode 6 fuel movement,” and “to delete the technical specifications associated with storage pool area ventilation.” *Id.* at 6, 9-10.

Both Petitioner declarants assert that the applied-for amendment “proposes to permit increased radiological emissions to the environment above current levels,” and that as nearby residents to Millstone they believe that they “will be at a heightened risk of radiological contamination from Millstone operations if the

¹ We note¹⁰⁻⁷ that Mr. Besade does not appear to have signed the copy of his Declaration provided to the Board, and that Ms. Guglielmo has not stated in hers that she is a member of STAR. The first of these in particular appears to be an easily curable defect, and we note Mr. Besade’s prior participation in proceedings such as the instant one on more than one occasion in a similar capacity. With regard to Ms. Guglielmo, the issue with her membership in STAR may also be easily curable, and so also note that our finding herein as to her standing is not based on this defect in her Declaration.

amendment is issued, with consequent increased risk to [their] health and the health of [their] famil[ies].” *Id.* at 6, 10. The Petitioners also make reference to, among other things, “negative biological effects of radiological contamination,” “licensee reports [from 1991 to 2001] of radioactive effluent releases,” “routine emissions,” alleged increase in releases, “the potential prospect of a terror attack [on Millstone] during a fuel movement activity at Unit 2,” and “many cases [of] administrative measures not [being] identified nor defined,” that are asserted to render the application “substantially incomplete.” *Id.* at 7-8, 10-11.

CCAM is described by Mr. Besade as “an organization of environmental advocacy and safe-energy groups, former employees of [Millstone] and families and individuals who reside within and beyond the five-mile emergency evacuation zone of Millstone.” *Id.* at 4. Ms. Guglielmo describes STAR Foundation as “a grass-roots environmental organization Concerned [*sic*] with the effects of power plants on local communities,” which “has been involved during the past four years in educating the public and elected officials about the risks that [Millstone] poses,” and has more than 3000 members, “the majority of whom are from the tri-state area including New York, Connecticut and New Jersey, including locations close to Millstone.” *Id.* at 11.

2. Dominion

Dominion argues that the Petitioners have not demonstrated standing because they have not shown a potential for increased offsite radiological consequences that would cause injury to persons offsite or that could be redressed in this proceeding. Answer of Dominion Nuclear Connecticut, Inc. to Amended Petition To Intervene and Request for Hearing of Connecticut Coalition Against Millstone and STAR Foundation, Inc., Dec. 27, 2002, at 4. Dominion asserts that the conclusion for which it argues “follows from the very nature of the license amendment at issue,” *id.*, and describes the rule revision that permits their LAR as offering “the potential to reduce regulatory burden without compromising any margin of safety,” and indeed as allowing for analyses that “may demonstrate greater safety margin than previously calculated.” *Id.*, citing 64 Fed. Reg. 71,990. Dominion states that “calculated doses from the original accident analyses and a re-analysis are not directly comparable,” and notes that its application has applied the alternative source term in a reanalysis of “only the *design basis Fuel Handling Accidents*,” relating to fuel movements in the Containment Building and the Spent Fuel Pool Building, which are “made only while the reactor is in Mode 6 (refueling mode) or a defueled condition.” *Id.* at 5-6.

Dominion further states that the accident reanalysis involves no physical modifications to plant equipment, including that used in the movement or storage of irradiated fuel, nor does it “alter the flowpath or the methods of processing and disposal of radioactive waste or byproducts, or increase the type and amounts of

effluents that may be released off-site.” *Id.* at 6, *citing* Application, Cover Letter at 2; Attachment 2 at 16. Dominion asserts that “[l]ocal area radiation monitors, effluent discharge monitors, and Containment gaseous and particulate radiation monitors, provide a defense-in-depth in monitoring Containment atmosphere and identifying the need for establishing the Containment atmosphere boundary”; that the Millstone Unit 2 “stack gaseous and particulate monitoring systems [will] continue to monitor any releases from normal or accident conditions”; and that “Health Physics practices and the Millstone Station Effluent Control Program monitor discharge paths and areas within the plant in which increases in radioactivity could occur when normal monitoring equipment is not available.” Dominion Answer at 6-7, *citing* Application, Attach. 1 at 9. In addition, Dominion states that no physical design changes are proposed for the Spent Fuel Pool Building ventilation systems, exhaust paths, or area radiation monitors. Dominion Answer at 7.

Dominion acknowledges that the reanalysis “does support certain certain proposed changes to the operability and surveillance requirements” of Millstone Unit 2 TSs, “with related changes to the [TS] bases,” but argues that the “re-analysis demonstrates that the radiological consequences of a Fuel Handling Accident — including postulated control room doses and doses at the exclusion area and low population zone boundaries — will be within the limits of 10 C.F.R. § 50.67, Reg. Guide 1.183, and 10 C.F.R. Part 100 without taking credit for Containment boundaries and certain equipment or automatic actions presently governed by the Technical Specifications.” *Id.* Thus, the Applicant argues, “these features are no longer required to be included in Technical Specifications (i.e., because they are not credited in the revised accident analyses).” *Id.*

As an example, Dominion notes that in the revised analyses a Containment penetration is assumed to be open for the full, 2-hour duration of a postulated Fuel Handling Accident release, allowing (for the sake of analysis) release of all available radioactivity from the accident, and asserts that the Containment boundary therefore need not be credited or controlled by TSs during fuel movements in order to meet the new NRC criteria — but explains that, “as defense-in-depth and consistent with Reg. Guide 1.183, [it] has proposed . . . to implement certain administrative controls,” which are “not required,” but which would “limit actual releases much lower than derived in the revised Fuel Handling Accident analysis dose calculations.” *Id.* at 7-8.

Another example provided by Dominion relates to the proposed deletion of a requirement under current TSs for an “operable automatic purge valve isolation signal, as it would apply during fuel movement at Mode 6 or defueled conditions.” *Id.* at 8. Dominion asserts that this deletion is appropriate, because under the revised analyses Containment purge is not credited to be operating or assumed to automatically isolate in the event of an accident, but further asserts that the manual capability will remain available “as a measure consistent with Reg. Guide

1.183,” and that “the revised Technical Specifications will require administrative controls to assure that the Containment boundary can be promptly established within 30 minutes.” *Id.*

A further defense-in-depth measure described by Dominion involves “procedural guidance related to the Spent Fuel Pool area atmosphere integrity.” *Id.* at 9. This measure is asserted to “further limit releases below those shown in the calculations,” even though, in its reanalyses of both a fuel assembly drop and a cask drop, applying a “number of conservatisms,” it found “radiological consequences . . . within the limits of 10 C.F.R. § 50.67, Reg. Guide 1.183, and Part 100, without any credit for Spent Fuel Pool area atmosphere integrity.”

Dominion argues that the Petitioners “have not demonstrated how, in any sense, the Application and, more precisely, the challenged administrative controls involve an obvious potential for off-site consequences that could lead to a [*sic*] off-site radiological injury that would therefore confer standing based on their residence — at either 2 or 23 miles from the station.” *Id.* at 9-10. Distinguishing its application, which involves only fuel handling accidents, from “any at-power accidents, loss-of-coolant accidents, or other severe accident involving the reactor core,” Dominion argues that its application is “in no sense . . . comparable to an operating license application.” *Id.* at 10. The Applicant in its argument further relies on the Petitioners’ lack of explanation of how the changes that will allow for open containment penetrations under administrative control during fuel movements, eliminate automatic closure requirements for the containment purge valve during Mode 6 fuel movement, and delete TSs associated with storage pool area ventilation “would lead to increased potential for off-site radiological injuries.” *Id.*

Dominion asserts that “none of the proposed changes to Technical Specifications in this area will lead to any significant increase in probability or consequences of off-site exposures,” and that they “merely reflect the revised assumptions of the accident analyses which show that, *even without the defense-in-depth administrative controls that will be implemented as part of the amendment*, the design basis accidents will not lead to any exposures in excess of NRC criteria.” *Id.* at 10-11 (emphasis in original). Dominion argues that, in the face of the no-significant-hazards determination in the November 12, 2002, *Federal Register* Notice, the petition is “inadequate in its face to demonstrate an obvious potential for off-site consequences,” and that various assertions made by Declarants Besade and Guglielmo are “without foundation” and/or “simply untrue.” *Id.* at 11-12. Contending that the revised accident analysis “does not alter the design of the equipment at the plant used to monitor and process off-site releases, or the procedures or equipment for handling fuel,” the applicant asserts that “there is no showing of how the amendment would lead to significantly increased releases above current levels or radiological injury.” *Id.* at 12.

Dominion argues in conclusion that a “challenge to existing regulatory siting requirements, exposure limits, release criteria, or the 10 C.F.R. § 50.67 criteria would not provide a basis for standing”; that a “challenge to the controls themselves could not lead to relief in this proceeding because the controls are unnecessary to meet NRC requirements”; that the residence presumption is “unavailable to the Petitioners”; that Petitioners have not shown any “plausible chain of causation [or] scenario suggesting how these particular license amendments would result in a distinct new harm or threat,” citing *Zion*, CLI-99-4, 49 NRC at 192; and that given the Petitioners’ “minimal showing” and the “nature of the Application,” the Petitioners have failed to establish “any credible likelihood of off-site injury that could be traced to the accident re-analysis or [proposed TS changes], or that could be redressed in this proceeding,” and have thereby failed to meet their burden of demonstrating standing. Dominion Answer at 12-13.

Finally, with regard to the “specific aspects” requirement of 10 C.F.R. § 2.714(a)(2), Dominion makes the following arguments: It asserts that the Petitioners’ proposed aspect relating to “reduction of protection . . . from unnecessary environmental releases of fission products” is “implausible,” and that the aspect alleging failure of the application to identify administrative measures and controls is “overly generalized and vague, as well as irrelevant,” since no such controls are necessary to meet NRC requirements and thus any challenge to completeness of the application is equivalent to a challenge to NRC regulations. And, citing *Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), CLI-02-25, 56 NRC 340 (2002), Dominion argues that the aspect concerning alleged failure of the application to address the potential of a terrorism attack is outside the scope of this proceeding and an “impermissible attack on Commission regulations governing security and safeguards, in that it would require analysis of events that are not required to be considered.” Dominion Answer at 14.

3. *Staff*

The Staff contends that the Petitioners have failed to establish standing in that they have neither (1) shown an obvious potential for offsite consequences that would give standing based on proximity, nor (2) shown an “injury in fact” to the interests of their members that is fairly traceable to Dominion’s LAR or that could be redressed in this proceeding, nor (3) identified an aspect within the scope of the LAR. Staff Response at 9. Noting that the changes proposed to the TSs affect (a) containment purge valve isolation signal, (b) radiation monitoring, (c) control room emergency ventilation system, (d) containment penetrations, (e) shutdown cooling and coolant circulation for high and low water level, and (f) storage pool area ventilation, the Staff asserts with regard to potential offsite consequences that the proposed LAR “does not involve any physical changes to plant equipment,” “will not result in an increase in power level, will not increase the production

of radioactive waste and byproducts, and will not alter the flowpath or method of disposal of radioactive waste or byproducts,” and therefore “will not increase the type and amounts of effluents that may be released offsite.” *Id.* at 10.

Noting, as does Dominion, that the petition recites some language from the November 12, 2002, *Federal Register* notice relating to what the proposed changes to the technical specifications do, *see* third paragraph of Background section above, the Staff points out, as does Dominion, *see* Dominion Answer at 11, that the petition omits to include language from the notice that states that “[t]hese proposed changes do not involve physical modifications to plant equipment and do not change the operational methods or procedures used for the physical movement of irradiated fuel assemblies in Containment or in the Spent Fuel Pool area,” and that, “[a]s such, the proposed changes have no effect on the probability of the occurrence of any accident previously evaluated.” Staff Response at 10-11, *citing* 67 Fed. Reg. at 68,732. The Staff argues that Petitioners have provided no explanation of how the TS changes would injure the Petitioners or their members, noting, as Dominion does, that “the revised results of dose consequences from the reanalysis are within NRC acceptance criteria,” and asserting on this basis that the Petitioners have failed to demonstrate any “obvious potential for offsite consequences” as required to establish standing by proximity. Staff Response at 11. The Staff also points out that “routine radiological effluents from Millstone, which continue to be controlled by the licensee’s approved offsite dose calculation manual and associated administrative controls, are not affected by the changes requested in this amendment request.” *Id.* at 13.

The Staff agrees with Dominion that the Petitioners have shown no causal nexus between any alleged injury and the challenged LAR, by, for example, showing any plausible way in which those activities that would be licensed by the challenged amendment would injure them. *Id.* at 11-12. Nor, asserts the Staff, does the petition indicate that, or how, any Millstone workers or residents of the community surrounding Millstone have authorized the petitioning organizations CCAM and STAR to represent them. *Id.* at 12-13. Referring to Mr. Besade’s allegation that NRC radiological emission standards are arbitrary, the Staff asserts that the Petitioners fail to show that the alleged injuries would be redressed by a favorable Board decision, and further question Mr. Besade’s and Ms. Guglielmo’s allegations by reference to asserted confusion on their part between routine radiological emissions with accident doses in the event of a hypothetical accident. *Id.* at 13-15, *citing* Besade Declaration ¶¶ 17, 20-22; Guglielmo Declaration ¶ 13.

Summarizing, the Staff argues that the harms alleged by Mr. Besade and Ms. Guglielmo are without bases, establish no likelihood of specific injury or harm traceable to the requested LAR, and should not be found to confer standing in this proceeding, “because the proposed changes (1) do not impact routine releases

or worker occupational exposure; (2) will not result in any significant increase [*sic*] doses to the public should a fuel handling accident occur; and (3) do not relax technical specification requirements on equipment shown to be necessary for maintaining public doses within NRC regulations.” Staff Response at 15. In addition, the Staff challenges the aspects raised by the Petitioners much as Dominion does, noting that “[t]he purpose of this requirement is not to judge the admissibility of the issues, but to determine whether the petitioner specifies ‘proper aspects’ for the proceeding,” and stating that “[t]he requirement is satisfied by identifying general potential areas of concern that are within the scope of the proceeding.” *Id.* at 16, citing *Consumers Power Co.* (Midland Plant, Units 1 and 2), LBP-78-27, 8 NRC 275, 278 (1978); *Vermont Yankee Nuclear Power Corp.* (Vermont Yankee Nuclear Power Station), LBP-90-6, 31 NRC 85, 89 (1990).

The Staff argues that the Petitioners’ references to health and safety risks are “vague,” that routine releases are outside the scope of the LAR, that the assertion that the application is incomplete by virtue of its failure to identify and define administrative measures is without basis, because the application “explicitly defines such administrative measures” in that Dominion “will establish administrative controls to ensure that any containment penetration which provides direct access to the outside atmosphere, including the equipment door and personnel airlock door, can be manually closed within 30 minutes of a fuel handling accident.” Staff Response at 16-17, *citing* Application, Attach. 2 at 8. The Staff also cites, without direct reference to contents, page 7 of Attachment 2 to the Application, along with Attachment 4 (Insert G), and Attachment 5 (pages B3/4 9-1a and B3/4 9-1b). With regard to the likelihood of a terrorist attack, the Staff cites the Commission’s recent ruling (issued the same day as *Private Fuel Storage*, CLI-02-25) in *Dominion Nuclear Connecticut, Inc.* (Millstone Nuclear Power Station, Unit 3), CLI-02-27, 56 NRC 367, 371 (2002), in which the Commission ruled such issues inadmissible under NEPA, finding them to be better addressed by other means. Staff Response at 17.

C. Board Ruling on Standing

As discussed above, the Petitioners make various assertions of harm in their petition and attached declarations, including claims of “adverse health and safety risks to their membership,” “increased radiological emissions,” “heightened” and “increased risk,” and “reduction of protection . . . from unnecessary environmental releases of fission products.” They challenge various changes that would occur if the LAR is granted, including modifications to certain containment closure and spent fuel pool ventilation requirements during fuel movement operations that would allow doors and other penetrations to remain open under administrative control and eliminate requirements for automatic

closure of openings. A member of Petitioner CCAM lives 2 miles from the plant; a person authorizing STAR to represent her lives 23 miles from the plant. With these circumstances in mind, along with the legal standards discussed above and the responding participants' arguments on standing, we begin our analysis with a consideration of whether a finding of standing based on proximity would be appropriate.

Viewing the issue in light of the Commission's direction that we focus, in such an inquiry, on the nature of the proposed action and the significance of the radioactive source, *see* "Legal Standards," above, we make the following observations: Dominion in its LAR proposes to make certain changes relating to fuel movement operations. If in such fuel movement operations, containment penetrations are left open, as challenged by Petitioners, rather than having automatic and other closing functions operable or in effect, it would seem self-evident that in the event of an accident there is a greater likelihood of a release of radioactivity that might have an impact on a person who lives near the plant, as alleged by Petitioners. For example, if a fuel handling accident occurs during refueling, and the containment door is left open, common sense indicates that more radioactivity is going to escape the containment than if the doors were closed. (Although the Petitioners have not made the distinction we draw between releases during normal fuel movements and releases resulting from fuel handling accidents, giving their arguments concerning "increased radiological emissions" the requisite favorable construction, it is apparent their concerns would apply not only to emission during normal fuel movement but also to releases resulting from an FHA.)

We agree with Dominion and the Staff that a sufficient showing has not been made with regard to the impact on one living 23 miles from the plant. STAR has presented no significant argument or scenario showing the impact of the actions at issue on such a person, assuming the proposed TSs were employed. Moreover, the likelihood of any normal releases, or releases arising from an FHA, during reactor shutdown conditions having any measurable effect at a distance of 23 miles would appear to be remote. Existing NRC case law involving actions other than reactor licensing, in which petitioning parties granted standing were closer than Ms. Guglielmo's 23-mile distance from the plant (in one instance considerably closer), supports such a conclusion. *See, e.g., Carolina Power & Light Co.* (Shearon Harris Nuclear Power Plant), LBP-99-25, 50 NRC 25, 29-30 (1999), and cases cited therein (county with nearest boundary 17 miles from power plant found to have standing in proceeding on request to increase spent fuel storage capacity of plant, in view of, among other things, the "strong interest that a governmental body . . . has in protecting the individuals and territory that fall under its sovereign guardianship," and an expert's affidavit explaining how offsite radiation doses could occur); *Northeast Nuclear Energy Co.* (Millstone Nuclear Power Station, Unit 3), LBP-00-2, 51 NRC 25, 27-28 (2000) (standing

found on the basis of residence 10 miles from reactor in proceeding on request to increase spent fuel storage capacity); *Pacific Gas and Electric Co.* (Diablo Canyon Power Plant Independent Spent Fuel Storage Installation), LBP-02-23, 56 NRC 413, 426-33 (2002) (Licensing Board in proceeding on application to license independent spent fuel storage installation utilized 17-mile mark established in *Shearon Harris* as limit in standing rulings).

As for a residence 2 miles from the plant, while the Licensee states that “[t]he Application does not alter any existing radiation protection standards nor does it propose to increase effluents or emissions,” Dominion Answer at 12 (emphasis added), it would appear that even in normal fuel movement operations there would be some increase in release of radioactivity if penetrations previously kept closed were left open. Indeed, in the November 12, 2002, Notice, although the Staff stated that results of the new dose analyses would “in all cases . . . [be] within the 10 CFR 50.67 and Regulatory Guide 1.183 acceptance criteria,” 67 Fed. Reg. at 68,732, and that “it is expected that the new analyses [*sic*] assumptions in some cases result in a decrease in dose at the site boundary,” it also observed that “in some cases [the new analyses] result in an increase in dose at the site boundary.” *Id.* (emphasis added). We note various arguments of Dominion and the Staff on the impossibility and/or implausibility of increased releases, but we find these arguments pertain more to potential merits issues, regarding the likelihood and extent of any increases under the proposed amendment, than to standing. Moreover, in considering whether threshold standing requirements have been met, “even minor radiological exposures resulting from a proposed licensee activity can be enough to create the requisite injury in fact.” *Oyster Creek*, LBP-96-23, 44 NRC at 158; *Atlas*, LBP-97-9, 45 NRC at 425.

Considering the event of a fuel handling accident involving spent fuel, we find that this would “quite obviously entail[] an increased potential for offsite consequences,” see *Zion*, CLI-99-4, 49 NRC at 191, at a distance of 2 miles. Thus, in the case of CCAM, we would find injury-in-fact and causality based on the 2-mile proximity of one of its members to the plant and the clear potential for increased offsite consequences arising from the open penetrations in the event of an FHA. With regard to redressability, a favorable Board ruling that, for example, disallowed leaving penetrations open, would obviously redress the harm alleged to arise from allowing the penetrations to remain open during movement of fuel.

With regard to the “aspect” arguments posited by Dominion and the Staff, although we agree that radiation exposure to plant operating personnel, terrorism concerns, and some other issues raised by the Petitioners would seem to be outside the scope of this proceeding, we find the aspect relating to the potential for increased releases of fission products to be sufficient, at least in the event of a fuel handling accident, to establish a litigable aspect in accordance with 10 C.F.R. § 2.714(a)(2).

In conclusion, we find that Petitioner CCAM has sufficiently set forth its concerns that the proposed changes will place its membership at greater risk from increased radiological emissions to establish the necessary injury-in-fact, fairly traceable to the challenged LAR and likely to be redressed by a favorable decision, for us to conclude that CCAM has established standing to participate in this proceeding under section 189a of the Atomic Energy Act and relevant NRC rules. On the other hand, based on the showing made relative to Ms. Guglielmo, we find that STAR has failed to establish its standing to intervene in this proceeding, and it must therefore be dismissed from this proceeding.

III. CONTENTION REQUIREMENTS AND DEADLINES FOR ADDITIONAL FILINGS

Pursuant to 10 C.F.R. § 2.714(b)(1), petitioners have the right to supplement petitions with regard to contentions.

(A) Petitioner CCAM shall file its supplemented petition and contentions no later than March 7, 2003.

(B) The Applicant and the Staff shall file their responses to the Petitioner's supplemented petition and contentions no later than March 28, 2003.

With regard to the filing of contentions, we offer the following guidance, in order to facilitate a more orderly proceeding:

First, the standards that licensing boards must apply in ruling on the admissibility of contentions, and that we shall therefore apply in ruling on any contentions proffered in this proceeding, are defined at 10 C.F.R. § 2.714(b), (d). The failure of a contention to comply with any one of these requirements is grounds for dismissing the contention. *Arizona Public Service Co.* (Palo Verde Nuclear Generating Station, Units 1, 2, and 3), CLI-91-12, 34 NRC 149, 155-56 (1991). And, pursuant to section 2.714(b)(1), the failure of a petitioner to submit at least one admissible contention is grounds for dismissing the petition.²

In *Duke Energy Corp.* (McGuire Nuclear Station, Units 1 and 2; Catawba Nuclear Station, Units 1 and 2), LBP-02-4, 55 NRC 49, 67-68 (2002), the

²Of course, if a petitioner should at a later date discover facts that might provide grounds for a contention, a petition containing such a contention could be submitted pursuant to 10 C.F.R. § 2.714(a)(1), and may be considered if the late-filed petition establishes that it is timely and appropriate under the factors listed in subsections (i)-(v) of section 2.714(a)(1). See *Duke Energy Corp.* (Oconee Nuclear Station, Units 1, 2, and 3), CLI-99-11, 49 NRC 328, 338 (1999); *Turkey Point*, CLI-01-17, 54 NRC at 24 n.18.

Licensing Board provided the following summary of the contention requirements as gleaned from case law that was also discussed in the Board's decision therein:

[A] contention must:

(A) under section 2.714(b)(2), consist of a *specific* statement of the issue of law or fact the petitioner wishes to raise or controvert; and

(B) under subsection 2.714(b)(2)(i), be supported by a brief *explanation* of the factual and/or legal basis or bases of the contention, which goes beyond mere allegation and speculation, is *not* open-ended, ill-defined, vague, or unparticularized, and *is* stated with reasonable specificity; and

(C) under subsection 2.714(b)(2)(ii), include a statement of the alleged facts or expert opinion (or both) that support the contention and on which the petitioner intends to rely to prove its case at a hearing, which must also be stated with reasonable specificity; and

(D) also under subsection 2.714(b)(2)(ii), include references to those specific sources and documents of which the petitioner is aware and on which the petitioner intends to rely to establish the facts it alleges and/or the expert opinion it offers, which must also be stated with reasonable specificity and, at a minimum, consist of a fact-based argument sufficient to demonstrate that an inquiry in depth is appropriate, and illustrate that the petitioner has examined the publicly available documentary material pertaining to the facility(ies) in question with sufficient care to uncover any information that could serve as a foundation for a specific contention; and

(E) under subsection 2.714(b)(2)(iii), provide sufficient information to show that a *genuine dispute* exists with the applicant on a *material* issue of law or fact (i.e., a dispute that actually, specifically, and directly challenges and controverts the application, with regard to a legal or factual issue, the resolution of which "would make a difference in the outcome of the licensing proceeding," 54 Fed. Reg. at 33,172, which includes either:

(1) *references to the specific portions of the application* (including the applicant's environmental report and safety report) that the petitioner disputes *and the supporting reasons for each dispute*, or

(2) if the petitioner believes that the application fails to contain information on a relevant matter as required by law, the *identification of each failure and the supporting reasons for the petitioner's belief*; and

(F) under subsection 2.714(d)(2)(ii), demonstrate that the contention, if proven, would be of consequence in the proceeding because it would entitle the petitioner to specific relief.

Also, as indicated in the text of subsection 2.714(b)(2)(iii), for issues arising under [NEPA], contentions must be based on the applicant's environmental report, and the petitioner can amend such contentions or file new contentions "if there are

data or conclusions in the NRC draft or final environmental impact statement, environmental assessment, or any supplements relating thereto, that differ significantly from the data or conclusions in the applicant's document.”

Id. In addition to the requirements of 10 C.F.R. § 2.714, contentions are necessarily limited to issues that are germane to the application pending before the Board. *Yankee*, CLI-98-21, 48 NRC at 204 n.7.

The Licensing Board in *McGuire/Catawba* noted the Commission's recent guidance that the “contention rule is strict by design,” having been “toughened . . . in 1989 because in prior years ‘licensing boards had admitted and litigated numerous contentions that appeared to be based on little more than speculation.’” *McGuire/Catawba*, LBP-02-4, 55 NRC at 64; *Dominion Nuclear Connecticut, Inc.* (Millstone Nuclear Power Station, Units 2 and 3), CLI-01-24, 54 NRC 349, 358 (2001) (citing *Duke Energy Corp.* (Oconee Nuclear Station, Units 1, 2, and 3), CLI-99-11, 49 NRC 328, 334 (1999)).

Thus, a petitioner must do more than merely make unsupported allegations. Contentions must *specifically* state the issue a petitioner wishes to raise and, in addition to providing support in the form of expert opinion, document(s) and/or a fact-based argument, a petitioner must provide reasonably specific and understandable *explanation* and *reasons* to support its contentions. If a petitioner in a contention “fail[s] to offer any specific explanation, factual or legal, for why the consequences [the Petitioner fears] will occur,” the requirements of the contention rule are not satisfied. *Millstone*, CLI-01-24, 54 NRC at 359. “An admissible contention must *explain, with specificity*, particular safety or legal reasons requiring rejection of the contested [licensing action].” *Id.* at 359-60 (emphasis added). The contention rule does not require “a specific allegation or citation of a regulatory violation,” but a petitioner is obliged, under 10 C.F.R. § 2.714(b)(2)(iii), either to “include references to the specific portions of the application . . . that the petitioner disputes and the supporting *reasons* for each dispute,” *id.* (emphasis added), or, if a contention alleges that an application “fails to contain information on a relevant matter as required by law,” *id.*, to identify “each failure and the supporting *reasons* for the petitioner's belief.” *Id.*; *Millstone*, 54 NRC at 361-62 (emphasis added).

There are various other sources that provide some elucidation in interpreting and applying the contention requirements, including the Statement of Considerations (SOC) for the final 1989 rule amendments, 54 Fed. Reg. 33,168 (Aug. 11, 1989), which provides guidance that is entitled to “special weight” under the authority of *Long Island Lighting Co.* (Shoreham Nuclear Power Station, Unit 1), ALAB-900, 28 NRC 275, 290-91 (1988), *review declined*, CLI-88-11, 28 NRC 603 (1988). In the SOC the Commission stated that a “contention will be dismissed if [a petitioner] sets forth no facts or expert opinion on which it intends to rely to prove its contention, or if the contention fails to establish that

a genuine dispute exists between the intervenor and the applicant,” and that petitioners must do more than submit “bald or conclusory allegation[s]” of a dispute with the applicant. 54 Fed. Reg. at 33,171. They must “read the pertinent portions of the license application, including the Safety Analysis Report and the Environmental Report, state the applicant’s position and the petitioner’s opposing view,” *Millstone*, CLI-01-24, 54 NRC at 358 (*citing* 54 Fed. Reg. at 33,170), and “explain[] why they have a disagreement with [the applicant].” 54 Fed. Reg. at 33,171.

The Commission’s *Statement of Policy on Conduct of Adjudicatory Proceedings*, CLI-98-12, 48 NRC 18 (1998), provides further guidance. Therein, the Commission emphasized that a “contention’s proponent, not the licensing board, is responsible for formulating the contention and providing the necessary information to satisfy the basis requirement” of the rule. *Id.* at 22. Finally, the Petitioner may wish to consult the Commission’s recent decision in *Duke Energy Corp.* (McGuire Nuclear Station, Units 1 and 2; Catawba Nuclear Station, Units 1 and 2), CLI-02-28, 56 NRC 373 (2002), for additional discussion of NRC contention requirements.

IV. FURTHER PROCEEDINGS

After receipt of the Petitioner’s supplemented petition and contentions, and responses thereto, the Board will schedule any oral argument that may be needed in this proceeding.

V. ORDER

Based upon the analysis set forth above, the Licensing Board hereby (1) finds that Petitioner CCAM has standing to participate in this proceeding; (2) finds that Petitioner STAR lacks standing, so that it must be dismissed from the proceeding; and (3) sets the above stated deadlines of March 7 and 28, 2003, respectively, for the submission of a supplemented petition and contentions, and responses thereto.

This Order is subject to appeal in accordance with the provisions of 10 C.F.R. § 2.714a(a). Any petitions for review meeting applicable requirements set forth therein must be filed within 10 days of service of this Memorandum and Order.

It is so ORDERED.

THE ATOMIC SAFETY AND
LICENSING BOARD³

Ann Marshall Young, Chair
ADMINISTRATIVE JUDGE

Dr. Richard F. Cole
ADMINISTRATIVE JUDGE

Dr. Thomas S. Elleman
ADMINISTRATIVE JUDGE

Dated at Rockville, Maryland,
this 14th day of February 2003.

³Copies of this Memorandum and Order were sent this date by Internet e-mail or facsimile transmission, if available, to all participants or counsel for participants.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:

Michael C. Farrar, Chairman
Dr. Jerry R. Kline
Dr. Peter S. Lam

In the Matter of

Docket No. 72-22-ISFSI
(ASLBP No. 97-732-02-ISFSI)

PRIVATE FUEL STORAGE, L.L.C.
(Independent Spent Fuel Storage
Installation)

March 10, 2003

**NUCLEAR REGULATORY COMMISSION: HEALTH AND SAFETY
RESPONSIBILITIES**

The NRC Staff's lengthy prehearing review process sets the stage for a hearing. Although the public may be concerned over the Staff's moving in concert with an applicant at a hearing, the Staff has come to such a position only after first satisfying itself that an application for a license passes muster under NRC regulations. In other words, the fact that the Staff eventually sides with an applicant at a hearing does not mean that the Staff has not been protecting the public interest.

REGULATIONS: SAFETY STANDARDS (CREDIBLE ACCIDENTS)

The Commission requires that any facility that it licenses be designed to withstand "credible accidents," that is, any accidents deemed sufficiently likely to occur that they should be guarded against. The probability criterion defining that likelihood is also defined by the Commission. Any potential accidents less likely than that criterion are considered "incredible" and are allowed to

be disregarded in designing the facility, that is, they do not become part of the facility's "design basis."

REGULATORY GUIDANCE: SAFETY STANDARDS (NUREG-0800)

To determine the probability of an aircraft crashing into a facility, a four-factor formula embodied in the "Aircraft Hazards" portion of Standard Review Plan NUREG-0800 has regularly been used. The formula for calculating this annual probability is $P = C \times N \times A/w$, where C equals the aircraft's historic accident rate (in accidents per mile flown), N equals the number of flights per year, A equals the effective area of the facility in square miles, and w equals the width of the airway in miles.

REGULATORY GUIDANCE

The structure and language of the series of Staff guidance documents containing a "Standard Review Plan" like NUREG-0800 make it clear that they do not establish binding principles that need to be followed in all circumstances. Rather, they set out but one method that the Staff will treat as an acceptable approach for an applicant in complying with regulations.

REGULATORY GUIDANCE

As a general matter, strict compliance with guidance associated with a Standard Review Plan is not required by relevant statutes or NRC regulations. An applicant for a license has the option — as it sets out to prove to the Staff in the first instance that its proposal meets applicable regulatory requirements — either (1) to adopt an approach outlined in, and to demonstrate compliance with, the Standard Review Plan (thereby in effect ensuring Staff approval) or (2) to present and to justify some alternative approach. *See Curators of the University of Missouri*, CLI-95-8, 41 NRC 386, 397 (1995). By the same token, an intervenor, though not allowed to challenge duly promulgated Commission regulations in the hearing process (*see* 10 C.F.R. § 2.758), is free to take issue with the terms of the Standard Review Plan, which represents only Staff guidance and thinking, not official Commission requirements.

REGULATORY GUIDANCE: INTERPRETATION AND APPLICATION (NUREG-0800)

Although Standard Review Plan NUREG-0800 does not explicitly contemplate the use of a modification factor (called the R factor by the Applicant) to account

for pilot avoidance of a facility, such a factor is not prohibited by NRC regulations, Commission precedent, or any other legal principle. A Board thus may permit such a modification if it is factually and technically well founded.

REGULATORY GUIDANCE: INTERPRETATION AND APPLICATION (NUREG-0800)

In assessing the value for pilot avoidance of a facility, the Applicant put forward two separate factors. For the first component, designated *R1*, the Applicant assigned an aircraft controllability value of 90% to account for various types of emergencies likely to occur in the vicinity of the facility. This value was accepted by the Board, albeit “just barely,” as the evidence presented was highly debatable.

REGULATORY GUIDANCE: INTERPRETATION AND APPLICATION (NUREG-0800)

The second component of the *R* factor, designated *R2*, purportedly accounted for the ability of pilots, before ejecting, to guide their crashing aircraft away from a particular ground site. The Board rejected the asserted 95% value for this component of the *R* factor because when the subject is the prediction of human behavior under stress, the successful establishment of near certainty inherently calls for a highly probative showing, which the Applicant did not meet in this case.

REGULATORY GUIDANCE: INTERPRETATION AND APPLICATION (NUREG-0800)

RULES OF PRACTICE: BURDEN OF PROOF

The Board accepts that in the event of an aircraft failure, in the vicinity of the PFS facility or elsewhere, pilots would generally do what they could, consistent with their other responsibilities, to guide their aircraft away from vulnerable ground facilities before ejecting. However, the 95% value of *R2* propounded by the Applicant — who has the burden of proof in this case — is far from sufficiently well founded. Probative contrary evidence undercut each of the three central factual premises — visibility, time, and training — underlying Applicant’s expert beliefs. When the concept being advanced is “near certainty” the proof must necessarily be solid. In this case, the evidence is too uncertain to make safety-related decisions for nuclear facility licensing purposes.

REGULATORY GUIDANCE: INTERPRETATION AND APPLICATION (NUREG-0800)

RULES OF PRACTICE: BURDEN OF PROOF

Any prediction of human performance that claims there will be, particularly during emergency or other stressful conditions, 95% success — which the Applicant asserts to be conservative compared to the 100% theoretically supportable by its approach — could benefit from a rigorous, in-depth evaluation and analysis of reliable operational data, which is lacking in this case.

REGULATORY GUIDANCE: INTERPRETATION AND APPLICATION (NUREG-0800)

Despite the extensive training provided to Air Force pilots, and notwithstanding their dedication, they commit human errors — and such errors would be expected to occur — particularly in instances where very high stress exists.

REGULATORY GUIDANCE: INTERPRETATION AND APPLICATION (NUREG-0800)

The Air Force's decision to produce and disseminate a training video provides additional evidence countering the Applicant's assertion that pilots nearly always do what they are trained to do. Incorporating that experience into a safety video to remind pilots of the need to follow their training is all to the good — but it demonstrates the fallacy in any holding that would rely on pilots almost always doing what their training (superb though it may be) told them to do.

REGULATORY GUIDANCE: INTERPRETATION AND APPLICATION (NUREG-0800)

The Air Force's publication of a document entitled ALSAFECOM 002/1996 embodied the clear message that despite the Air Force training, crew members continued to commit significant errors during emergency situations. These situations included being distracted during in-flight emergencies, delaying ejection due to futile attempts to recover failed engines, and ejecting below the minimum published altitudes. The issuance of the ALSAFECOM reemphasizes the need to adhere to the lessons that are learned during training and that these lessons are too often ignored — powerful evidence against the notion that pilots can be counted on almost always to follow their training.

REGULATORY GUIDANCE: INTERPRETATION AND APPLICATION (NUREG-0800)

Evidence that pilots make mistakes in all phases of flight (including many that involve non-emergency, less stress-filled activities than a pre-ejection emergency) provides additional support for the finding that there is no sufficient basis to declare that they will almost never err when it comes to performing, in a high-stress situation, avoidance of a ground site.

REGULATORY GUIDANCE: INTERPRETATION AND APPLICATION (NUREG-0800); SAFETY STANDARDS

It is far from certain that in a nuclear regulatory safety context, pilots can be counted on not to take improper action, or to take proper action, in emergency or non-emergency situations.

REGULATORY GUIDANCE: INTERPRETATION AND APPLICATION (NUREG-0800); SAFETY STANDARDS

Opportunity to act and rigorous pilot training are certainly necessary conditions if there is to be a reliance on pilot behavior in a nuclear licensing action. But the evidence establishes that those conditions are not sufficient, and cannot be dispositive, particularly when the evidence reflects compelling examples of pilot errors made when the opportunity for taking the correct action existed.

REGULATORY GUIDANCE: INTERPRETATION AND APPLICATION (NUREG-0800); SAFETY STANDARDS (HUMAN FACTORS ANALYSIS)

The conflicting evidence about pilots' both following and ignoring their training leaves a record that shows reliable prediction of pilot behavior in an emergency is a serious and complex human factors analysis question. Where usually there is a grave concern that a human factors element will detract from safety assurances, here that element would be used to augment what would otherwise be a deficient safety showing. Although such an approach may not be entirely precluded, relying on it has to overcome the additional uncertainty of attempting to take credit for avoiding human error rather than, as is usually the case, making allowances for human error.

REGULATORY GUIDANCE: INTERPRETATION AND APPLICATION (NUREG-0800)

In deriving the value for “*N*” in the NUREG-0800 formula, the Staff suggested that the overall number of flights should be reduced by one-half to account for the lateral offset of half the flights. The Staff asserts that because of that offset, the aircraft more to the east of the two (and the two easternmost aircraft in the usual formation of four) would pose a negligible probability of impacting the facility and thus can be discounted as contributors to the impact probability calculation. Applying the halving concept to reduce “*N*” results in an obvious additional direct impact on another aspect of the four-factor formula in NUREG-0800, that being the width, *w*, of the effective airway. It was not demonstrated by the Staff (and in fact seems facially invalid) that the technique used in deriving a value for “*N*” can be employed, while at the same time leaving the value for the width unchanged. On the other hand, if the halved *N* value were to be accompanied by a halving of the airway width, the result of the four-factor calculation would remain unchanged. Although NUREG-0800 provides for offset airways, it does not condone the method employed by the Staff.

REGULATORY GUIDANCE: INTERPRETATION AND APPLICATION (NUREG-0800)

Because density is a function of width, the logical construct behind these elements suggests that the airway width, *w*, for purposes of the NUREG-0800 formula, should appropriately be determined based on where aircraft predominantly fly, not on the simple geographic width of the available airspace. Employing this standard, the remaining discrepancy among the parties’ views reflects differing approaches which are a part of the overall uncertainty of the estimate. The evidence presented only serves to demonstrate that the actual value for *w* is indeterminate to the extent that it depends on individual pilot preference.

REGULATORY GUIDANCE: INTERPRETATION AND APPLICATION (NUREG-0800); SAFETY STANDARDS

While there is uncertainty in the estimates of the NUREG-0800 four factors, the uncertainty is not troublesome if the formula is used as it was apparently intended, i.e., as a rough screening device. The formula was to be applied cautiously. Thus, it is inappropriate to rely, as the Staff did in this case, on an order-of-magnitude confidence interval bracketing or surrounding the applicable acceptance criterion. Rather than stretch the acceptable criterion to let the applicant move forward in the licensing process, the appropriate course is to let the criterion and the screening

formula serve their purpose — that of alerting the applicant and the Staff to a problem so that the applicant has the opportunity to address it.

REGULATIONS: SAFETY STANDARDS (DESIGN BASIS)

Under the Commission’s site evaluation regulations (covering nuclear reactors and adapted for spent fuel storage facilities), an applicant must show that if a credible accident were to occur, the consequences would not result in the release of radioactivity that would cause doses in excess of 10 C.F.R. Part 100 guidelines. *See* 10 C.F.R. §§ 72.90, 72.94, 72.98, 110.10; NUREG-0800 at 3.5.1.6-2. As a legal matter, then, the ultimate focus is on a unified question, i.e., the probability of an accident that would lead to radiation doses beyond Part 100. As a practical matter, however, the regulatory focus and approach often turn out not to be on that unified question but on one of two separate, subsidiary issues, either of which can be determinative in particular circumstances. If it can be shown that the likelihood of the triggering accident is so low that the accident can be discounted as not credible, there is no need for an inquiry into whether the dose consequences would be excessive if an accident were to occur. On the other hand, an applicant can take the opposite approach and assume that the accident would occur, but attempt to demonstrate that there would be no consequences because the facility’s “design basis” is shown to be such that it can withstand or mitigate them adequately.

NUCLEAR REGULATORY COMMISSION: ROLE OF NRC STAFF (REVIEW OF LICENSE APPLICATION)

Under the Commission’s time-tested licensing and hearing processes, the Staff’s evaluation of an applicant’s proposal — reached as it conducts its independent review of an application — is considered an integral part of the record that is developed regarding any contentions challenging what the applicant has put forth. Even though the Staff’s position may not prevail at trial, it is presumed that the development and exploration of a contested issue will benefit from the Staff’s analysis and presentation. Thus, a licensing board is reluctant to undertake to decide an issue of potential significance in the absence of Staff review of that issue in either its Safety Evaluation Report or its proffered testimony.

NUCLEAR REGULATORY COMMISSION: COMMISSION POLICY (CONDUCT OF LICENSING PROCEEDINGS)

RULES OF PRACTICE: REFERRAL OF RULING

Conscious of the Commission’s instructions that licensing boards should adopt case-management techniques that will help move licensing proceedings along

as expeditiously as possible, allowing an applicant to proceed on parallel tracks before the licensing board and the Commission — rather than forcing it to proceed sequentially — seems likely to best achieve that objective. *Commonwealth Edison Co.* (Byron Nuclear Power Station, Units 1 and 2), ALAB-770, 19 NRC 1163, 1169-70 (1984).

RULES OF PRACTICE: REFERRAL OF RULINGS

Although appellate proceedings ordinarily deprive a lower tribunal of jurisdiction over the substance of the matter that was before it, there is no fundamental inconsistency between the Commission's conducting a referred review of matters decided by the Board, while the Board simultaneously considers other undecided issues arising in that same proceeding.

TECHNICAL ISSUES DISCUSSED

The following technical issues are discussed: Independent Spent Fuel Storage Installation, NUREG-0800, Human Factors Analysis, Safety Standards, Pilot Avoidance, Credible Accident Scenario (Aircraft Crash Hazard), Sensitivity Analysis, Crash Rate of F-16s, Number of F-16 Flights, Effective Area of Facility, Effective Airway Width, Potential Ordnance Hazard, Orders of Magnitude, ALSAFECOM.

PARTIAL INITIAL DECISION (Regarding "Credible Accidents")

Private Fuel Storage (PFS) is a consortium of electric utility companies that applied for an NRC license to build and to operate, on the reservation of the Skull Valley Band of Goshute Indians some 50 miles southwest of Salt Lake City, an aboveground facility for the temporary storage of spent fuel rods from the nation's nuclear reactors. During a 9-week trial in Salt Lake and at NRC Headquarters, ending in mid-2002, the Applicant PFS attempted to demonstrate — over the opposition of the State of Utah and the Southern Utah Wilderness Alliance (SUWA) — that its proposal was acceptable in terms of meeting certain safety and environmental regulatory criteria established under federal law, including the Atomic Energy Act and the National Environmental Policy Act (NEPA).

Our decision today deals with just one of the issues considered at that trial, i.e., *the chance that military aircraft operations in Utah's West Desert might*

pose a risk to the facility.¹ We find that probability to be too high when measured against the applicable NRC safety criterion governing protection against the risk of accidents at a regulated facility.

Under that criterion (and speaking very generally²), an applicant must show either that (1) a postulated accident is so unlikely (i.e., not “credible”) that it need not be guarded against, or (2) the facility’s design is such that the accident’s consequences would be of no real concern. Here, the “credible accidents” issue arises because the proposed facility would sit under the airway that pilots use to fly F-16s (single-engine military jet aircraft) from Hill Air Force Base, located to the north of Salt Lake City, down Skull Valley toward the southern entry to the military’s Utah Test and Training Range (UTTR) in the State’s West Desert.

The State urged us to find that, under standard NRC calculational protocols, the probability of an F-16 crash into the spent fuel casks is too high to ignore in our safety analysis. The Applicant urged that other factors — particularly the expectation that pilots would take care to avoid the site before ejecting in an emergency situation — serve to reduce the calculated accidental crash probability to a level low enough to be disregarded.

On the facts presented, and with the Applicant having the burden of proof, we find that the State’s position on accident probabilities prevails: on the key issue, we essentially reject — as insufficiently proven for nuclear regulatory safety analysis purposes — the Applicant’s “pilot avoidance” theory. Then, applying the probability criterion the Commission established in this very case, *we find that there is enough likelihood of an F-16 crash into the proposed facility that such an accident must be deemed “credible.” The result is that the PFS facility cannot be licensed without that safety concern being addressed.*

As is apparent, there are at least two ways in which that concern might be alleviated. One would be for the Applicant to convince the Air Force to agree to reduce the number, and/or to alter the pattern, of Skull Valley overflights. Although we have no role to play in — and thus no views on — whether the formulation of any such agreement should be entertained, we do note that the emergence of that type of agreement seems relatively unlikely in view of the

¹This leaves open two matters tried before this Board: (1) whether PFS has established that its proposed facility satisfies the NRC’s seismic safety criteria; and (2) whether the rail spur proposed for transporting spent fuel casks from the main line down Skull Valley is routed as well from an environmental standpoint as the alternatives, including those SUWA suggested, and does not run afoul of wilderness management constraints. We are not yet ready to rule on those two items, having chosen to give priority to completing the matter decided today. Drafting the decisions on those matters is well along, however, and we expect to issue them in the next few weeks. *See also* notes 6 & 13, below, to the same effect on matters before another Board.

²We explain this concept in more detail in Subpart E, below.

content of a written “limited appearance” statement (described later herein) filed on behalf of the Secretary of the Air Force early in our 2002 hearings.³

A second option for the Applicant would be to attempt to establish that the contemplated (or upgraded) design of the proposed facility’s spent fuel storage casks is so robust that an F-16 crash would not have appreciable health and safety consequences. That matter is not now before us, for — apparently believing that the issue would not need to be reached — the Applicant shaped the application it submitted to the NRC Staff for review, and the material it submitted to us pretrial, in a manner that kept evidence on the “consequences” issue from reaching us in a fashion that would have allowed us to address that issue properly.

If the Applicant were to rehabilitate its application by addressing that issue fully, this matter might eventually come before us again, this time with the benefit of Staff analysis. For now, *we cannot approve the sought-after PFS license*.⁴

Our decision today, so briefly summarized above, is necessarily a long one. In Part I, we set forth in narrative form the underlying reasoning that led us to that decision:

- In Subpart A, we open by setting the stage in terms of the procedural history of the “credible accidents” contention and by recounting the context in which the matters now being decided arose.
- In the next three portions of the decision, contained in Subparts B through D, we explain our views on certain overarching issues. Specifically, Subpart B deals with the “pilot avoidance” issue, where the Applicant’s

³As explained at greater length later (*see* note 11, below), limited appearance statements are not evidence upon which the merits of a decision can be based. Our only purpose in referring to the Air Force filing — which may be viewed electronically on the NRC ADAMS site (Accession #ML021160024) — is as a possible indicator of the future course of the proceeding.

⁴As the parties are aware, the issue being decided today involves only the risk of *accidental aircraft crashes*. The risk from *intentional aircraft attacks* and other potential terrorist activities is not before us in this proceeding, but is being considered by the Commission in a much broader context, not only in this case but across the entire regulatory landscape. *See, e.g.*, CLI-01-26, 54 NRC 376 (2001), and CLI-02-25, 56 NRC 340 and related cases (Dec. 18, 2002). In CLI-02-25, the Commission considered, at our request, the question whether NEPA requires the NRC to address in licensing decisions the impact of terrorism as seen in the light of the September 11, 2001 attacks. In ruling that the impacts of a potential terrorism attack need not be considered by licensing boards as part of the NRC’s environmental review in particular adjudications, the Commission noted that it is itself in the process of more broadly reviewing the potential effects of suicidal aircraft crashes on NRC-regulated facilities. *See* CLI-02-25, 56 NRC at 356. Nothing now before us indicates whether any studies that may have been performed to aid the Commission in evaluating the consequences of aircraft-related *terrorism* would shed light upon the consequences of the aircraft-related *accidents* that we have been considering and which could now become the subject of further proceedings herein.

novel approach is embodied in a so-called “*R*” factor; Subpart C deals with the four other factors that go into a typical aircraft accident probability calculation; and Subpart D deals with the nature of the safety norm against which that calculation is measured.

- We go on in Subpart E to discuss why questions about the projected consequences of an accident — including whether a crashing F-16 would penetrate a spent fuel cask — were not considered at this hearing but may be considered at a later stage.

We then provide, in Part II, a lengthy “Detailed Analysis of Record and Findings of Fact” that reviews the evidence and includes determinations either providing support for, or resulting from, the opinions and holdings expressed in the earlier, narrative portion of this decision. Finally, in Part III, we recite briefly our formal Conclusions of Law and our Order.

An outline of the remainder of this Partial Initial Decision’s contents, then, is as follows:

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I. NARRATIVE OPINION

A. Introduction, Background, and Summary

This decision — by our count the fifty-fifth one published in the course of carrying out the Licensing Board’s adjudicatory role in this proceeding — brings to a conclusion at our level (for a time, at least) the legal and factual debate over one issue crucial to the Applicant’s plans. The debate on that and other issues has gone on for a long time, most visibly since the Applicant’s proposal was noticed for hearing on July 21, 1997.⁵ The State of Utah and a number of other

⁵ See 62 Fed. Reg. 41,099 (1997).

parties opposed that proposal, filing some 125 “contentions,” or issue statements, challenging the proposal from various safety or environmental standpoints.

Our previous decisions, or voluntary action by the parties, have since resolved — whether on legal arguments, evidentiary presentations, settlement agreements, or some combination thereof — most of those matters, leaving pending before this Board but three of those contentions. Those remaining three issues — aircraft accidents, seismic safety, and rail-line alternatives — were the subject of full-blown, trial-type evidentiary presentations in various Salt Lake City venues and in our own Washington, DC-area hearing room.

In total, that trial consumed, between April 8 and July 3 of last year, some 45 days of hearing evidence and of conducting related business.⁶ The transcript of those proceedings covers some 11,000 pages; during those hearings, the parties presented direct testimony (and usually rebuttal testimony as well) from nearly forty witnesses, through whom they proffered some 475 exhibits. The parties submitted two sets of post-trial briefs on each of the three issues; those opening and reply “Proposed Findings of Fact and Conclusions of Law” and related materials totaled some 2200 pages.

The last of those briefs was filed on October 16, 2002, triggering the formal period for preparation of our decision.⁷ As a prelude to the substance of today’s decision, in Section 1 below we cover in more detail how the proceeding unfolded (and address a misperception about our proceedings), and then in Section 2 explain how the key issues developed.

1. The Procedural Setting

a. The Application Review

All the issues, including the one matter we decide today, had their genesis in an application filed with the Nuclear Regulatory Commission by the Private Fuel Storage, L.L.C., consortium on June 20, 1997. Triggered by the nuclear power

⁶That 2002 trial initially included a fourth issue, involving hydrological concerns, that was settled in mid-hearing. A previous trial, conducted some time earlier by our predecessor Board (*see* note 13, below), involved issues relating to the facility’s emergency planning arrangements and the Applicant’s financial qualifications, matters that that Board has either since resolved and or will resolve shortly (*see also* note 1, above).

⁷The Commission urges that, in a typical case, a decision be rendered within 60 days of the filing of the final briefs. *Statement of Policy on Conduct of Adjudicatory Proceedings*, CLI-98-12, 48 NRC 18, 21 (1998). Just as the trial necessarily took much longer than counsel had predicted (before they each disclosed the large number of witnesses being put forward), the decisionmaking process has taken longer here, for reasons adverted to in our unpublished Orders of December 11, 2002, and January 23, 2003. In that regard, the lengthy decision-writing process on this issue was aided immeasurably by the extraordinarily thorough and well-crafted papers filed by all three parties.

industry's uncertainty about the timely availability of an underground repository for the permanent storage of spent nuclear fuel (as currently contemplated for Yucca Mountain in Nevada), the PFS application sought NRC approval for a facility for temporary aboveground storage of those same fuel rods, now located at various electric-power-generating reactors around the country.

The application envisions as many as 4000 casks — each nearly 20 feet high and 11 feet in diameter, made of concrete and stainless steel — resting on 500 concrete pads arrayed on 99 acres of the Reservation of the Skull Valley Band of Goshute Indians.⁸ That Reservation is located within the borders of — but is essentially not subject to regulation by — the State of Utah;⁹ it is in Skull Valley (which lies between the Stansbury Mountains to the east and the Cedar Mountains to the west), some 50 miles southwest of Salt Lake City (more locally, it is southwest of the town of Tooele and north of the Dugway Proving Ground).

The PFS application was duly reviewed by the NRC Staff. In this proceeding, as in others, the role of the Staff at that stage is to scrutinize the application carefully, to seek additional information where it deems it appropriate, and to indicate where it believes improvements in approach or design are necessary. (*See also* pp. 83-84 and Subpart E, below.)

At least partially as a result of that process, PFS filed some nineteen amendments to its application before, on September 29, 2000, the NRC Staff indicated it would approve the application. An additional four application amendments were filed thereafter, the last coming on November 21, 2001, some 4 years after the application was first filed.

b. The Hearing Process

As the Staff review was starting, the NRC published in the *Federal Register* the July 1997 hearing notice (referred to above) indicating, among other things, that anyone opposed to the issuance of the license could seek to intervene in the proceeding and to request a public hearing before an NRC Atomic Safety and Licensing Board. A number of parties did so, framing their challenges as the “contentions” called for by the NRC’s procedural rules.

An NRC Licensing Board was duly appointed to preside over the proceeding in September 1997 (*see* 62 Fed. Reg. 49,263 (1997)). That initial Board was chaired by Chief Administrative Judge G. Paul Bollwerk, III, and had the same two technical members as this Board (Judges Jerry R. Kline and Peter S. Lam). After

⁸The Band would derive substantial income from making its Reservation available to the Applicant for the facility. (The disputes among various Band members over the nature of that arrangement, and the distribution of funds thereunder, do not fall within our jurisdiction to resolve. *See* CLI-02-20, 56 NRC 147 (2002), *reversing* LBP-02-8, 55 NRC 171 (2002).)

⁹*See, e.g., Skull Valley Band of Goshute Indians v. Leavitt*, 215 F. Supp. 2d 1232 (D. Utah 2002).

that Board devoted enormous effort to resolving a vast number of preliminary matters in the case, responsibilities for the completion of the case from that point on were split between that original board, chaired by Chief Judge Bollwerk, and this second board, chaired by Judge Michael C. Farrar, all pursuant to, and as detailed in, a December 19, 2001, Notice of Reconstitution issued by Judge Bollwerk.¹⁰

As the proceeding before the Licensing Board(s) took shape, the parties intervening in opposition to the project ordinarily found themselves aligned not only against the Applicant PFS but also against the NRC Staff. Aware of that situation, some Salt Lake area residents who made presentations at the “limited appearance” sessions¹¹ we held last April 8th (at the Salt Palace) and April 26th (at Tooele High School) expressed sentiments seemingly critical of, or reflecting confusion about, the role played by the NRC Staff in proceedings like this.

In view of those sentiments, and the discussion later herein about the role of the NRC Staff (*see* Subpart E, below, pp. 139-41), it is worth repeating briefly the explanation we attempted at the time, about how the Staff’s lengthy prehearing review sets the stage for the hearing. Although the public may observe the Staff’s seeming to move in concert with an applicant once the hearing begins, the Staff has come to such a position at the hearing only after first satisfying itself — as it did during the multiyear internal scrutiny described above (*see* p. 82) — that an application passes muster.¹² In other words, that the Staff eventually sides with

¹⁰ *See* 66 Fed. Reg. 67,335 (2001). For purposes of completeness in this procedural history, we have noted herein how the existence of the two Boards came about. Generally, however, unless the context demands otherwise or we so indicate, references in this decision to “this Board” or “the Licensing Board” are *not* intended to distinguish between rulings made by the original Board and by this second Board, for there has been no lack of continuity in our respective roles.

¹¹ “Limited appearance” sessions are conducted in order to allow members of the public who, although unable to undertake the task of becoming a full party to the proceeding and participating in the creation of the evidentiary record, nonetheless would like to make their views known. Those views, which are made part of the agency’s official docket, are not evidence upon which a Board decision can be based but, to the extent relevant to the issues being heard, can serve to trigger inquiry by the Board or presentations by the parties. As part of that process, and because of its relevance to an aspect of our decision (*see* Subpart E, below), we address in the text the concern expressed about the Staff’s role.

¹² In this regard, an applicant is theoretically free during that review process to reject a Staff determination that its presentation is not acceptable and to request a hearing of its own to challenge adverse Staff decisions. *See, e.g., Ohio Edison Co.* (Perry Nuclear Power Plant, Unit 1), LBP-92-32, 36 NRC 269 (1992); *Consumers Power Co.* (Midland Plant, Units 1 and 2), LBP-85-2, 21 NRC 24, 46 (1985); *Kerr-McGee Chemical Corp.* (West Chicago Rare Earths Facility), LBP-84-42, 20 NRC 1296, 1306 (1984). Historically, however, applicants have usually elected not to make such challenges on safety matters in original licensing actions, but instead have found it more prudent to accept the Staff’s critique and to make the suggested corrections.

an applicant at a hearing does not mean that the Staff has not been protecting the public interest.

c. The Opposition Contentions Generally

From the outset of this proceeding, the primary opposition to the facility has come from the State of Utah. The Southern Utah Wilderness Alliance (SUWA) also pressed a number of contentions. (Other entities, including the Skull Valley Band, Ohngo Gaudadeh Devia, Confederated Tribes of the Goshute Reservation, Castle Rock Land and Livestock, Skull Valley Company, and Ensign Ranches of Utah, participated in a more limited fashion or eventually withdrew.)

Several of the State's contentions were the subject of a full evidentiary hearing in front of the Bollwerk Board¹³ before we held the lengthy 2002 hearing described above. A number of other contentions had been rejected without a hearing on a variety of grounds. Some were dismissed at the outset for such reasons as not providing necessary supporting documentation, not raising issues litigable in this forum, and/or not furnishing sufficient justification for being filed outside established time periods.¹⁴

Other contentions, although initially admitted as appropriate to litigate, were later dismissed by one Board or the other on "summary disposition," a procedure invoked when there are no significant factual disputes about a matter and controlling legal principles warrant resolving it without the formal presentation of evidence at a trial. As to those issues, the Applicant was able to convince us that no evidentiary hearing was necessary to determine that the State's, or other parties', claims lacked merit.¹⁵ In other instances, after discovery of additional facts bearing on particular claims, an intervening party withdrew contentions on the grounds that its concerns had been satisfied.

Several of the State's contentions survived all this screening and moved into the hearing process before this Board. These State issues included two safety matters

¹³ Specifically, as noted earlier (*see* note 6), that Board conducted a hearing in mid-2000 on the merits of several contentions involving financial assurance and emergency planning. A partial initial decision was issued on the latter. LBP-00-35, 52 NRC 364 (2000), *petition for review denied*, CLI-01-9, 53 NRC 232 (2001). The financial assurance matters are still under advisement but will be decided no later than the rest of the matters before this Board.

¹⁴ We need not recite here the Board's many prior decisions on the initial admissibility of contentions (referred to in the text above) or on summary disposition of previously admitted contentions (*see* next paragraph of text). We do note that some 120 contentions were covered.

¹⁵ As just noted, we need not detail those here, for each was the subject of a published Board opinion. To the extent that any of the Board's prehearing rulings were not ripe for appeal to (or for review by) the Commission at the time, they will become ripe when a partial initial decision to which they relate is issued, or (if unrelated to any earlier decision) when our last initial decision is issued. CLI-00-24, 52 NRC 351, 353-54 (2000).

— involving concerns about seismic activity and aircraft accidents — as well as an environmental issue involving potential water pollution from operations. For its part, SUWA’s surviving contention challenged the routing of the proposed rail spur as being inconsistent with environmental and other norms reflected in the National Environmental Policy Act and elsewhere.

Each of the foregoing four issues — which eventually became the subject of the Salt Lake 2002 hearings — arose in different fashion, and took different amounts of time to try before either the matter was settled (in the case of the water pollution issue) or the trial was completed. We need not discuss here the background of the other issues that remain pending, for that will be done in due course in the later decisions resolving those issues.

d. The “Credible Accidents” Contention Specifically

We focus instead on how the issue we decide today, involving the likelihood of aircraft accidents, has presented itself. Again speaking generally (*see* p. 77, above, and Subpart E, below), the Commission requires that any facility it licenses be designed to withstand “credible accidents,” that is, any accidents deemed sufficiently likely to occur that they should be guarded against. The probability criterion defining that likelihood is also set by the Commission. Any potential accidents *less* likely than that criterion are considered “incredible” and are allowed to be disregarded in designing the facility, that is, they do not become part of the facility’s “design basis.”

Against that background, the State presented a contention — eventually denominated Utah K/Confederated Tribes B — arguing that a variety of risks from military and other operations in Utah’s West Desert could lead to airborne and other accidents that could threaten the facility.¹⁶ As the State saw it, the cumulative probability of those accidents made them a credible threat to public health and safety, such that they had to be taken into account in some fashion. In contrast, the Applicant, supported by the NRC Staff, saw those accidents as not credible and thus safely disregarded. The subsidiary issues that were the subject of our hearing on the contention are described in the next section.

¹⁶ A variant of the State’s contention was filed by Intervenors Confederated Tribes (who opposed the project but did not participate actively at the trial) and Castle Rock Land and Livestock Co. and Skull Valley Co. (representing neighboring landowners who withdrew before trial). The contentions were all consolidated and revised to read as follows: “The Applicant has inadequately considered credible accidents caused by external events and facilities affecting the [proposed facility] and the intermodal transfer site, including the cumulative effects of the nearby hazardous waste and military testing facilities in the vicinity and the effects of wildfires.” LBP-98-7, 47 NRC 142, 253, *aff’d on other grounds*, CLI-98-13, 48 NRC 26 (1998).

2. *The Key Issues*

a. *The Prior Decisions*

The “credible accidents” issue presented in this proceeding has had a complicated history, a brief review of which should aid understanding of the action we take today. A more complete history appears in two prior rulings: (1) this Board’s decision granting in part and denying in part the Applicant’s motion for summary disposition and referring a key matter to the Commission for its pretrial resolution (LBP-01-19, 53 NRC 416 (2001)), and (2) the Commission’s resolution of that matter (CLI-01-22, 54 NRC 255 (2001)).¹⁷

In a nutshell, in LBP-01-19 we found there to be no reason to go to trial on a number of concerns the State had attempted to raise about the risk of potential flying or falling objects that might result from certain aspects of military or civilian aircraft operations or airborne testing experiments.¹⁸ But some of those concerns, we held, did justify a trial. As to those, we sought Commission guidance on, and approval of our views about, the appropriate test for “credibility” of an accident — did that test reach occurrences as unlikely as one in ten million

¹⁷ See also our decisions in LBP-99-34, 50 NRC 168 (1999), LBP-99-35, 50 NRC 180 (1999), and LBP-99-39, 50 NRC 232 (1999), all of which led to the contention’s eventually being limited to and reframed as: “The Applicant has inadequately considered credible accidents caused by external events and facilities affecting the [proposed facility], including the cumulative effects of military testing facilities in the vicinity.” LBP-99-39, 50 NRC at 240.

¹⁸ In that decision, we ruled on whether or not a genuine dispute of material fact existed regarding several categories of events that the State asserted in its amended contention were “credible accident scenarios.” These categories involved assertions that the facility would be at risk from (a) the use of military ordnance at Dugway Proving Ground; (b) the testing of cruise missiles on the UTTR; and (c) the potential for a variety of aircraft accidents.

In the first two instances, we granted the Applicant’s motion to dismiss and thus eliminated the need for further litigation on those issues. With respect to the first, the use of ordnance at Dugway, we found that no genuine dispute of material fact existed because the State no longer contested the Applicant’s evaluation of munitions hazards. LBP-01-19, 53 NRC at 424. As to the second, we found that cruise missile testing did not present a genuine dispute of material fact because even in situations where cruise missiles have crashed, the State could not point to any circumstances in which the missiles had strayed more than 1 mile from the original flight path, a distance that would not bring the proposed site within range. *Id.* at 427-29.

The third category, aircraft crash hazards, presented several issues about which we found a genuine dispute of material fact to exist; those are the issues on which we went to trial and with which we deal herein. But we also held that other aspects of the State’s assertions — regarding the hazards of commercial aircraft flying to and from Salt Lake City International Airport and of other general aviation activity — presented no genuine dispute of material fact. *Id.* at 451, 452. In making that ruling, we found that the State’s expert witness had not provided any concrete scientific analysis to controvert the Applicant’s submissions, and thus resolved the matter in the Applicant’s favor. *Id.*

(1×10^{-7}), the criterion applied to nuclear power plants, or for facilities like this¹⁹ need it reach (as we thought) only those occurrences more likely to take place, i.e., with at least a one in a million (1×10^{-6}) likelihood per year?

The Commission adopted the one in a million criterion, for the reasons it explained at some length in CLI-01-22. In essence, the Commission reasoned that, because of the lesser consequences that would attend an accident affecting a spent fuel cask than one affecting a nuclear power plant (*see* CLI-01-22, 54 NRC at 265),²⁰ a greater likelihood of an accident (i.e., an accident anticipated to occur more frequently) could be tolerated for spent fuel facilities before requiring that the accident be designed against.²¹ Accordingly, the Commission held that for proceedings of this nature, any accident with a likelihood of occurrence of less than one in a million per year could be disregarded.²² *Id.* That is, then, the standard we apply to the F-16 overflights and related matters.

b. The Accident Likelihood

Although a number of other accident scenarios were still before us (*see* Section C.6, below), principal focus as the trial began was on the risk from F-16 flights down Skull Valley on their way to the UTTR. To determine the probability of an F-16 crash into the spent fuel casks, attention turned first to a four-factor formula the NRC Staff had developed long ago — and embodied in the “Aircraft Hazards” portion of its Standard Review Plan (in a document known as “NUREG-0800,”

¹⁹ In NRC parlance, the proposed interim storage facility is called an Independent Spent Fuel Storage Installation, or ISFSI. *See* 10 C.F.R. § 72.3.

²⁰ Given the conclusions we reach later in this opinion (*see* Subpart E, below), it is important to observe that the Commission’s discussion of hypothetical “consequences” — in the context of setting a probability criterion — was of a general, comparative character and does not provide any insight into the specific, precise level of consequences that might result if a spent fuel cask accident indeed did take place. *See also* the notation in CLI-01-22 of the views of Commissioner Dicus, 54 NRC at 265-66.

²¹ The pleadings that had been filed when the Commission made the above ruling had placed almost exclusive emphasis, as to F-16s, on the probability, not the consequences, of an aircraft hitting the facility. For example, the Commission’s opinion referred to the Applicant’s having indicated that “various accident scenarios [were] extremely unlikely” and that “*in some cases* . . . even if the posited accident did occur, no radioactive materials would be released.” CLI-01-22, 54 NRC at 258 (emphasis added). That “in some cases” reference was to general aviation aircraft, not to F-16s, as may be seen by examination of the material cited.

²² It appeared at that time that, had the Commission ruled that the stricter “one in ten million” criterion should apply, the Applicant would have conceded that the accidents we discuss herein would be deemed credible and thus that they must be designed against. *See* LBP-01-19, 53 NRC at 431. Instead, the Commission’s adoption of the less stringent standard left it open to the Applicant to argue that those accidents were not credible, with the result that their specific consequences would *not* have to be considered. The impact this had on how the case later developed is reflected in Subpart E, below.

described more precisely below) — that had regularly been used to calculate the risks of aircraft crashing into NRC-regulated facilities.

Although much argument took place about the values to be given various of the factors in this case, exception was not taken to the underlying legitimacy of the formula itself, i.e.,

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

whose factors for calculating yearly accident probability (P) represent, respectively:

- C — the aircraft’s historic accident rate (in accidents per mile flown);
- N — the number of flights per year;
- A — the effective area of the facility (in square miles); and
- w — the width of the airway (in miles).

As will be seen, in this proceeding there was considerable controversy over deriving “ C ,” the appropriate historic or projected accident rate to use; about projecting “ N ,” the number of flights in future years; and about defining “ w ,” the useable width of the airway (but essentially none about “ A ,” the effective area of the facility). But in whatever fashion those disputes were resolved, it appeared early on, from its own calculations, that the Applicant would have some difficulty proving that the accident scenario was “incredible” under the basic four-factor formula.

This led to the most extensive and crucial controversy, involving the Applicant’s attempt to modify the basic four-factor formula by including a fifth factor (denominated “ R ”). We were told that such a multiplier would reduce the yearly accident probability by accounting for “pilot avoidance,” i.e., the purported action pilots would be expected to take, when able to do so, in guiding their doomed planes away from particular ground locations — like the PFS facility — before ejecting.

Pointing to the nature of most inflight emergencies that might be expected over Skull Valley and to the quality of Air Force training to deal with those emergencies, the Applicant proposed to take an approximately 85% reduction in the accident likelihood because of the so-called R factor.²³ To justify that

²³As defined, R represents the probability that a crashing F-16 will hit the site by the pilot’s *not avoiding* it before ejecting. As will be explained in more detail, R is a function of the product of two components — which we call $R1$ and $R2$ (as they were sometimes referred to during the hearing and in the parties’ proposed findings (*see, e.g.*, Staff Findings ¶2.165)) — that measure conditions leading to accident *avoidance*. Accordingly, R is best described as follows: $R = 1 - (R1 \times R2)$. On occasion at the hearing, however, the product of the two components was itself loosely referred to as “ R ,” and the Transcript must be read accordingly.

reduction, it analyzed accident causes as reflected in the set of F-16 accident reports prepared by the Air Force, and then relied almost entirely on expert opinion about pilot behavior in emergencies provided by its three-man panel of former high-ranking Air Force officers (whose qualifications, including their familiarity with Skull Valley, we detail later); it also drew upon the accident reports for exemplars of such behavior.

In opposition, the State made two basic arguments: (1) the NUREG-0800 formula is set and will not admit of a fifth factor; and (2) the Air Force's accident reports and the Applicant's expert opinions do not support an 85% reduction value for *R*. In support of the second argument, the State — relying in part on the opinions of its own expert, a former F-16 (and currently Southwest Airlines) pilot who, while serving at Hill Air Force Base, had flown over 150 missions in the UTTR and also served as Deputy Commander of the 388th Operations Wing — pointed not just to its contrary interpretation of the contents of the reports themselves but also to the purpose for which the reports were prepared and to examples of circumstances in which pilots had erred by ignoring their training.

In essence, we reject the first of the State's arguments (against adding an *R*-type factor), but accept the second (about the value assigned to *R* here). We explain why we do so in Subpart B, below.

Having thus not given the Applicant the credit it attempted to assign to the fifth factor, we turn in Subpart C to consideration — under the classic “four-factor” formula — of the likelihood of an accident at the PFS site. On the facts presented, we find that probability exceeds the one-in-a-million criterion by over a fourfold margin. We then go on in Subpart D to explain why we cannot accept the Staff's argument that there is so much flexibility in the “one-in-a-million” criterion that the Applicant's proposal should — notwithstanding the adverse Subpart C result — be deemed to meet that criterion.

Our ultimate holding, then, is that the accident in question must be deemed “credible,” which in turn demands additional analysis from the Applicant if it wishes to pursue its license application, such as by demonstrating that the accident's consequences are not significant. Given the importance that the “consequences” issue could thus well take on as the proceeding goes forward, we set out in Subpart E our understanding of how that matter had come to us only tangentially at the 2002 hearing and thus was — as the Staff conceded — not then ready for consideration. We go on to mention briefly how that issue can now become ripe for full consideration, if the Applicant chooses to exercise the option of attempting to demonstrate that there would be no untoward consequences if the “credible accident” indeed did take place.

B. The Proposed Pilot Avoidance (“R”) Factor

As has been seen, in order more accurately to reflect its view of reality, the Applicant proposed to add a “pilot avoidance” factor — called “R” — to the NUREG-0800²⁴ formula in an effort to show that the probability of an aircraft crash on the site is much less than the unmodified formula would indicate. As the Applicant sees it, inclusion of the R factor enables it to demonstrate that the facility meets the Commission’s licensing requirements.

Underlying the R factor formula modification is the belief of the Applicant’s experts that, when possible (which they say is 90% of the time), Air Force pilots would almost invariably (95% of the time) act affirmatively to avoid striking the facility’s spent fuel casks in the event of an impending crash. If this predicted “pilot avoidance” behavior could be relied upon, goes the argument, it would reduce substantially — by some 85% — the calculated probability of impact on the site and thus permit NRC approval of licensing.

As has been noted (note 23, above), the R value the Applicant wishes to add as a factor in the probability formula is a function of two components. The R1 component represents the proportion of times a crashing plane is nonetheless “controllable,” said by the Applicant to be 90%; the R2 component represents the proportion of times a pilot in control would avoid the site, said here to be 95%. With R set as equal to $1 - (R1 \times R2)$, the product of the two components is 0.855 (representing site avoidance), and the value of R to be inserted in the formula is 0.145 (representing nonavoidance, or the occurrence of the accident).²⁵

The State makes several arguments against adoption of the R factor. First, it says, the standard NUREG-0800 formula is set with its four factors and does not admit of any alteration. Second, claims the State, the values the Applicant proposes for the components of the R factor do not have sufficient support either in the historic accident reports or in the expert opinion proffered by the Applicant’s witness panel.

As to the reports, the State says they do not justify the conclusion the Applicant would draw that 90% of the time a pilot would be in control of the aircraft in

²⁴ PFS Exh. RRR, U.S. Nuclear Regulatory Commission, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, NUREG-0800 (Rev. 2, July 1981).

²⁵ See note 23, above. R1 and R2 as we use them should not be confused with the R₁ and R₂ that were used in earlier documents to represent different concepts that led to the same value for R through a different set of calculations (see, e.g., PFS Exh. N, Aircraft Crash Impact Hazard at the Private Fuel Storage Facility (Rev. 4, Aug. 2000) at 7-8 [hereinafter Aircraft Crash Report]). Although the mathematical calculational process relating to the R factor can be approached in different fashions to reach the same result (compare *id.* with note 23, above), in all such approaches the key issues concern the accuracy of the 90% “in control” and 95% “will avoid” component values upon which the Applicant relies to reach its 85.5% crash reduction rate (and its complement, the 14.5% crash likelihood).

an emergency. As to the expert opinion about pilots following their training and taking avoidance action when in control of their planes, the State argues those opinions are undercut by actual experience, including pilot errors that are not only recounted in the very reports that the Applicant presented, but that occur sufficiently frequently to warrant the Air Force's preparing and distributing a retraining video and a written safety reminder. Nor, says the State, can those reports serve as probative exemplars of the Applicant's theories of pilot behavior in issue here, when viewed with an understanding of the limited, very different purposes for which the reports were created.

We discuss the parties' competing arguments in Sections 1 and 2 below.²⁶ Once again, we do not accept the State's argument that no alterations to the formula are legally or conceptually permissible. But we reject the value the Applicant proposes for its *R* factor alteration as not proven by the evidence before us.

1. Amending the Standard Formula

The State asserts that the Applicant's modification of the venerable four-factor NUREG-0800 formula is invalid, almost as a matter of law.²⁷ It points out that NUREG-0800 makes no reference to any *R*-type factor in the crash probability formula, and contains no suggestion that the pilot of a crashing aircraft might be able to avoid its impacting the ground site of concern. *See* State Findings ¶ 57. The State also notes that the key Staff witness — Dr. Kazimieras Campe, who has for 30 years been evaluating accident hazards, including aircraft crashes (*see* Tr. at 4080 (Campe)) — testified that he has never been presented a significant departure from the four-factor formula, and knows of no authoritative sources that recognize a pilot avoidance factor. *See* Tr. at 4109, 4126 (Campe).

We reject the State's arguments on this score. As we conclude, the structure and language of the series of Staff documents (like NUREG-0800) that set out

²⁶ At this juncture, we should expand on our previous mention (pp. 78-79, above) of the interrelationship between this Part I Narrative Opinion, explaining our reasoning, and the more detailed supporting material, reviewing and evaluating the evidence, that appears in Part II. In terms of cross-references, particularly with respect to Subparts B and C of both parts, it is our intention — whether or not a particular thought in the Narrative is accompanied by a specific reference to the detailed findings — to place reliance on the portion of the detailed findings that supports the narrative thought.

As a general matter throughout the remainder of this decision, if we cite to a Proposed Finding submitted by one of the parties, rather than to the evidentiary record, it is because (1) we are merely stating that party's position; (2) the matter under discussion is noncontroversial; and/or (3) we intend to incorporate by reference the record citations included in the Proposed Finding. On a related topic, if through inadvertence there appears to be a discontinuity between our written text and our record references, the text is to be deemed to reflect our views more accurately.

²⁷ *See* State of Utah's Proposed Findings of Fact and Conclusions of Law Regarding Contention Utah K/Confederated Tribes B (Aug. 30, 2000) ¶ 57 [hereinafter State Findings].

the basis for the Staff's "Standard Review Plan" analysis make it clear that they do not establish binding principles that must be followed in all instances. Rather, they are intended as guidance, setting out but one method that the Staff will treat as an acceptable approach to complying with NRC regulations. To that end, NUREG-0800 declares in a standard cover-page explanation that "compliance with [this guidance] is not required."

This construction — that compliance with guidance associated with the Standard Review Plan is not required by the relevant statutes or by NRC regulations — has long been recognized in NRC practice and jurisprudence. As a general matter, an applicant for a license has the option — as it sets about to prove to the Staff in the first instance that its proposal meets applicable regulatory requirements — either (1) to adopt an approach outlined in, and to demonstrate compliance with, the Standard Review Plan (thereby in effect assuring Staff approval) or (2) to present and to justify some alternative approach. *See Curators of the University of Missouri*, CLI-95-8, 41 NRC 386, 397 (1995). By the same token, an intervenor, though not allowed to challenge duly promulgated Commission regulations in the hearing process (*see* 10 C.F.R. § 2.758), is free to take issue with the terms of the Standard Review Plan, which represents only Staff guidance and thinking, not official Commission requirements.²⁸

That general understanding of the role of the Standard Review Plan is captured in the materials before us. Specifically, with respect to the four-factor formula, NUREG-0800 recognizes in section III.2 (at 3.5.1.6-3) that the formula is just "one way" of calculating the probability of an aircraft crash. Building on that concept, Staff witness Dr. Campe, one of the original authors of the section of NUREG-0800 dealing with aircraft hazards, expressed the view that the use of *R* — if factually supported — would be an acceptable way to accommodate the

²⁸To understand NRC adjudications in terms of matters like that just discussed in the text, it is important to distinguish among the roles, duties, and responsibilities of, respectively, the Commission(ers), the Staff, and the licensing boards. To that end, we take some care in all our writings to distinguish among those entities; when, instead, the context calls for us to speak of the agency as a whole, we use the term "NRC."

To begin with, it is the five presidentially appointed and Senate-confirmed Commissioners who, empowered and directed by the governing statutes (like the Atomic Energy Act and the National Environmental Policy Act), set licensing requirements by issuing regulations on safety and environmental matters. Those regulations are binding on the NRC Staff and on licensing boards.

In the course of applying and enforcing agency regulations, the NRC Staff may provide guidance to the regulated community. Boards — being entirely independent of the Staff — are not bound, however, to follow such guidance; they are bound only by the Commission's regulations and its adjudicatory precedents (which it issues in the course of conducting judicial-style review of our decisions, much as a higher court reviews a lower court's decisions).

concept that military pilots might avoid a particular ground site.²⁹ *See* Tr. at 4098 (Campe).

Accordingly, although NUREG-0800 does not explicitly contemplate the use of an *R*-type modification factor, we hold that use of such a factor is not prohibited by NRC regulations, Commission precedent, or any other legal principle. Thus, the Board may permit such a modification if it is factually and technically well founded.

The dispute among the parties as to the use of the *R* factor, then, comes down to whether the components of the *R* factor, and the values the Applicant would assign them, are justified by the evidence before us. In the next section, we address whether those values were proven.

2. Evaluating the Proposed *R* Factor

a. The Applicant's Position

The overall *R* factor is a function of the frequency with which pilots undergoing an emergency in which a crash is likely can be expected to take avoidance action before ejecting from the aircraft. The State does not so much challenge the general theories behind the Applicant's promotion of the *R* factor's two components as it takes issue with the specific values the Applicant would give each of them.

The legitimacy of the *R* factor thus turns on whether the Applicant has adequately demonstrated (1) how often F-16 pilots are in control of their aircraft while experiencing emergencies; and (2) how often a pilot in such control will, before ejecting, take action to make sure the crashing plane avoids particular ground locations. The Applicant's conceptual basis for developing those two components derives from two beliefs held by its panel of expert witnesses, all retired high-ranking Air Force officers, one with special familiarity with statistical analysis, another with significant safety expertise, and a third with extensive flight experience in Skull Valley.³⁰

The first belief is that, in an aircraft emergency, a pilot will often have the time and the opportunity to steer the disabled plane away from a ground site before ejecting.³¹ The second is that a pilot with the time and opportunity to take such

²⁹ We do not find this view to be in any way inconsistent with Dr. Campe's also having indicated that he had not previously been presented with such a concept. *See* p. 91, above.

³⁰ Our detailed findings of fact in Part II, below, reflect the witnesses' qualifications and our findings that they did qualify as experts. *See* pp. 149-52.

³¹ *See* Applicant's Proposed Findings of Fact and Conclusions of Law on Contention Utah K/Confederated Tribes B (Aug. 30, 2000) at 19-20 [hereinafter PFS Findings].

avoidance action will — to a near certainty — do so as a consequence of the rigorous training that pilots receive. *See* PFS Findings at 24-25.

With those assumptions in mind, the Applicant’s experts proceeded to estimate the numerical value of *R*, relying on an analysis of historic F-16 accident reports and on their own expert opinion. *See* PFS Findings ¶¶ 69, 71. The Applicant determined the values of the *R* factor’s two components through two separate analyses.

The *RI* analysis first required an elaborate protocol to screen out inapplicable reports, i.e., reports addressing accidents that occurred under “non-Skull-Valley” conditions. *See id.* ¶ 72. In that regard, as will be discussed in more detail in Subsection C.4.a, below, the portion of an F-16’s training flight that takes place over Skull Valley, while not risk-free, was viewed by the Applicant’s experts as akin to “normal flight,” in that operations over Skull Valley involve neither takeoff or landing nor (as described in note 70, below) the sort of high-risk maneuvers that take place in the UTTR.

From the remaining set of accident reports, the experts determined the frequency (*RI*) with which pilots who had been operating in “Skull Valley conditions” were presented with the opportunity to steer the aircraft in an emergency situation, which the witnesses set at 90%. *See* PFS Findings ¶ 74. Then, the Applicant’s panel drew upon their collective expertise to propound the view about *R2* that, when encountering an emergency while traversing Skull Valley, a pilot able to control an F-16 about to crash will, before ejecting, guide the aircraft away from the PFS site (or from any site that should be avoided) 95% of the time. *See id.* ¶ 91. We delineate below the detailed methodology utilized by the Applicant in determining the values of the two components.

(i) PROBABILITY OF A PILOT BEING IN CONTROL OF AN AIRCRAFT

As was noted above, the *RI* component represents the percentage of F-16 crashes that might occur in Skull Valley in which the pilot would be expected to retain control of the aircraft. The Applicant asserts that the most likely cause of an emergency threatening a crash in Skull Valley — with its “normal flight” conditions — is engine failure, which leaves the pilot in some degree of “control” (*see id.* ¶¶ 68, 73), as that term was employed in the hearing. For all crashes that might occur in Skull Valley, the Applicant assessed at 90% the probability that the pilot would be in such control of the aircraft before ejecting. *See id.* ¶ 74.

The Applicant’s expert witnesses reached this figure by independently assessing each of the Air Force’s available reports (for fiscal years 1989 through 1998) about F-16 accidents (occurring anywhere) that resulted in the aircraft being destroyed. *See id.* ¶ 69. Those reports were prepared by Air Force Aircraft Accident Investigation Boards, each of which is typically chaired by a Colonel and includes experts on the relevant subject matter. *See id.* ¶ 70.

Initially acting independently of each other, the three members of the Applicant's panel reviewed these accident reports. *See id.* ¶ 71. A joint review followed to resolve any discrepancies in their separate professional judgments. *See id.* As a result of this procedure, the experts categorized each accident on two principal counts: (1) could its causes have resulted from the flight conditions experienced during Skull Valley operations; and (2) did the pilot have enough control over the aircraft prior to ejection to steer the aircraft away from a site such as the PFS facility. *See id.* ¶ 72.

Out of the 121 F-16 accidents that destroyed the plane and for which reports were available, the Applicant's experts initially concluded that 61 were Skull-Valley-type events, and that in 58 of those — or just over 95% — the pilot retained control of the aircraft. *See id.* ¶ 74.³² For purposes of conservatism, however, for the proportion of accidents that would leave a pilot in control, the Applicant took credit for only 90% rather than the calculated 95%. *See id.* For its part, the Staff concurs with the PFS assessment of the accident reports in this regard.³³

(ii) PILOT'S ACTING TO AVOID THE SITE WHEN IN CONTROL

As was also noted above, the second component, or R2, in the Applicant's aircraft crash hazard calculation involves the probability that a pilot who is able to control an aircraft experiencing an in-flight emergency would actually take sufficient action before ejecting to avoid a particular ground site. Starting with their strongly held beliefs about pilot training and dedication — and before examining any of the accident reports and without conducting any statistical analysis — the Applicant's expert panel assessed the value of this component to be 95%. *See id.* ¶ 92.

In reaching this judgment, the Applicant's panel considered a number of factors that they believed were well founded and would aid a trained, dedicated pilot in accomplishing avoidance: (1) the time the pilot would typically have before ejecting (estimated at one or more minutes, as derived from Air Force data regarding F-16 performance following engine failure); (2) the pilot's ability to conduct restart operations or otherwise to complete all necessary emergency response actions in timely fashion; (3) the slight turn required to avoid the PFS facility; (4) the training that pilots receive about avoiding inhabited or built-up

³² Later, the Applicant conceded that one additional accident could have occurred in Skull-Valley-type conditions. *See Cole/Jefferson/Fly Post Tr.* 3090, at 78-81. Treating that aircraft as having been in control before the pilot ejected, the proportion of "in control" crashes became 59 of 62, marginally increasing the resulting 95% value.

³³ *See* NRC Staff's Proposed Findings of Fact and Conclusions of Law Concerning Contention Utah K/Confederated Tribes B (Inadequate Consideration of Credible Accidents) ¶ 2.283 (Aug. 30, 2002) [hereinafter Staff Findings].

areas on the ground;³⁴ (5) the familiarity that pilots at Hill AFB would have with the location of the PFS facility; (6) the existence of open spaces around that facility; (7) the excellent weather and clear visibility typical of Skull Valley; and (8) the F-16 flight control computer that keeps the aircraft on a straight flight path after ejection. *See id.*

To corroborate its *R2* estimate, the Applicant discussed fifteen accident reports as exemplars during the hearing. *See Tr.* at 3662 (Cole). After the Board repeatedly questioned the statistical legitimacy of such a limited proffer,³⁵ the Applicant submitted all of the relevant accident reports, which were duly introduced into evidence.³⁶

b. The Staff's Position

The Staff asserts that taking credit for a pilot's ability to direct a crashing plane prior to ejecting is a legitimate approach and that the *R2* value is not based on purely subjective opinion.³⁷ The Staff concurred that a pilot with adequate control of the aircraft and sufficient time to direct it away from a ground site before ejecting would indeed be able to have it avoid the facility at least 95% of the time. *See Staff Findings* ¶2.475.

In support of this position, the Staff joined the Applicant in strongly asserting that Air Force training will prepare a pilot to respond successfully to emergency situations. *See id.* ¶2.295; Staff Reply ¶104. As the Staff would have it, the

³⁴The relevant F-16 manual urges a pilot preparing to eject to carry out a number of tasks, including — time permitting — guiding the plane away from “populated areas.” At the hearing, some discussion took place, as a general matter, about what this term means and what type of action is contemplated, as well as how the instruction should be interpreted in the specific circumstance involving spent nuclear fuel casks (and perhaps other areas to avoid). Although those discussions about “populated areas” were not entirely illuminating, we explain later (*see* note 67, below) why we do not rest our decision on any interpretation of that concept.

³⁵The questions the Board posed to the Applicant sought an explanation as to how the estimated 95% probability of a pilot successfully avoiding a land target was derived from 15 out of 126 accident reports. *See Tr.* at 3663 (Lam). On its face, 15 successful events out of a total of 126 events yields only a 12% probability of success. *See Tr.* at 3668 (Lam). The Applicant's position was, however, that it had not placed principal reliance on the accident reports in determining the 95% success probability estimate. *See Tr.* at 3215-16 (Jefferson).

³⁶Following the admission into evidence of the initially proffered 15 accident reports, *see Tr.* at 3740-45, there was later discussion (recounted at *Tr.* at 8673-78) about whether all 126 accident reports needed to be before us for a sound decision to be made on the *R1* and *R2* components. To afford the State an opportunity to analyze and to respond to the additional reports, the hearing was recessed (to consider other issues already scheduled) and reconvened at a later point. *See Tr.* at 8677-78.

³⁷*See* NRC Staff's Proposed Findings in Reply to the State of Utah's Proposed Findings Concerning Contention Utah K/Confederated Tribes B (Inadequate Consideration of Credible Accidents) ¶89 (Oct. 7, 2002) [hereinafter Staff Reply].

success of the training programs is evidenced by the accident reports recounting occasions in which pilots have, in ejecting, been successful in causing their crashing planes to avoid objects on the ground. *See* Staff Reply ¶104. In this regard, the Staff points out that “[i]n no report do we find that a pilot with time and opportunity to avoid a ground site failed to do so.” *See id.* ¶89. From this the Staff contends that the Applicant “could have reasonably set the determination at 100%, but, as a measure of conservatism chose to set the value at 95 percent avoidance.” *See id.*

The Staff also put forward a sensitivity analysis that it performed as part of its consideration of the 95% value presented by the Applicant. The Staff testimony characterized that sensitivity analysis as evaluating the effect of “increasing by 20 times” the predicted likelihood of a crashing plane hitting the PFS facility. *See* Campe/Ghosh Post Tr. 4078, at 21. Doing so, the Staff said, increases the overall crash probability by only a factor of 2.5. *See id.* From that, the Staff urged us to find that the crash probability is thus “not highly sensitive” to variations from the 95% avoidance factor.³⁸ *See id.*

c. The State’s Position

The State asserts that the Applicant’s *RI* assertion — that in 90% of crashes the aircraft is controllable — is deficient on two grounds. First, although noting that much was made by the Applicant of the evidence that engine failure (*see* State Findings ¶70) — a circumstance in which the aircraft remains controllable — is the most likely cause of a crash, the State points out that, according to F-16 manufacturer Lockheed Martin, crashes that occur due to engine failures account for only 36% of Class A mishaps. *See id.* ¶67. From this, the State reasons that as a general matter, in a much lesser percentage than the Applicant’s postulated 90% would control of the aircraft be retained. *Id.*

Second, asserting that the accidents that took place in “non-Skull-Valley” flying conditions should not be eliminated from consideration, the State claims that 42% of the 121 crash reports indicate the pilot did not have sufficient control of the aircraft to have avoided the PFS site. *See* State Reply at 36. Therefore, according to the State, only 58% of those crashes could have resulted in the pilot retaining control of the aircraft, rather than the 90% asserted by the Applicant. *See id.*

³⁸More specifically, the Staff examined a “failure to avoid” probability range from 1% to 20%, which it referred to as a “20 times increase.” *See* Staff Exh. C, Consolidated Safety Evaluation Report Concerning the Proposed Private Fuel Storage Facility (Mar. 2002) at 15-58 [hereinafter SER]. Had that range been expressed in terms of the *R2* “avoid” component, the range would, of course, have been from 99% to 80%. We discuss later (*see* note 66) the appropriateness of representing that range as a “20 times increase,” and then asserting therefrom that the 95% base value is not highly sensitive.

Turning to the *R2* component, the State asserts that the value of 95% used by the Applicant “is a purely subjective determination made collectively” by the Applicant’s experts, one that “was made without performing any calculation or statistics” and indeed “was made prior to reviewing the F-16 accident reports.” State Findings ¶ 69. The State also asserts that the statistical evidence is flawed because it lacks affirmative support; all that is being shown, it says, is the purported absence of negative information, as epitomized by the Applicant’s experts testifying that “we found no case where they tried to avoid something, and they didn’t avoid it.”³⁹

In short, the State vigorously challenges the correctness and reliability of the analytical protocols followed by the Applicant to obtain numerical values for *R1* and *R2*. In addition to these specific challenges to the Applicant’s data, the State makes two general arguments in an effort to undercut the Applicant’s approach on a broader scale.

First, the State argues that, because of the way the accident reports were compiled, they were never intended to be utilized as the Applicant is doing, and thus cannot validly be used to confirm the Applicant’s theories. *See* State Reply at 35-36. The accident reports were prepared, goes this argument, under Air Force Instruction 51-503, which does not have as one of its intended purposes a determination of whether a pilot was able to control an aircraft during the emergency so as to avoid a ground site.⁴⁰

The State’s second argument is that the reports not only are unfit for use as evidence of the pilot avoidance action the Applicant would rely upon, but also that they cut against the Applicant’s position. *See* State Reply at 47. As the State sees it, the reports contain examples of pilot error, and illustrate deviations from pilot training, that — rather than supporting the Applicant’s premise that pilot action is helpful — demonstrate that pilots cannot always be counted on to perform as trained. *See id.* at 47-50; State Findings ¶¶ 99-102.

d. The Board’s Decision

R1. We find that the 90% controllability value the Applicant would assign to *R1* is supported by sufficient evidence to justify our adopting it. The central issue on this point is whether it is legitimate to distinguish flight conditions in

³⁹ *See* State of Utah’s Reply to the Proposed Findings of Fact and Conclusions of Law of the Applicant and the NRC Staff on Contention Utah K/Confederated Tribes B (Oct. 7, 2002) at 5 (*quoting* Tr. at 13,103 (Jefferson)) [hereinafter State Reply].

⁴⁰ *See* State Reply at 35; State Exh. 60, U.S. Air Force, AF Instruction 51-503, Aircraft, Missile, Nuclear, and Space Accident Investigations (Apr. 5, 2000) [hereinafter AFI 51-503].

Skull Valley from those over the UTTR for purposes of distinguishing among the types of emergencies likely to be triggered in each. On that score, while certain maneuvers have to be conducted on the way down Skull Valley, and those maneuvers are not risk-free, they are significantly less intense than the mock combat and similar exercises that take place over the UTTR. *See* Aircraft Crash Report, Tab H at 8. We find it was appropriate, therefore, for the Applicant to limit its *RI* analysis to the subset of F-16 crashes consisting of those that occurred in “Skull-Valley conditions.”⁴¹

But this alone does not establish that the 90% controllability value is a permissible one. The State saw, in a number of the accident reports, facts that led it to argue that particular aircraft that the Applicant said were controllable, indeed were not. *See* State Reply at 37-38. We discuss those disputed reports in our Detailed Findings (B-14 to B-39) in Part II, below. As we find there, the Applicant has the better of that evidence, albeit just barely.

R2. In contrast, we find that the proposed 95% value for the *R2* factor was unproven. In essence, the Applicant’s experts believed that in an emergency situation, there was effectively a near certainty that a combination of factors — primarily visibility, time, and training — would lead ejecting pilots to send their crashing planes away from the PFS site.⁴² *See* Tr. at 8882 (Jefferson). But when the subject is the prediction of human behavior under stress, the successful establishment of an assertion of near certainty inherently calls for a highly probative showing.

To be sure, the Board has no quarrel with the general value system held by the Applicant’s experts, to the extent that they strongly believe that Air Force pilots are well trained, that they will in good faith attempt to act to the best of their ability and training in an emergency situation, and that as pilots they are committed to high standards of human behavior. In that regard, we note the existence, in more than one official or unofficial accident report in the record, of heroic action whereby a pilot — at the cost of his life — stayed with his plane,

⁴¹ The above analysis also explains the difference between the Applicant’s *RI* evaluation and the apparently significantly different evaluation by the F-16 manufacturer. Lockheed Martin’s 36% engine-failure analysis covered all accidents, regardless of where they occurred, while the Applicant’s 90% focused only on accidents occurring in normal flight, thereby eliminating from consideration those occurring on takeoff or landing or in special flight conditions, each of which implicates many other types of crash causes.

⁴² As has been seen (pp. 95-96, above), the Applicant put forward eight factors to support its pilot avoidance claim. But upon inquiry from the Board, the Applicant’s witness agreed that the three factors just mentioned in the text were the primary ones.

rather than ejected safely, so as to be sure to avoid people in harm's way on the ground.⁴³

The question is not, however, whether some pilots will perform heroic deeds, even at enormous personal risk, when called upon to do so. *The question is, instead, whether the preponderance of the credible evidence supports the notion that, for nuclear safety regulatory purposes, pilots under the special stress of an ejection-type situation can be counted on almost invariably to perform exactly as their training has prepared them to do, or whether, in contrast, their performance is likely to be affected by such things as lack of time or visibility or by what amounts to, in the State's words,⁴⁴ "human factors" sources of errors.*

We accept that in the event of aircraft failure, in the vicinity of the PFS site or elsewhere, pilots would generally do what they could, consistent with their other responsibilities, to guide their aircraft away from vulnerable ground areas⁴⁵ before ejecting. But the 95% value of *R2* propounded by the Applicant — which has the burden of proof — is far from sufficiently well founded.⁴⁶ We are forced to conclude, for the reasons set out below, that the evidence supporting a high value for the *R2* factor is too uncertain to be relied upon to make safety-related decisions for nuclear facility licensing purposes.

In short, probative contrary evidence undercut each of the three central factual premises — visibility, time, and training — underlying the Applicant's expert beliefs. When the concept being advanced is "near certainty," the proof necessarily must be solid. We find that in the face of the powerful evidence the State submitted to support its challenge, the Applicant has not met that burden — to the contrary, the State's evidence predominates.⁴⁷

⁴³ See PFS Exh. YYY (pilot died avoiding a school); PFS Exh. ZZZ (pilot intending emergency landing on parade ground died avoiding marchers); Tr. at 3763-65.

⁴⁴ See State Findings ¶104; see also individual accident reports that mention this concept: PFS Exhs. 187, 193, 197, and 200.

⁴⁵ As indicated earlier (see note 34), because it is not necessary to our decision, we do not decide some key questions about the intent and scope of the F-16 Training Manual's instruction to "avoid populated areas." Thus, although we lay out some of the questions below (see note 67), we assume for purposes of this decision that pilots would for one reason or another treat the spent fuel casks the same as "populated areas."

⁴⁶ In this regard, none of the Applicant's expert panel, well qualified though they might be in other respects, had ever ejected from a plane. See Tr. at 3216-17 (Jefferson/Cole/Fly). Faced with conflicting hearsay testimony about the thoughts of pilots who *had* ejected, the Board suggested obtaining direct, live testimony from pilots who had undergone that testing experience. See Horstman Post Tr. 4214, at 18-19; Tr. at 3222-24 (Jefferson/Fly). As will be seen, evidence provided by one — Colonel Frank Bernard — was particularly instructive on the key question underlined in the preceding paragraph.

⁴⁷ We provide, in the opening and closing paragraphs of Subpart B of Part II, below, additional thinking on the way in which the State's evidence predominates.

Detailed analysis exposes the weaknesses in the Applicant's three basic reasons supporting its claim of 95% "pilot avoidance" success, which we first paraphrase. *See* Tr. at 8882 (Jefferson). First, because the weather in the areas surrounding the PFS site is almost always clear, pilots can almost always see problematic ground areas. *See* PFS Findings ¶¶ 99, 129-130. Second, there is almost always sufficient time before ejecting for the pilots to take action to steer the crashing planes away from those ground areas. *See id.* ¶ 94. Third, the exceptional training Air Force pilots receive will almost always cause them, prior to ejecting, to attempt to guide their aircraft to avoid those areas. *See id.* ¶ 96. The State has vigorously challenged each of these asserted reasons.

To put our evaluation of the State's challenge in perspective, the Applicant's asserted *R2* value essentially predicts almost certain success in human performance during emergency, stress-filled conditions.⁴⁸ Prevailing on such a claim is difficult, precisely because it takes very little in terms of examples of failure to defeat such a high success claim. Moreover, any prediction of human performance that claims there will be, particularly during emergency, stressful conditions, 95% success — which the Applicant asserts to be conservative compared to the 100% theoretically supportable by its approach — could benefit from a rigorous, in-depth evaluation and analysis of reliable operational data, which is lacking here.

The State has mounted a frontal challenge to the Applicant's evaluation and analysis. As to the visibility factor, the State's expert witness pointed out a variety of reasons why an F-16 pilot might be precluded from seeing a land feature. Those reasons included line-of-sight problems because of the configuration of the cockpit and the attitude of the aircraft⁴⁹ and the ways scattered cloud formations or fog can obstruct a pilot's sights.⁵⁰ For the pilot deliberately to avoid a land feature 95% of the time, the pilot must either be able to see the site, or have situational awareness of its existence, that same 95% of the time.⁵¹ The State's expert testimony cast significant doubt on whether the conditions necessary for visibility — line of sight and meteorological conditions — are present 95% of the time.

⁴⁸ Colonel Bernard, who ejected from an F-16 during a training mission and whose testimony we draw upon in other respects below, testified that the greatest stress levels by a "significant measure" faced by a pilot occur during the moments before ejection. Tr. at 3897-98 (Bernard). He pointed out that there is a period of divided attention during an emergency that "completely becomes focused on what you need for your survival." *Id.*

⁴⁹ *See* Tr. at 13,302-07 (Horstman); Horstman Post Tr. 4214, at 24.

⁵⁰ *See* Horstman Post Tr. 4214, at 21-24; Tr. at 8377-84, 13,416-24 (Horstman).

⁵¹ The Applicant's witnesses stressed throughout the hearing the importance they placed on Air Force pilots' developing and maintaining constant situational and positional awareness, so that regardless of where they are flying and where they are headed, they are cognizant of their surrounding environment. *See* Part II, below, pp. 176-77.

Secondly, the State offered evidence that there are instances where sufficient time is not available for pilot actions to avoid problematic land features. In this regard, a major concern is that because a successful restart is the most desirable outcome in engine failure emergencies, pilots are trained — and perhaps more importantly, strongly motivated — to attempt repeatedly to restart the engine.⁵² The motivation is obvious: a successful restart of the engine means the incident is over, the plane is saved, the pilot is no longer in jeopardy, and the pilot need not eject.⁵³ This may lead to too many (in terms of lost altitude) attempted unsuccessful restarts, resulting in too little time for taking all the other steps called for in the situation before ejecting. *See* Horstman Post Tr. 4214, at 18-19; State Exh. 57, U.S. Air Force, ALSAFECOM 002/1996 (1996) at 3 [hereinafter ALSAFECOM 002/1996].

Moreover, the time pressure increases as the plane's altitude diminishes for, as the Air Force Manual provision on ejection procedures stresses, minimum ejection altitude should be no less than 2000 feet above the ground to provide the pilot the best survival opportunity.⁵⁴ Indeed, to promote pilot safety, Air Force training emphasizes that pilots should not eject too low. *See* Manual at 3-42. But the desire to avoid ejection (with its potential for personal injury and its certainty of aircraft loss) by restarting the plane sometimes leads to ejecting below the desired altitude. *See* ALSAFECOM 002/1996 at 3. In that situation, the pressure of belatedly carrying out other responsibilities can take away from the time needed to guide the plane away from the “populated areas” referred to in the Manual (see related discussion, note 67, below).

Regarding the third asserted reason, the State introduced evidence that despite the extensive training provided to Air Force pilots, and notwithstanding their dedication, they commit human errors — and such errors would be expected

⁵² *See* Horstman Post Tr. 4214, at 15-16, 18-19; *see also* Tr. at 3979-80, 4007-11, 4010-11 (Cosby), 3338-40 (Cole/Fly). In this regard, although pilots practice starting a failed engine on a simulator, an engine is never deliberately failed in flight as a training maneuver (unlike the training given to civilian pilots of small aircraft). *See* Tr. at 3333-37 (Cole/Fly).

⁵³ *See* Horstman Post Tr. 4214, at 19. Although ejection has saved many pilots' lives, it is far from a risk-free maneuver — for there is significant threat of various injuries, including life-threatening ones, from ejecting from an aircraft even during ideal conditions (on this score, the State offered evidence concerning pilot fatalities and significant injuries from F-16 ejections). *See* State Exh. 151, Lt. Col. George D'Amore & Lt. Col. Tom Luna, *USAF II Ejections and You, the Aircrew*, U.S. Air Force Flying Safety, Sept. 2001, at 11-13; Tr. at 3901 (Bernard); *see also* Tr. at 3145 (Cole), 3270-71, 3303-04 (Jefferson), 3273-74 (Fly/Cole). Of course, actual ejection is never practiced (simulators can allow a pilot to practice all the steps preceding ejection and to experience being shot 12 to 15 feet up a set of anchored rails). *See* Tr. at 3335-36 (Cole/Fly). Accordingly, there is no way — other than through an actual previous ejection — to experience the full stress of the ejection phenomenon before it takes place in an actual emergency situation that is already stress-filled. *See* Tr. at 3333-37 (Cole/Fly).

⁵⁴ *See* PFS Exh. PPP, U.S. Air Force, Technical Order 1F-16C-1, at 3-42 [hereinafter Manual].

to occur — particularly in instances where very high stress exists. The State demonstrated convincingly that four interrelated factors contribute to these pilot errors:

- Pilots are trained to focus on attempts to save the aircraft by constantly trying to restart its single engine. This can leave very little time for a safe ejection when the pilot eventually realizes that restarting the engine is futile. *See* Horstman Post Tr. 4214, at 15-16, 18-19; ALSAFECOM 002/1996 at 3. *See also* Tr. at 3979-80, 4008, 4010-11 (Cosby).
- Preparation for ejection from the aircraft — which poses a significant threat to the pilot — takes much of the pilot’s attention, competing with trying to avoid a given land area, which the Manual says to do ‘if time permits’ after attending to other matters. *See* Horstman Post Tr. 4214, at 15-16, 18-19; Manual at 3-42; *see also* Tr. at 4030 (Cosby) (pilot might be pressured by restart or other concerns that may direct his attention away from trying to avoid the facility), 3896-99 (Bernard).
- Ensuring the plane’s altitude is not too low to avoid major injury or fatality upon ejection from the aircraft also competes for the pilot’s attention. *See* Horstman Post Tr. 4214, at 17.
- The stress level involved is expected to be extreme, in that a pilot is put in the situation where saving the plane, saving his own life, and saving lives on the ground create conflicting priorities. *See* Horstman Post Tr. 4214, at 20; ALSAFECOM 002/1996 at 3.

These factors, obviously interrelated with the time factor, effectively counter the notion that pilot training eliminates pilot error.⁵⁵

⁵⁵ The Applicant’s reliance on pilot training and commitment to carry the day is perhaps facially analogous to the rationale underlying the Commission’s ‘realism rule,’ which presumes that in an emergency, trained professionals — state and local emergency response officials — will act as they are expected to do by responding with their ‘best effort’ in the event of a nuclear power plant accident. *Long Island Lighting Co.* (Shoreham Nuclear Power Station, Unit 1), CLI-86-13, 24 NRC 22, 31 (1986); *see also* 10 C.F.R. § 50.47(c)(1)(iii)(B). The Applicant here did not expressly rely on that rule and in any event, as we explain below, it cannot be used to bolster predictions about the future *behavior* of Air Force pilots flying through Skull Valley, whose *commitment* is not in doubt.

Consistent with the analyses of the former NRC Appeal Board and the United States Court of Appeals for the First Circuit regarding the realism presumption, it is apparent this precept applies only to the macrolevel policy decision made by an official about whether governmental agencies *will respond at all to an emergency*, rather than to the countless microlevel, action-oriented decisions made by individual actors on *how to carry out their specific tasks* as the actual crisis unfolds. *See Massachusetts v. United States*, 856 F.2d 378, 383 (1st Cir. 1988) (recognizing that realism rule is directed toward

(Continued)

Specifically in this regard, we find compelling the purpose of the Air Force training video the State introduced late in the hearing.⁵⁶ This training video incorporates a cockpit video recording made on board Colonel Frank Bernard's F-16 aircraft during a 1986 training mission in which he ejected after he had engine trouble. The Air Force used the video — which features not only the cockpit video but a recounting by Colonel Bernard both of how the situation and the belated ejection unfolded, and of the lessons he learned and wanted to pass on — to provide safety training for F-16 pilots.

The central message of the Bernard Video can be taken as reinforcing the need in emergencies to follow training instructions, from someone whose failure to do so almost cost him his life when he ejected at only 170 feet above the ground. On the video, Colonel Bernard says it was an error on his part to have utilized all his time focusing on trying to solve his engine problem rather than to eject earlier, when he reached the minimum safe altitude prescribed by the Manual. *See also* Tr. at 3896 (Bernard).

This video demonstrates, the State suggests, that even though Air Force pilots are well trained, they still make critical mistakes, mistakes so important and so frequent that the Air Force believed a “reminder video” was warranted. *See* State Findings ¶81. We agree that this dramatic evidence — that pilots ignore their training often enough to warrant vivid reminders — is highly probative of the issue before us. The Air Force's decision to produce and disseminate the training video featuring Colonel Bernard provides additional evidence countering

response on the state and local government level, rather than responses on an individual actor level); *Public Service Co. of New Hampshire* (Seabrook Station, Units 1 and 2), ALAB-937, 32 NRC 135, 148-49 (1990) (realism rule is directed solely toward “those persons in leadership positions (such as governors, mayors, civil defense directors, and state police superintendents) whose regular duties include the initiation of measures to protect the public health and safety in the event of an emergency that puts the populace at risk”); *see also Public Service Co. of New Hampshire* (Seabrook Station, Units 1 and 2), LBP-89-32, 30 NRC 375, 600 (1989) (calling a municipality's declaration that it would not be able to implement an emergency plan a “political decision”).

In our view, these cases establish that the critical factor in determining whether the realism presumption applies is the nature of the decisions in question. For policy decisions, the realism rule in effect says the relevant official will respond regardless of any prior stated lack of commitment to do so. For military pilots, in contrast, there is no doubt as to their commitment. Instead, the types of choices they make in attempting to address an emergency (e.g., changing direction, adjusting altitude) are very action-specific decisions not at all akin to the broad policy decisions — such as those made by a mayor to dispatch police and fire departments to the scene of an emergency — to which the realism rule is applicable.

⁵⁶ *See* State Exh. 220, Videotape: Late Decision to Eject (U.S. Air Force 1986) [hereinafter Bernard Video].

the Applicant's assertion that pilots nearly always do what they are trained to do.⁵⁷ That his experience was incorporated into a safety video to remind pilots of the need to follow their training is all to the good — but it demonstrates the fallacy in any holding that would rely on pilots almost always doing what their training (superb though it may be) told them to do.

With similar import to its production and dissemination of the Bernard Video, the Air Force published in 1996 the written document entitled ALSAFECOM 002/1996 to which we have previously referred. One of only four such directives published that year, that document embodied the clear message that despite Air Force training, crewmembers continued to commit significant errors during emergency situations — including becoming distracted during in-flight emergencies, delaying ejection because of futile attempts to recover failed engines, and ejecting below the published minimum altitudes. Once again, in the Air Force's commendably reemphasizing the need to adhere to lessons learned in training, we find in its premise — that training lessons are too often ignored — powerful evidence that any suggestion that pilots can be counted on almost always to follow their training is not sustainable.⁵⁸

We could rest our decision, rejecting the R2 value advanced by the Applicant, on the foregoing alone. But in examining — for purposes of reviewing any direct “pilot avoidance” evidence — all the F-16 accident reports submitted by the Applicant, we found something else, namely, a large number of examples of pilot error committed in other phases of the particular mishap flight being investigated. We list those in Part II, below, pp. 180-84, by quoting directly from forty of the reports, which embody the findings and conclusions of the investigator.

As that material indicates, the pilots involved in those accidents made a number of errors. To be sure, those errors were made in entirely different phases of their flights than that in which ground-site avoidance measures would be taken. But that is not the point. The point is that *the evidence that pilots make such mistakes in other phases of flight* — many of which involve non-emergency, less stress-filled

⁵⁷ The Applicant would have us disregard Colonel Bernard's experience because the problem took place in, and was caused by, conditions not akin to those encountered in Skull Valley. *See* Tr. at 13,692 (Fly). That premise is true, but does not take away from the lesson we draw from his experience — pilots make mistakes, and the Air Force recognizes it. *See, e.g.*, ALSAFECOM 002/1996. There is no basis for us to find that — although they make mistakes in other phases of flight, in other locations — they would almost never make a mistake while having the opportunity, under the stress of impending ejection, to avoid the PFS site.

⁵⁸ In so finding, we do not doubt the sincerity of the beliefs of the Applicant's expert panel, who — after lengthy and distinguished Air Force careers — were seen clearly to take pride in the capabilities of their pilots, the training given them, and the commitment and dedication they exhibit. But the existence of those experiential filters through which the experts view the matter cannot be allowed to obscure the evidence — i.e., that as superb as they and their training are, pilots make mistakes, and the Air Force recognizes it.

activities than the preejection sequence we have been considering — *provides additional support for our finding that there is no sufficient basis to declare that they will almost never err when it comes to performing, in a high-stress situation, “pilot avoidance” of a ground site.*⁵⁹

In contrast, the accident reports relied upon for corroboration of the Applicant’s claims were far less probative.⁶⁰ The fact that initially only 15 reports were offered for that purpose is telling. As the Board suggested during the hearing, the Applicant’s assertion that the 95% *R2* value was confirmed by the contents of only 15 out of a total of 121 available accident reports was questionable at the outset. *See* Tr. at 3663, 3668-70. As we see it, the reports are of limited value in that (1) pilot behavior is not specifically evaluated; (2) the methodology is open to biased selection with no meaningful objective measure of which reports should be included and which excluded; and (3) the methodology relies on inferences drawn from the investigative reports rather than on direct observation of the facts surrounding the accidents.⁶¹

⁵⁹We think four of those reports (PFS Exh. 187, 193, 197, and 200) warrant particular notice because of the emphasis they place on human factors. Those reports call attention to such things as “a momentary lapse into ‘seat-of-the-pants’ flying due to some form of distraction” and note that “the human factor continues to be the ongoing limitation to perfect results” (Exh. 187); observe that “even with the most thorough preparation and capability, the human factor continues to limit perfect success.” (PFS Exh. 193); cite “failure to use proper ‘see and avoid’ techniques to ensure a clear flight path,” and human factors, including decreased situational awareness secondary to motivation to succeed, task saturation in association with the stress performance curve, task misprioritization, channelized attention, and misperception of speed/closure rate (PFS Exh. 197); refer to how pilot “channelized his attention on some aspect of the attack and descended below the briefed recovery altitude, became spatially disoriented and impacted the terrain” (PFS Exh. 200). Again, we are not saying these particular accidents could happen in Skull Valley conditions; at the risk of repetition, these reports illustrate that pilots do not always perform as they were trained to do, i.e., they make mistakes under stress. And, as Colonel Bernard emphasized, the preejection situation is the most stressful encountered during training.

⁶⁰In making this finding, we recognize that the Applicant’s witness panel made clear from the outset that, in advocating their *R2* value, they placed principal reliance on their expert opinion, not on the accident reports. Tr. at 3215, 3967, 13,100 (Jefferson).

⁶¹As has been seen, compelling evidence exists to defeat the Applicant’s *R2* claim. Having come to that conclusion, we make the passing observation that it is also significant that only a few of the accident reports contain any direct evidence on the question of likely avoidance behavior of pilots in emergency situations. Instead, the Applicant’s witnesses relied on inferences drawn from the accident reports to conclude that the pilots acted consistently with the witnesses’ own selected acceptance criteria. For example, although the reports contain little reliable, direct information on whether pilots took any deliberate evasive action in an emergency, the Applicant would have us infer that nearly all had the opportunity to so act and then did so. Yet the other reports, as it turned out, were ambiguous or silent on the point — and this is not helpful where near certainty is the target. As the Board continues to see it, all that was shown was what happened in 15 out of 121 cases — a far lower percentage

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Further in that regard, much of the problem, as we see it, stems from trying to draw conclusions about one subject from investigative reports prepared for the purpose of inquiring into a different subject. Specifically, accident reports are prepared by the Air Force for the purpose of learning why an accident occurred. *See Cole/Jefferson/Fly Post Tr. 3061, at 10; Horstman Post Tr. 4214, at 26.* In the course of conducting the investigation and preparing the report, additional, collateral information may be obtained. But that information is not subject to the same scrutiny given to the principal topics before us. Moreover, as we read the reports, many are silent on whether the pilot, on the verge of ejecting, had the opportunity or the need to avoid specific ground targets. Others noted that the pilot avoided a specific ground feature but did not elaborate on how difficult that might have been, or on whether there were other features that might also have been avoided. *See, e.g., PFS Exh. 115, 134, 140, 158, 205.*

In short, the accident reports do not carry substantial weight in the Applicant's favor. As we read them, they stand for the proposition that, all things being equal, pilots with the opportunity to do so may well attempt to avoid ground features that should be avoided. But, as we have seen, the reports also make clear that, in many other respects, pilots frequently take action that they should not, or have been advised not to, take. This leaves us far from certain, *in a nuclear regulatory safety context*, that pilots can be counted on — to the degree necessary for us to make the findings the Applicant would have us make — not to take improper action, or to fail to take proper action, where this one particular facet of their flight activity is concerned.⁶²

In the end, these reports and the related expert testimony failed to identify a rigorous test protocol whose elements would have permitted a valid statistical inference to be drawn from the data. What was presented did not contain consistent, probative data on the causes and frequency of human failure when the conditions

than that proposed for R2. And examination of the rest of the reports has revealed, as we outlined above, a large number of pilot errors — where “near certain” flawless performance is the thesis being advanced.

⁶²We stress that in not crediting pilot performance in the manner the Applicant has urged, we in no way mean to impugn either pilots' commitment to making their best efforts to follow their training, or the skills they bring to the service they provide this country. And we recognize that, for purposes of pilots' combat endeavors, the country must count on them to perform as trained, for there is no other choice in that regard. For purposes of nuclear safety regulation, however, there are other choices, including designing the proposed facility so that — even if pilots, over whom the NRC has no regulatory jurisdiction, do not perform to near perfection once a stress-filled accident sequence is initiated — the public will not be harmed by the consequences of a “credible accident.”

and opportunity for successful action are present.⁶³ The Applicant's arguments are subjectively appealing; nonetheless, the evidence it cited is inadequate to permit a valid statistical inference on the hypothesis of reliable pilot action in an emergency.⁶⁴

To be sure, we have been shown evidence both of opportunity to act and of rigorous pilot training. These certainly are *necessary* conditions if there is to be a reliance on pilot behavior in a nuclear licensing action. But the evidence establishes those conditions are not *sufficient*, and cannot be dispositive, particularly when the evidence reflects compelling examples of pilot errors made when the opportunity for taking the correct action existed.

In sum, the conflicting evidence about pilots' both following and ignoring their training leaves us with a record that shows reliable prediction of pilot behavior in an emergency is a serious and complex human factors analysis question. In the final analysis, for the Applicant to prevail — in the face of the compelling evidence presented by the State — we seemingly would be obliged to stand "human factors" analysis on its head.

That is, where usually there is grave concern that a human factors element will *detract* from safety assurances, here that element would be used to *augment* what would otherwise be a deficient safety showing. We have been pointed to no instance, and are aware of none, in which the nuclear licensing basis is solely dependent on reliability of human behavior without the added protection of engineered safety features. Although such an approach may not be entirely precluded, relying on it has to overcome the additional uncertainty of *attempting to take credit for avoiding human error rather than, as is usually the case, making allowances for human error.*

⁶³ What might have been probative were data recording and evaluating what pilots do in emergency circumstances, so that rigorous answers could be obtained to the question being considered. As is not uncommon in statistical analysis, the failure to take this approach introduces subtle error and analytical bias, precisely because the protocol followed might be unconsciously designed to produce just what it did produce, i.e., to confirm what amounted to a vote of the experts as to how Air Force pilots will behave, based on their character and training. This, however, does not carry the burden of proof the Applicant must bear in this nuclear licensing proceeding.

⁶⁴ It should be added that the Applicant falls short in its attempt to support the R2 component through the United Kingdom's Atomic Energy Authority assessment. See PFS Exh. TTT, United Kingdom Atomic Energy Authority, A Method for the Site-Specific Assessment of Aircraft Crash Hazards (1987) [hereinafter UK Study]. The UK Study, which provides a basis for excluding from hazard calculations crashes in which the pilot is in control of an aircraft just before impact based on observations about pilot avoidance, concludes that pilots might avoid ground sites about 50% of the time. See UK Study at 8. It is, according to the Applicant, consistent with the F-16 accident reports and the testimony of the pilots in this proceeding who agreed that when time and circumstances permit, a pilot will attempt to avoid a facility. PFS Findings ¶¶ 21-22. In the Board's judgment, however, this UK Study — evaluating disproportionately different crash rates in urban and rural areas — is based on too crude an analysis to benefit us.

The R2 issue cannot be resolved in the Applicant's favor either by subjective expert opinion that has not been borne out by events⁶⁵ or by an ad hoc analysis of data not collected for the purpose to which it is being put. This is particularly so in the face of the State's credible, probative evidence that significantly undercuts each of the three major premises — visibility, time, and training — that underlie the Applicant's experts' opinions that R2 should be assigned a value of 95%.⁶⁶

By the very nature of its claim of virtual certainty there would be no pilot error in a high-stress situation, the Applicant set for itself an inherently daunting challenge to produce evidence that would successfully support its position. Having now thoroughly reviewed the showing that was made, it is clear to us that the Applicant has not met its burden of establishing by a preponderance of the evidence the validity of its claim that under emergency situations an F-16 pilot can almost always (95% of the time) guide a crashing plane so as to avoid a problematic land area.⁶⁷

⁶⁵ This case demonstrates that relying almost solely on subjective expert opinion for the development of scientific or engineering parameters can have significant disadvantages. When such parameters are obtained by objective measurement, their validity can be checked through systematic inquiry into the methodology of their development. When, however, there are no reliable objective measurements available to establish the parameter in question (such as the R2 value here), there must be a significant concern that the opinions expressed, though truthful from the expert's perspective, suffer from having overlooked, or discounted inordinately, material from other wholly valid perspectives, resulting in seriously skewed conclusions.

⁶⁶ In deciding this aspect of the case, we were not aided by the Staff's sensitivity analysis (discussed in note 38). As explained there, the Staff claimed that it had tested the effect of variation (in the "failure to avoid" rate) on the value of R2 over a twentyfold range (1% to 20%) of pilot nonavoidance and found only a small impact on the resulting crash probability. This impressive claim invites ready acceptance. But a look at the complementary value reveals that the "successful avoidance" rate varies only from 80% to 99%. This is, of course, not a twentyfold variance, and the whole matter has far less significance than we were led to believe.

At best, then, we found in the Staff's sensitivity analysis nothing positive upon which to draw. Compare Subpart E, below, pp. 139-41, where we comment on the importance to the process of the Staff's independent review of an applicant's proposals.

⁶⁷ In reaching this conclusion, we have assumed that pilots whose mission involved flying down Skull Valley would, for one reason or another, view spent fuel casks on the site as the functional equivalent of a "populated area" that should be avoided, time permitting. For example, whether or not the Manual was intended to be read with that definition, a mission commander could simply provide pilots that instruction.

Having said that, we do note — without relying on it to justify our decision — that it is unclear how fine-tuned the "populated area" directive is intended to be. Even if it were reinterpreted or understood to include, broadly, something on the order of "areas that it would be better in all the circumstances not to hit," there is evidence that it simply refers to generally directing the aircraft away from a large geographic area, not from a specific site. Tr. at 13,531-32 (Horstman). In this regard, we were told that the Air Force does not teach pilots to look for specific sites on the ground in

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We are persuaded that the State has shown by a wide margin — with evidence that is far more deeply rooted than a few examples of failures — that the Applicant’s expert testimony advocating an *R2* value of 95% is not adequately supported. We turn, then, to an analysis of the classic four-factor NUREG-0800 formula.

C. The Four-Factor Outcome

With the “pilot avoidance” theory thus unproven, the question of whether an F-16 accident is sufficiently likely to be “credible” turns on application of the classic four-factor NUREG-0800 formula. The State’s “credible accidents” contention is not, however, limited to concerns over F-16s flying down Skull Valley; it includes the potential for other aircraft, as well as ordnance, to strike the spent fuel casks on the PFS site.

In this subpart, we evaluate the evidence presented by the three parties regarding the application of the four factors to all the asserted accident scenarios. Although some of the values required for the four-factor calculation cannot be known directly, but must be derived from other data, leaving some margin of uncertainty, we find that in any event the evidence is insufficient to establish that the accident in question has “less than a one in a million per year” chance of occurring. Accordingly, it is “credible” and must be protected against.

1. Nature of the F-16 Flights

Military air operations in the vicinity of Skull Valley include (1) Air Force F-16 fighter aircraft transiting Skull Valley from Hill Air Force Base⁶⁸ on their way to the South Area of the Utah Test and Training Range (UTTR);⁶⁹ (2) F-16s

an emergency, Tr. at 8550-51 (Horstman), and that there is no Air Force training or guidance to avoid a house, a facility, or other specific ground site and pilots do not have the tools for such a task. Tr. at 13,464-65 (Horstman). It is, then, not clear that a pilot is even expected to take precise action to avoid one particular habitation or site rather than another.

Given the altitude at which ejections are supposed to take place and the distance the aircraft will thus glide before crashing, “avoidance” action may be only general in nature. To be sure, the lower the altitude before ejection, the more precise choices there may appear to be. But then there is less time and more stress. In recognition of this, the Manual’s directive is prefaced with “if time permits.”

⁶⁸ As indicated earlier, flights down Skull Valley are not risk-free, but they are significantly less intense than the high-stress, aggressive maneuvers involved in combat and similar exercises that take place over the UTTR. See Aircraft Crash Report, Tab H at 8.

⁶⁹ The UTTR, located in Utah’s West Desert, is comprised of both an on-ground training range and a larger training airspace. Its land area lies on either side of Interstate 80, which runs east-west and effectively splits the UTTR into (1) a north area located on the western shore of the Great Salt Lake, and (2) a south area located west of the Cedar Mountains.

returning on occasion from the UTTR South Area to Hill AFB via the relatively little-used “Moser Recovery Route” (MRR), which runs in a northeasterly direction, crossing Skull Valley 2 to 3 miles north of the PFS site; (3) military aircraft, comprised mainly of large transports, flying on military airway IR-420 to and from Michael Army Airfield, which is located (within the Dugway Proving Ground) about 17 miles southeast of the PFS site; and (4) F-16s from Hill AFB and various other military aircraft conducting training exercises in the UTTR.⁷⁰ See PFS Findings ¶ 7.

We focus most of our attention on the first of the above categories, for it predominates the probability calculation. F-16s transiting Skull Valley en route from Hill AFB to the UTTR South Area typically use (according to information the Applicant received from the Air Force) a corridor ranging east of the proposed PFS site. See Cole/Jefferson/Fly Post Tr. 3061, at 16. The F-16s typically fly through what is called the Sevier B Military Operating Area (MOA), between 3000 and 4000 feet above ground level (AGL), with a minimum altitude of 1000 feet AGL.⁷¹ A few aircraft fly higher, through the Sevier D MOA, which overlays Sevier B between approximately 5000 feet AGL and 14,000 feet AGL.⁷² It is unusual for aircraft to fly through Skull Valley at altitudes above 14,000 feet AGL. Aircraft fly through Skull Valley at approximately 350 to 400 miles per hour.

2. Methodology for Calculating the Crash Probability

In determining whether to license facilities, the NRC considers the possibility that various accidents — such as aircraft crashes — may affect them. In evaluating these potential accidents, the agency first determines whether these are sufficiently “credible,” i.e., likely to occur, to warrant protective measures.

⁷⁰ In the UTTR’s restricted airspace, pilots conduct a variety of activities with their aircraft, including air-to-air combat training, air-to-ground attack training, air refueling training, and transportation to and from Michael Army Airfield. Cole/Jefferson/Fly Post Tr. 3061, at 17.

⁷¹ An MOA is airspace of defined dimensions allocated to the military to separate or segregate certain military operations from other flight operations. The PFS site lies below the Sevier B and D MOAs, 18 miles east of the UTTR South Area’s eastern *land boundary* (which lies to the west of the Cedar Mountains) and 2 miles east of the eastern edge of UTTR-related *restricted airspace* (which extends eastward from the UTTR’s land area over the Cedar Mountains and into Skull Valley). The Sevier B MOA airspace, approximately 145 miles long, is some 12 miles wide in the vicinity of the PFS site and extends more than 100 miles south of Skull Valley. See Cole/Jefferson/Fly Post Tr. 3061, at 13.

⁷² The Sevier D MOA airspace lies directly above the Sevier B MOA. See SER at 15-59.

As explained earlier, the formula for calculating aircraft crash probability for nuclear facilities is

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

where P is the annual probability of an aircraft crash and the four factors represent, respectively, the Crash rate (per mile), the Number of flights (per year), the Area of the facility (in square miles), and the width of the airway (in miles). There is no dispute among the parties — apart from that over the R factor — that this formula is an appropriate method for calculating the aircraft crash hazard for the proposed facility. The governing Commission criterion, established in this case, allows a facility like this one to be licensed if the calculated probability of an aircraft crash on the site is less than one in a million (1×10^{-6}) annually. (*See also* Subparts D and E, below.)

3. *Summary of Disputed Issues*

The State disputes the numerical values the Applicant and Staff would assign to three of the four factors required by the NUREG-0800 equation. The disputed factors are crash rate (C); number of aircraft (N); and width of airway (w).⁷³ According to the State, both the Applicant and the Staff have selected values for these parameters that are incorrect and result in estimates of annual crash probability on the proposed site that are too low.

The crash-rate factor is expressed in terms of crashes per mile for a specified aircraft type, such as the F-16. The Applicant put forward 2.736×10^{-8} per mile as the appropriate value for crash rate (C), basing that determination on Air Force crash data recorded from 1989 through 1998, the most recent 10-year period available when it performed the analysis. The State disputes whether this was the appropriate period to use, asserting that the Applicant should have used the crash rate of 4.10×10^{-8} per mile for the F-16's entire service life. The Applicant's analysis is also inadequate, says the State, because it failed to take account of the higher crash rates that occur at the beginning and end of service life, as well as the likely higher crash rate of the Joint Strike Fighter that will replace the F-16 during the life of the facility and that will assertedly experience its own high crash rates associated with the beginning of service life. The Staff adopted the same crash-rate value as that proffered by the Applicant.

⁷³There is no dispute among the parties regarding the fourth factor, the effective area of the PFS site. All parties accept the area determined by the Applicant (0.1337 square mile) as the appropriate value. The Board has reviewed the method by which that area value was derived and accepts it as reasonable.

The number of flights transiting Skull Valley (N) per year is also disputed. The Applicant asserts that the correct number is 5870 flights per year, which is based on Air Force data that are kept for the MOA (but not explicitly for Skull Valley). The State asserts that the Applicant's estimate is too low, and that the more correct value is 7040 flights per year. The Applicant's analysis is flawed, says the State, because it eliminated some flights from consideration and also used a historical average rather than the most recent data, which indicate a significant increase in aircraft traffic in Skull Valley. Although the Staff's basic estimate of annual Skull Valley flights agrees with the State's, the Staff went on in its analysis to reduce that value by half, based on certain analytical assumptions it made.

The Applicant asserts that the width of the airway (w) in Skull Valley is 10 miles.⁷⁴ The State asserts that the Applicant has not taken into account the "buffer zone" effect the nearby "restricted area" airspace has in limiting practical airspace in the MOA, and other similar factors that reduce the effective width of the Skull Valley airway to 5 miles. To that end, the State points out that flights down Skull Valley are not only limited by the obvious physical presence of the mountains to both sides, but are further limited by the UTTR-related mandatory restricted areas (intrusion into which, without permission, has serious adverse consequences for pilots). Thus, the State argues, even though the theoretically usable width of the Valley's airway may be as large as the 10 miles asserted by the Applicant,⁷⁵ the reality is that the restrictions to the west and the presence of the Stansbury Mountains to the east cause pilots to observe "buffer zones" that as a practical matter decrease the width of the available airway.

The values the parties advance for each of the four factors are compiled in Table 1, below, the final line of which reflects the Board-calculated aircraft strike probability that is generated from use of each party's four factors:⁷⁶

As may be seen, despite the varying views of the parties, not only the State's but also the Applicant's and the Staff's values fail to meet the 1×10^{-6} per year acceptance criterion adopted by the Commission in CLI-01-22.

⁷⁴ Because "w" appears in the formula's denominator, a *wider* airway results in a *lesser* crash probability. For all the other factors, the larger the value the greater the crash probability.

⁷⁵ As best we can determine from the record, the geographical width of the Valley floor at the site is some 13 miles. See FEIS at 2-3.

⁷⁶ Because the Applicant and Staff also employed the R factor, they did not themselves produce a four-factor probability. The calculation is, however, a straightforward one.

TABLE 1

	Applicant	State	Staff
Crash Rate	2.736×10^{-8} per mile	4.10×10^{-8} per mile	2.736×10^{-8} per mile
Number of Flights	5870 per year	7040 per year	$7040 \times \frac{1}{2}$ per year
Facility Area	0.1337 square mile	0.1337 square mile	0.1337 square mile
Airway width	10 miles	5 miles	10 miles
Probability ⁷⁷	2.15×10^{-6} per year	7.72×10^{-6} per year	1.29×10^{-6} per year

4. Board Analysis of Four Factors

a. Crash Rate of F-16s

To calculate a crash rate, the Applicant utilized Air Force F-16 crash data reflected in the *Data Development Technical Support Document for the Aircraft Crash Risk Analysis Methodology (ACRAM) Standard*. As noted in the table, the final figure derived from these data was 2.736×10^{-8} per mile.⁷⁸ According to the Applicant, this figure represents an average of the Class A and Class B mishap rates⁷⁹ over the 10-year period from FY 1989 to FY 1998 for normal flight operations.⁸⁰ The Applicant asserts that it utilized this 10-year period in order “to minimize the effect of statistical fluctuations from year to year and to capture

⁷⁷The table thus illustrates that even if we accepted the Applicant’s values for the four factors (which we do not), the Commission’s one-in-a-million criterion would not be met without the *R* pilot-avoidance factor providing more than a 50% reduction to the four-factor result. Use of the Applicant’s proffered value of some 85% reduction would indeed result in a value for *P* of less than 1×10^{-6} per year. But, starting with the Applicant’s *R1* value of 90%, an *R2* of, say, 50% would provide an *R* reduction of only 45%, which would adjust the Applicant’s four-factor calculation to just under 1.2×10^{-6} .

⁷⁸The Air Force records *overall* crash data in terms of crashes *per hour of flight*. Aircraft Crash Report at 9, Tab D. To derive a *Skull Valley* crash rate *per mile of flight*, a degree of data manipulation must be employed, thereby introducing an element of estimation and uncertainty in addition to those inherent in determining (1) which operational segment of historic crash rates is most relevant to Skull Valley operations and (2) what years provide historic crash rates most predictive of the future lifetime of the facility.

⁷⁹The Air Force defines a Class A mishap as one in which the aircraft was destroyed or suffered more than \$1 million in damage or there was a fatality. A Class B mishap involves damage to the aircraft between \$200,000 and \$1 million. Aircraft Crash Report, Tab C at 4-4.

⁸⁰The ACRAM data are based on four phases of flight: (1) takeoff, (2) landing, (3) normal flight, and (4) special operations. The Skull Valley operations are said by the Applicant to involve “normal flight” as they do not involve takeoff, landing, or aggressive maneuvering on a training range. See Aircraft Crash Report, Tab C.

the most recent, and thus most relevant, period at the time the analysis was first conducted.” PFS Findings ¶ 25.

The State argues that the Applicant should have used the published mishap data for all 27 years that the F-16 has been in service. *See* State Findings ¶ 35; State Reply at 30-34. It points out that aircraft, like other products, experience problems at the beginning and end of service life that are higher than in mainstream service. These higher beginning and ending failure rates are so well recognized as to often be described as “bathtub curves,” so named for the shape the statistical failure-rate curve takes. *See* Horstman Post Tr. 4214, at 13. As the F-16 approaches the end of its service life, says the State, it may well demonstrate the high crash rate characteristic of end-of-life performance, and the new aircraft that replace it can be expected to encounter high rates characteristic at the beginning of life. The State argues that relying on only the best-performing years of the F-16’s service life skews the crash rate too low. *See* State Findings ¶ 35.

In addition, the State argues that since the Air Force mishap data did not separate the mishaps into the four phases of flight and the ACRAM report did not divide the data into Class A- and Class B-type occurrences, the data should not be divided for our purposes. *See id.* ¶¶ 28, 37-38. On this premise, and including all years in its calculations of the crash rate, the State asserts that the more appropriate value for the F-16 crash rate is 4.10×10^{-8} per mile, i.e., some 50% higher than the rate put forward by the Applicant (and endorsed by the Staff). *See id.* ¶¶ 37, 38.

We accept that the “bathtub effect” may occur over the life of some products. But the crash data for the F-16 are not yet showing it. To be sure, when the F-16 was first put into service, it experienced a crash rate higher than later in its lifetime. But there has been no perceptible upturn in crash rate as end of life approaches.⁸¹ This occurrence was attributed by the Applicant’s experts to improvements in pilot training, technology, and maintenance practices and procedures over the life of the aircraft. *See* Tr. at 3370-71 (Cole).

Indeed, Air Force data indicate that aggregate crash rates for all planes have steadily decreased over time. Based on this performance trend, the Applicant’s panel believes that the eventual F-16 replacement aircraft would not raise the crash rate for Hill AFB operations. PFS Findings ¶¶ 30-35. That is particularly true because the F-16’s replacement — the Joint Strike Fighter — is not scheduled

⁸¹ We note that the State witness attempted to show an upturn in crash rate near end of life for the aircraft by correlating selected crash rates with the passage of time. Resnikoff Post Tr. 8698, at 9. We find that that selection of data involved an invalid statistical technique and place no reliance upon it. We can find no reliable evidence yet showing a significant upturn in end-of-life crash rate for the F-16. And it would be speculative now to attempt to predict how any changes in the worldwide deployment situation (*see* discussion of the “N” factor, below) might have a related, indirect effect on crash rates.

to undergo its break-in period in Air Force service, much less at Hill AFB. Tr. at 8656-57 (Fly), 3371-72 (Cole).

To be sure, an argument can be made that a better approach than the 10-year period the Applicant utilized would have been to use the lifetime crash data, excluding only the break-in period. But we find that such a “lifetime minus break-in” crash rate is little different from the crash rate calculated from the 10-year sample upon which the Applicant relied. PFS Findings ¶26. And we do not accept as representative of long-term trends the more selective data upon which the State’s expert relied. We therefore find the crash rate proffered by the Applicant to be a reasonable one supported by the preponderance of the evidence.

b. Number of Flights

The Air Force does not keep records for Skull Valley transitions as a subset of Sevier B and D MOA usage and thus there exists no exact count of aircraft flying through Skull Valley. Revised Addendum at 3. Thus, the value for *N*, like that for *C*, the crash-rate factor, has to be derived from data prepared for other purposes and involving different considerations.⁸²

Based on the average of the previous 2 years’ data, and a proportional increase to reflect the authorized increase in F-16s at Hill in FY 2001, the Applicant estimated there will be 5870 flights per year along the airway in the future. See PFS Findings ¶54. That estimate began with approximately 5000 as the 2-year average number of aircraft using the Sevier B MOA, based on Air Force indications that was likely to be representative of the number of flights in Skull Valley. See *id.* ¶55. The Applicant took care to adjust that estimate upward by 17.4% to account for the fiscal year 2001 increase in the number — from sixty-nine to eighty-one — of F-16’s stationed at Hill AFB. See *id.* ¶59.

The State believes the Applicant’s estimate to be too low. First, the State believes that only the most recent year’s data — which showed a substantial increase from the previous year’s — rather than the average of the 2 years, should be used as a starting point. Second, the State would add in Sevier D flights,⁸³ noting that Air Force records indicate that most of the aircraft in both the Sevier B and D MOAs are F-16s transiting Skull Valley. In addition, some Skull Valley

⁸² The problem stated in the text concerning the raw data, though described in superficially similar terms to the problem of attempting to use the accident reports for R2-related purposes (see p. 107 above), presents a different situation. The existing data are susceptible to adjustment through various techniques (although the parties disagree as to which techniques are legitimate) to derive data having different parameters. But when reports are prepared for one purpose, there is no ready way to “adjust” them to provide sound analysis on other matters that they did not set out to address.

⁸³ The Applicant excluded the Sevier D aircraft count on the theory that it would include flights that took place elsewhere in the airway without overflying Skull Valley. Tr. at 3355-56 (Jefferson).

F-16 flights are not reported because the flights are above both MOAs. The State asserts that those uncounted Skull Valley flights should serve as a rough offset to those in the MOAs that do not enter Skull Valley. *See* State Findings ¶¶ 47-50.

The State, adding the B and D MOAs together, estimated that the total number of flights in the Sevier airspace was 5997 in FY 2000. *See id.* ¶ 48. Increasing that number by 17.4%, just as the Applicant did, gave the State a total of 7040 estimated flights per year through Skull Valley. As we explain below, as to that basic estimate we find that the preponderance of the evidence more nearly supports the State's (and the Staff's) view than the Applicant's.

For its part, the Staff adopted reasoning similar to the State's and likewise concluded that the number of flights over Skull Valley is approximately 7040 annually. *See* Staff Findings ¶ 2.117. In deriving a value for N , however, the Staff — to account for those aircraft in the usual flight formations that the Staff believes would not pose a threat to the facility — reduced the 7040 flights by half. *See id.* ¶¶ 2.118-119.

We consider first whether to begin the derivation of the N value with the Applicant's (lower) 2-year average or the State's (higher) most recent year. Our purpose, of course, is to predict the number of flights that will likely take place annually during the facility's lifetime. This is an inherently problematic venture, however, given that the number of training missions down Skull Valley depends on a number of unpredictable variables.

The most notable variable is the extent of deployment of U.S. forces around the world to engage in military operations. The crucial factor is not the *extra training* that might be involved in the *runup to deployment*, but *aircraft removal* from Hill AFB as part of the *actual deployment* to international operations. If fewer aircraft are onsite, the number of training flights will, of course, be substantially diminished. *See* Cole/Jefferson/Fly Post Tr. 3061, at 18-20.

Another variable mentioned was the eventual replacement of the F-16 by the "Joint Strike Fighter." Its existence may lead to different kinds and numbers of training missions. *See* Cole/Jefferson/Fly Post Tr. 3061, at 22-23.

One variable not mentioned, but apparent in federal law, is the impact of the "Base Closing Act." 10 U.S.C. § 2687 (2000). That statute calls for periodic review of the relative value of all military bases. The result is that some bases might be closed, while those remaining open would be called upon to assume the extra burden of activities previously handled at those that were closed. In either event, the number of flights down Skull Valley could be quite different in the future than it is today.

As may be seen, then, selecting a value to represent N , the number of annual flights, is another less-than-definitive aspect in the application of the four-factor formula. Not wishing (or being permitted) to speculate on future events lacking any basis in the record, we make the decisions that are within our grasp.

The first is the choice between the recent 2-year average (proposed by the Applicant as smoothing out year-to-year changes) and the higher, most recent year (proposed by the State and endorsed by the Staff). We choose the latter on the basis of the general NUREG-0800 thesis (§ III.2, at 3.5.1.6-4) — itself fully consistent with a fundamental principle of safety assessment — that its proper use involves the selection of conservative input values. Similarly, the State’s and the Staff’s inclusion of flights from the Sevier D MOA is the better approach both to deriving an accurate conceptual count, and to following the NUREG-0800 thesis mentioned above.

In the absence of data neatly applicable to the issue before us, and given the resulting need to derive useful data somewhat subjectively, we see some merit in the Applicant’s estimation of 5870 flights per year over Skull Valley. But based on all the evidence, we find more persuasive the State estimate of the overall number of flights at 7040, in which the Staff concurs. The difference represents the uncertainty of the estimate, which is not further reducible on our record.

We turn now to the Staff’s suggestion that the overall number of flights thus derived (upon which it and the State agree) should be reduced by one-half. *See* Staff Findings ¶2.119. The Staff came to that conclusion by looking at the lateral offset within each two-ship formation (and by considering a normal four-ship formation as two formations of two aircraft each, one formation flying in front of a second one). The Staff asserts that because of that offset, the aircraft more to the east of the two (and the two easternmost aircraft in the usual formation of four) would pose a negligible probability of impacting the facility and thus can be discounted as contributors to the impact probability calculation. *See* Staff Findings ¶2.118.

The Staff would therefore say that the number of aircraft to be considered is only half the total estimated to be flying down Skull Valley. Thus, the Staff would use 3520, not 7040, as the value of N in the probability equation. *See* Staff Findings ¶2.119. Correspondingly, the Staff technique would thus reduce the calculated probability by a factor of two.

Applying that halving concept to reduce “ N ” has, however, an obvious additional direct impact on another aspect of the four-factor formula. That is, when the Staff reduces the number of aircraft by half, it does so because aircraft occupying certain offset portions of the available airway are said to produce negligible hazard to the facility. *See* Staff Findings ¶2.119. *But this has significant implications for another factor, i.e., the definition, and the width, of the effective airway.* Manifestly, that width must be reduced by half to account for the Staff’s elimination from the probability calculation the flights in the other half.

Put another way, it was certainly not demonstrated — and in fact seems facially invalid — that the technique the Staff used in deriving a value for the N factor can be employed, while at the same time leaving the value for the width of airway

unchanged.⁸⁴ On the other hand, if the halved N value (appearing in the numerator of the formula) were to be accompanied by an equivalent halving of the airway width (appearing in the denominator), the result of the four-factor calculation would remain the same (as would the density of the remaining aircraft), and the calculated result would again be in accord with the realities of the situation.

Before leaving this subject, we note that NUREG-0800 makes provision for offset airways, but not in the fashion the Staff would employ here. It does so, in the very definition of the “ w ” value, by adding to the actual width of the airway another width value, namely, twice the distance that the nearest edge of the airway is *offset from* the facility.⁸⁵ But in situations like that we face here, in which the nearest edge of the airway in effect *lines up* with the facility, the formula suggests no adjustment from the values applicable to an airway *centered on* the facility. In effect, then, NUREG-0800 treats an airway centered over a site the same as one with its edge at the site, thereby again providing an element of conservatism that is fully in keeping — for purposes of a screening formula — with the overall approach that NUREG-0800 explicitly adopts.

Viewed in this light, the Staff’s attempted reduction of N is, in effect, simply a different way of making the very adjustment for an “edge of site” airway that NUREG-0800 declined — apparently deliberately — to recognize. For that reason, as well as because it failed to make the fundamental change to the width of the airway that should accompany the elimination of the flights in one-half of that airway,⁸⁶ we reject the Staff’s proposal as inconsistent with the premises underlying the four-factor formula as well as lacking any sound technical basis.

c. *Effective Area of Facility*

The Applicant calculated the effective area of the facility to be 0.1337 square mile. This figure was obtained by considering how the facility’s actual ground area is enlarged as a target in relation to the glide angle of the crashing aircraft as it

⁸⁴The Staff formulation, while invalid as it stands, does have within it an acceptable concept, i.e., that narrower flight paths, offset from the site (*see* text preceding page), might exist (in actual practice, not in mathematical construct) which would reduce the probability of aircraft crashes to acceptable levels. As suggested elsewhere herein, the Applicant may wish to explore with the Air Force discretionary modification of the effective airway.

⁸⁵NUREG-0800 at 3.5.1.6-3 (§ III.2).

⁸⁶Perhaps to avoid this criticism, the Staff indicated that, after halving the number of flights, it would treat the remaining flights as if spread over the original width of the airway and thus keep the “ w ” value unchanged. That adjustment is unavailing, however, in that if the airway remains at its original width (as the Staff would have it) after N is reduced by half, then that entire airway would still be available to the remaining half of the aircraft. Presumably, half of those aircraft would then occupy the eastern portion of the airway that the Staff found produced a negligible crash hazard. But in keeping with the Staff’s offset notion, those aircraft now in the eastern half could then be ignored.

approaches the site. In proffering this maximum area figure, the Applicant points out that it is conservative in that it considers the facility to be at full capacity (4000 spent fuel storage casks) — a status that may never be achieved. *See* PFS Findings ¶ 38.

The Staff and the State did not dispute the Applicant's calculation. *See* State Findings ¶ 52; Staff Findings ¶ 2.51. The Board has reviewed it and we find that 0.1337 square mile is reasonable and supported by the preponderance (indeed all) of the evidence before us.⁸⁷

d. Width of Skull Valley Airway

In calculating a value for *w*, the Applicant assumed that the Sevier B MOA could be treated like an airway, with F-16 flights evenly distributed across its width from the Stansbury Mountains on the east to the edge of the restricted airspace (east of the Cedar Mountains) in the west. Taking the maximum potential usable airspace in that corridor at the latitude of the facility, the Applicant came up with a 10-mile width for the airway. *See* PFS Findings ¶ 43.

The State countered by arguing that the portion of the Sevier B MOA in *actual* use by F-16 formations is narrowed because of pilots' practices. In the State's view, the airway width is about 6 miles, extending from east of the western Sevier B MOA boundary to west of the eastern MOA boundary (near the Stansbury Mountains). *See* State Findings ¶¶ 43-44. It points out that State Exhibit 156B, which is an illustration originally taken from the Applicant's Crash Report, indicates that at an altitude of 3000 to 4000 feet AGL, the *maximum* airspace available is 10 miles wide at the latitude of the facility. *See* State Reply at 12-13. By the State's reckoning, however, most pilots will not use the full

⁸⁷ The conservatism in the Area factor to which the Applicant points, based on less-than-full capacity, we see only as offsetting a potentially nonconservative feature of the facility. Specifically, we have been told from time to time in the proceeding that if the facility were filled to capacity and future events established that the crash rate or number of flights was understated, the Staff could investigate and take remedial action, as it does with nuclear power plants. *See* Tr. at 4156-58 (Campe). In that regard, if the Staff discovers a problem at an operating power plant, it has the option to order the plant to shut down, thus relatively quickly reducing the nature of the particular risk in issue.

But we asked in vain about what prompt remedial action the Staff would be able to direct PFS to take, as possible future licensee of a facility at full capacity, if it were determined, based on changed circumstances, that the crash probability then exceeded what had previously been envisioned. The record before us indicates that bringing spent fuel to the proposed facility will be a slow process, limited by the facility's capability of offloading and transferring the canisters in which the fuel rods will be transported. By the same token, it is not apparent on this record how it would be possible to effectuate, significantly faster than the casks were delivered, any Staff order to remove casks. Of course, if the facility were not at capacity, the Staff could halt delivery of any more casks. Other than to that extent, then, we cannot rely on any future Staff remedial action as a protection against understating the crash probability.

airspace available to the west to avoid straying into the bordering Restricted Area further west, and likewise, to give the Stansbury Mountains a wide berth, will not use all the airspace in the east. *See* State Reply at 13 n.21.

Because of these buffer zones, the State asserts, most F-16s that pass through Sevier B MOA tend to fly, for all practical purposes, within about a 6-mile-wide flight path. Allowing for other adjustments, the State concludes that the value that should be utilized in the formula for the airway width is 5 miles. *See* State Findings ¶ 44.

The parties are in accord that F-16s do not fly further west than approximately 1 mile east of the UTTR Restricted Area. *See* Tr. at 8572 (Horstman); Tr. at 3415-16 (Fly); SER at 15-63. With respect to airspace on the east, there is evidence that the distance pilots remain west of the Stansbury Mountains varies from “a couple thousand feet” (Tr. at 8647-48 (Fly)) to up to 3 miles. Tr. at 8613-14, 8571-72, 8593-94 (Horstman), 8648 (Fly).⁸⁸ Thus, notwithstanding that pilots have about 10 miles of potentially usable airspace in Skull Valley, the preponderance of the evidence compels the conclusion that the State is correct in its assertion that, in practice, the effective airspace used in formation flying is narrower than that 10 miles.

To determine how much narrower so as to arrive at a “w” value, we must return to first principles, namely, that probability of impact is a function of average flight density in the vicinity of the site. Density, in turn, is a function of airway width. The logical construct behind these elements suggests that the airway width, for purposes of the formula, should appropriately be determined based on where aircraft predominantly fly, not on the simple geographic width of the available airspace.

Employing that standard, the remaining discrepancy among the parties’ views reflects differing approaches which are, again, a part of the overall analytical uncertainty of the estimate. The evidence presented only serves to establish that the actual value of the airway width is indeterminate to the extent that it depends upon individual pilot preference. From that perspective, the preponderance of the evidence supports the State’s viewpoint, but only to the extent that the State has correctly urged that the airspace actually used is 6 miles. The State’s further adjustment to 5 miles lacks evidentiary support, while the 10 miles advocated by Applicant and Staff does not account for the predominant pilot practice shown by the evidence.

⁸⁸ The Air Force has not established a minimum distance that pilots must maintain from the Stansbury Mountains. Tr. at 4343 (Horstman).

5. *Calculated Four-Factor Probability*

Utilizing in the NUREG-0800 equation the four values found in Section 4, above, the Board calculates the probability of impact on the site as follows:

$$\begin{aligned} P &= \text{Crash Rate} \times \text{Number of Flights} \times \text{Area of Facility} \div \text{width of Airway} \\ &= (2.736 \times 10^{-8})/\text{mile} \times 7040/\text{year} \times 0.1337 \text{ sq. mile} \div 6 \text{ miles} \\ &= 4.29 \times 10^{-6} \text{ per year.} \end{aligned}$$

Consequently, we find on the basis of the evidentiary record before us that the Applicant has failed to meet the Commission's acceptance criterion articulated in CLI-01-22.

We note, as Table 1 reflects, that without the aid of the *R* factor none of the parties' inputs produces a result that would satisfy the 1×10^{-6} per year standard. In fact, the variance that exists (a more than threefold difference between the Applicant and the State, and a sixfold difference between the Staff and the State) reflects the unavailability of direct, observable data that, in turn, results in input values having to be derived by indirect means. Not surprisingly, therefore, the arguments in favor of one or another estimate — for example, both estimates of *N* — are supported by plausible arguments. Be that as it may, pursuing the four-factor analysis any further to attempt to reach a more precise resolution of these differences would not be productive given that, as we noted earlier, the evidence is insufficient to give the critical second component of the proposed *R* factor the weight the Applicant would assign it.

6. *Other Aircraft Risks*

Although the predominant contributor to hazard to the PFS site is F-16 flights over Skull Valley, the Board must also consider hazards arising from other sources in order to arrive at an overall assessment of the overflight crash probability. We do so at length for some scenarios, but briefly for those whereupon examination it is apparent that the probabilities in most instances are so low (in the 10^{-8} range) that our decision would not be materially affected by even relatively large changes in their values.

a. *Moser Recovery Route*

The major area of additional concern for the State involves aircraft activity on the Moser Recovery Route (MRR).⁸⁹ The MRR provides an alternative for aircraft

⁸⁹The MRR runs from southwest to northeast and passes 2 to 3 miles north of the PFS site. SER at 15-80.

returning from the UTTR South Area to Hill AFB.⁹⁰ It is utilized only during marginal weather conditions, or at night, under specific wind conditions that require the use of a northwest-heading approach to Runway 32 at Hill AFB. *See* Cole/Jefferson/Fly Post Tr. 3061, at 11. The Air Force is not otherwise inclined to use the MRR because it can create conflicts with Salt Lake City International Airport commercial and other traffic. Cole/Jefferson/Fly Post Tr. 3061, at 11; Aircraft Crash Report at 48a & n.56A.

The Air Force does not keep precise data on the number of flights per year that use the MRR.⁹¹ All parties, therefore, had to look elsewhere to derive estimates of annual MRR flights.

The Applicant estimates that approximately 5% of the F-16 flights return to Hill AFB via the MRR. Cole/Jefferson/Fly Post Tr. 3061, at 97. That estimate drew upon conversations between General Cole and the Vice Commander of the 388th Fighter Wing at Hill AFB and a civilian air traffic controller in the Salt Lake City Air Traffic Control Center. Tr. at 3456-58 (Cole).

To estimate the number of flights that will occur on the MRR in the future, the Applicant assumed that the sortie rates on the UTTR, and thus the number of flights on the MRR, increased proportionally to the number of F-16 flights in Skull Valley. Using FY 1998 data for UTTR F-16 sorties, the Applicant estimates that some 280 flights used the MRR in 1998.⁹² The Applicant then increased this number of sorties proportionally to account for the increase in F-16s in FY 2000 and FY 2001, and to account for the increase in number of F-16s to be stationed at Hill AFB in the future. Cole/Jefferson/Fly Post Tr. 3061, at 97.

Defining the MRR airway width as 11.5 miles, and using previously selected values for the crash rate, effective area, and R , the Applicant estimated the crash impact probability to be 2.0×10^{-8} per year. Cole/Jefferson/Fly Post Tr. 3061, at 97. Without the R factor of 85.5% reduction, which we have previously rejected, that probability would have been approximately 1.4×10^{-7} per year.

The Staff prepared an independent analysis of the number of flights on the MRR using actual FY 2000 UTTR data, estimating there are 353 flights per year on the MRR. *See* SER at 15-80 to 15-82; Staff Findings ¶ 2.529. The Staff agreed with the Applicant that about 5% of UTTR sorties used the MRR, because (1) the MRR is used only under specific wind conditions; (2) the MRR is not favored by Air Force pilots due to conflicts with Salt Lake City International Airport

⁹⁰The vast majority return to Hill AFB from the UTTR South Area by exiting the northern edge of that range (which is not near the PFS site). Cole/Jefferson/Fly Post Tr. 3061, at 96-97.

⁹¹*See* Cole/Jefferson/Fly Post Tr. 3061, at 96-97; Aircraft Crash Report at 48a-49.

⁹²According to the Air Force, 5726 F-16 sorties were flown on the UTTR South Area in FY 1998, almost all of which flew from Hill AFB (not all aircraft transit Skull Valley enroute to the South Area). From this, the Applicant determined that 286 aircraft ($5\% \times 5726$) from Hill *and elsewhere* used the Moser Recovery Route on their return flights for FY 1998. Cole/Jefferson/Fly Post Tr. 3061, at 97.

air traffic; and (3) because Air Force personnel have confirmed that the MRR is rarely used. *See* Staff Reply ¶143. Using the NUREG-0800 formula, the Staff determined the hazard probability from aircraft traversing the MRR to be 2.5×10^{-8} per year using a value similar to the Applicant's to account for pilot avoidance. Campe/Ghosh Tr. 4078, at 40; SER at 15-82.

The State asserts that future flight numbers along the MRR are likely to be substantially larger than projected by either the Applicant or the Staff. *See* State Findings ¶110. The increase will occur, says the State, because the Air Force plans to increase the frequency of night flying to train pilots in using night-vision goggles. According to the State, up to 33% of all future flights on the UTTR are likely to be night training flights, all of which, it says, will return via the MRR. Horstman Post Tr. 4214, at 30.

The State also asserts that there will be some 10,410 aircraft using the UTTR in future years. This estimate is substantially larger than estimates used by the Staff or Applicant, each of which relied on their previous estimates of F-16 flights transiting Skull Valley.

The State calculates, using the foregoing data, that the projected number of aircraft using the MRR will be 3436 per year ($10,411 \times 33\%$). That value for N resulted in the State's estimating crash probability on the PFS site from MRR flights as 1.64×10^{-6} per year. *See* State Findings ¶111. If accepted, this estimate would, by itself, and without regard to the contribution of other accident scenarios to cumulative risk, indicate sufficient probability of impact to exceed the NRC acceptance criterion of 1×10^{-6} .

In estimating the MRR use factor, the State assumed that a 33% increase in UTTR night training activity automatically translated to a corresponding numerical increase in MRR use because of its understanding of an Air Force report that all those increased night flights would use the MRR for recoveries. That Air Force statement was, however, of a contingent nature: use of the MRR for night flight recovery is contingent upon the existence of certain wind conditions. Indeed, the Air Force expects no overall increase in MRR usage resulting from its night training. Campe/Ghosh Post Tr. 4078, at 39; Cole/Jefferson/Fly Post Tr. 3061, at 98 & n.168. The State's assertion that 33% of all UTTR flights will use the MRR is therefore lacking in record support.

As to the other part of its estimate, the State derived its view that approximately 10,410 flights would use the UTTR by extrapolating from fluctuations in use data for prior years. Specifically, the State viewed the data as reflecting an upward trend portending more flights on the MRR after the year 2001 than had occurred up to that time.

The UTTR data do not, however, show any such unambiguous upward trend before 2001. A more realistic interpretation of the data is that UTTR flight numbers simply fluctuated from year to year without showing any overall trend. We find it invalid to select a particular short period's incidental upturn in fluctuating data

for extrapolation as if it were a trend. The Board therefore finds that the State's projected number of UTTR flights was derived by invalid techniques, and is thus lacking in record support.

We find that the State's overall analysis of the crash probability on the PFS site arising from flights on the MRR is not appropriate, because both its estimate of future aircraft use on the UTTR and its estimate of the percentage of UTTR flights returning along the MRR are overstated. We therefore reject the State's MRR crash probability estimate of 1.64×10^{-6} as unfounded. On the other hand, the Board finds that the Staff estimate of crash probability of approximately 1.6×10^{-7} per year (without credit for a pilot avoidance factor) is reasonable, as is the Applicant's somewhat different estimate of 1.4×10^{-7} , for the reasons expressed in their analyses.

The Board recognizes that all numerical values used in this analysis are derived from indirect estimates, rather than consisting of actual counts of aircraft using the MRR. All such estimates are subject to considerable but unmeasured uncertainty. Nevertheless, even in the face of this analytical uncertainty, we can conclude there is reasonable assurance of only small crash probability from MRR traffic because, in this instance, there is some margin between any of the reasonable estimates and the acceptance criterion. In other words, the screening formula worked well enough here — unlike the analysis of Skull Valley flights — to permit this particular accident scenario to be put aside (other than for cumulative risk purposes).

b. Michael Army Airfield

Another State concern is the hazard posed by aircraft flying to and from Michael Army Airfield (MAA) on IR-420. MAA is located on Dugway Proving Ground, 17 miles south-southwest of the PFS site. IR-420 is a military airway that runs from the northeast to southwest and terminates about 7 miles north of the PFS site, at the northern edge of the Sevier B MOA. *See* Cole/Jefferson/Fly Post Tr. 3061, at 98; Campe/Ghosh Post Tr. 4078, at 41.

The majority of flights to and from MAA are F-16s conducting training exercises. *See* Campe/Ghosh Post Tr. 4078, at 41. The Applicant used the same method to calculate the probability of an MAA-related aircraft impacting the PFS site it did for F-16s transiting Skull Valley. *See* PFS Findings ¶ 195.

There are also a number of large cargo aircraft flying to and from MAA. NUREG-0800 provides an in-flight crash rate of 4.0×10^{-10} per mile for large commercial aircraft. The Applicant applied that crash rate to its estimated maximum of approximately 414 annual flights to MAA by aircraft other than

F-16s.⁹³ See PFS Findings ¶ 195. PFS calculated the effective area of the site as 0.2116 square mile, using the same method employed to calculate the effective area of the PFS site relative to an F-16. Using the NUREG-0800 formula, the probability of any of these aircraft impacting the PFS facility is negligible, i.e., 3.0×10^{-9} per year. See PFS Findings ¶ 195.

The State did not submit any testimony on the hazard posed from aircraft flying to and from MAA in the direction of IR-420. See PFS Findings ¶ 195. Similarly, the Staff does not dispute the Applicant's estimate of risk posed from flights transiting IR-420. See Staff Findings ¶ 2.542. For our part, we have examined the calculations and find them reasonable and supported by the preponderance of the evidence, allowing this accident sequence to be put aside as well.

c. Utah Test and Training Range

The State has also expressed concern over the hazard to the facility from aircraft training on the UTTR. Aircraft on the UTTR South Area perform a variety of activities, including air-to-air combat training, air-to-ground attack training, air-refueling training, and transportation to and from the MAA. See Cole/Jefferson/Fly Post Tr. 3061, at 90-91. The Applicant asserts that the hazard from air-to-air combat training on the UTTR poses a negligible hazard to the PFS facility because activity on the UTTR occurs too far away from the facility. See PFS Findings ¶¶ 185-186.

The UTTR South Area is composed of four restricted areas, and the PFS site is located 2 miles from the eastern edge of two of the restricted areas. In much the same manner that pilots try to avoid encroaching into restricted airspace when flying down Skull Valley, it is reasonable to assume that pilots will also try to avoid performing restricted activities outside of the controlled area for fear of harming other aircraft as well as to avoid serious consequences for violating Air Force policy. Hence, the Applicant assumes a 3-mile buffer zone inside the UTTR restricted airspace as a practical limitation on how close pilots will fly to the outer edge of the UTTR.

Review of the F-16 crash reports indicates that most accidents would occur toward the center of the restricted ranges. Relying on the asserted 5-mile glide distance of the plane (see PFS Findings ¶¶ 186-189), the Applicant asserts that accidents that did not leave the pilot in control of the aircraft would not pose a threat to the PFS facility: the facility would be 2 miles from the eastern boundary

⁹³ This estimate was derived from FY 1997 data obtained from MAA. Based on the total number of aircraft that took off and landed at MAA in later years (FY 1998 to FY 2000), a lesser number resulted, i.e., 212 non-F-16 flights per year. The Applicant also points out that the total number of aircraft flying over Skull Valley would actually be less than that total, for it includes aircraft flying to and from the airfield in all directions. See PFS Findings ¶ 195 & n. 138.

of the UTTR airspace, and a 3-mile buffer will be observed inside that boundary. Using the NUREG-0800 formula, the Applicant thus calculated that the crash probability from F-16s performing activities in the UTTR is less than 1×10^{-8} per year.

In response, the State asserts that the Applicant's estimate of crash hazard is unrealistic because it is reduced by the *R* factor. *See* State Findings ¶ 123. In addition, State's witness Dr. Resnikoff argued that an aircraft could indeed pose a hazard to the facility, based on the assumption that a crashing F-16 could fly 10 miles before impact. *See* Resnikoff Post Tr. 8698, at 17-19; Tr. at 8792-94 (Resnikoff). Using these data, the State calculated the hazard to the facility from this activity to be 2.74×10^{-7} per year.

We agree with the Applicant that a 5-mile glide for an F-16 is a reasonable estimate. The State's witness based his belief in a 10-mile glide distance from a preliminary estimate the Applicant made before it obtained and analyzed the actual accident reports, which showed different data. In any event, even after removing the *R* factor, the UTTR risk is small compared to that posed by F-16s in Skull Valley.

d. Military Ordnance

The final area of concern for the State involves the potential hazard to the facility from ordnance explosions. Ordnance can pose a hazard to the PFS facility both directly and indirectly in four respects: (1) an F-16 carrying ordnance might crash directly into the facility; (2) an F-16 carrying ordnance might jettison ordnance directly onto the facility; (3) an F-16 carrying ordnance might crash near the facility causing an explosion that can impact the facility; and (4) an F-16 carrying ordnance might jettison it near the facility with similar explosive impact.

Although the Applicant and the Staff assessed the probability of each of the four scenarios in their respective analyses (*see* Aircraft Report at 74-83k; SER at 15-83 through 15-93), the State addressed only the second scenario, the probability of jettisoned ordnance directly striking the facility. *See* Resnikoff Post Tr. 8698, at 19-20; *see also* State Findings ¶¶ 114-122; State Reply at 53-54. We consider below each of the four scenarios.

(i) HAZARD FROM DIRECT IMPACT FROM F-16 CARRYING ORDNANCE

The Applicant has determined that the probability that an F-16 transiting Skull Valley with live ordnance on board would crash into the facility is about 7×10^{-9} per year. Aircraft Crash Report at 78. This estimate is based on the assumptions that: (1) the fraction of crashing F-16s that do not jettison their ordnance is 10%, and (2) only 5% of all F-16s carry bombs. *Id.* The Board finds these assumptions

reasonable, and even with the uncertainties involved, the estimated probability of 7×10^{-9} per year is well within the acceptance criterion of 1×10^{-6} per year.

(ii) HAZARD FROM DIRECT IMPACT OF JETTISONED ORDNANCE

In calculating the probability of jettisoned ordnance directly hitting the facility, the Applicant used the following formula: $P = N \times C \times e \times A/w$. *See* PFS Findings ¶ 196. In this modification of the NUREG-0800 formula, N represents the number of annual flights through Skull Valley carrying live and/or inert ordnance; C is the F-16 crash rate per mile; e is the percentage of crashes that leave the pilot in control of the aircraft and able to jettison the ordnance; A is the combined dimensions of the CTB and storage pad area; and w represents the width of the airway. *See id.* ¶ 197.

The Applicant estimates that N , the number of aircraft carrying live or inert ordnance through Skull Valley per year, is 150. *See id.* This estimate is based on the average number of F-16s carrying ordnance through Skull Valley in FY 1999 and FY 2000 (2.556% of the total number of Skull Valley sorties, increased by 17.4% to account for the additional aircraft based at Hill AFB in FY 2001) — or 2.556% of 5870. *See id.*; Cole/Jefferson/Fly Post Tr. 3061, at 102.

For C , the Applicant used the crash rate for F-16s calculated above, or 2.736×10^{-8} per mile. *See* PFS Findings ¶ 197. The Applicant then assumed that the pilot would jettison ordnance in 90% of all crashes, when the pilot is 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). *See id.* Therefore, e is equal to 0.9.

The Applicant determined A , the product of the width and the depth of the cask storage area, plus the product of the width and depth of the CTB, to be 0.08763 square mile. *See id.* Finally, the Applicant treated Skull Valley as an airway with a width, w , of 10 miles. *See id.* Based on these input values, the Applicant calculated the hazard to the facility from jettisoned ordnance to be 3.2×10^{-8} per year. *See id.*

The State, on the other hand, uses an unmodified NUREG-0800 formula to calculate the crash probability for jettisoned ordnance: $P = N \times C \times A/w$. *See* State Findings ¶ 120. The State disputes the Applicant's use of e , asserting that PFS offered no evidence in support of the assumption that ordnance will be jettisoned less frequently than the F-16 crash rate. *See* State Findings ¶ 122. In calculating N , the State relied on the following data for combined sorties carrying ordnance for the 388th and 419th Fighter Wings: 866 sorties in FY 1998, 193 sorties in FY 1999, and 164 sorties in FY 2000. *See id.* ¶ 115. Because the Applicant does not know the reason for the decline in the number of sorties carrying ordnance from FY 1998 to FY 2000, the State argues that it is neither realistic nor conservative

to assume that future flights through Skull Valley will carry ordnance less often than flights in FY 1998. *See id.* ¶ 116.

Thus, using data from FY 1998, the State posits that 21.2% (866 flights carrying ordnance/4086 total flights through Skull Valley) of Skull Valley flights carried ordnance in 1998. *See id.* ¶ 117. Using the total number of estimated flights for Skull Valley per year — 7040 — (*see id.* ¶¶ 46-48) the State then determined *N*, the number of F-16s that will carry ordnance through Skull Valley, to be 21.2% of 7040, or 1492. *See id.* ¶ 119. In its calculation of *N*, the State assumed that all F-16 sorties with ordnance transit Skull Valley. *See id.* ¶ 117.

Alternatively, the State suggests that even if the Board were to accept the Applicant's methodology of determining the percentage of all flights carrying ordnance by dividing the number of sorties carrying ordnance (866) by the number of UTTR South Area sorties (5726),⁹⁴ rather than Skull Valley sorties, the Applicant's value for *N* is not sufficiently conservative. *See id.* ¶¶ 118-119. Using the Applicant's reasoning, the State calculates that 15.1% of all flights (866/5726), including those through Skull Valley, carried ordnance in FY 1998. *See id.* ¶ 118. The State further argues that it would be neither conservative nor realistic to adopt a value for *N* of less than 1063 ($15.1\% \times 7040$). *See id.* ¶ 119.

With respect to the remaining variables, the State used an F-16 crash rate, *C*, of 4.10×10^{-8} . *See id.* ¶ 120; *See also id.* ¶ 38. For *A*, the State determines the area to be 0.12519 square mile, assuming a skid distance similar to that of an F-16 and a 35-degree impact angle. *See State Findings* ¶ 120; Resnikoff Post Tr. 8698, at 20. Finally, the State finds the width of the airway, *w*, to be 5 miles. *See State Findings* ¶ 120; *see also id.* ¶ 44. Based on these input values, and a value of *N* of 1492, the State estimates the annual probability of impacts from jettisoned ordnance to be 1.53×10^{-6} . *See State Findings* ¶ 120. Using the alternative value of *N*, 1063, the State argues that it would not be realistic to use an annual probability of less than 1.09×10^{-6} . *See id.* ¶ 121.

For its part, the Staff agrees with the Applicant's use of *C*, 2.736×10^{-8} ; of *e*, 90%; and of *w*, 10 miles. *See Staff Findings* ¶¶ 2.483-.484. Relative to variable *N*, although the Staff considers the Applicant's value of 150 (2.556% of 5870) to be acceptable, the Staff estimates *N* to be slightly higher. *See id.* ¶ 2.493. The Staff used only the data from FY 2000 in calculating *N*. *See id.* ¶ 2.487. The fraction of the number of flights carrying ordnance, adjusted to account for the number of additional flights due to the twelve additional F-16s stationed at Hill AFB, was estimated by the Staff to be 2.3%. *See id.* ¶ 2.493. Thus, *N* was found by the Staff to be 2.3% of 7041 flights, or 162. *See id.* ¶ 2.493.

With regard to *A*, the Staff finds the Applicant's estimation of the cask storage area to be acceptable; however, in its calculation, the Staff increased the size of

⁹⁴ *See Aircraft Crash Report* at 82.

the area of the CTB by using the length and width of the CTB at its widest point, resulting in a marginal increase. *See id.* ¶2.495. Based on the above input values, the Staff estimates the annual probability of jettisoned ordnance impacting the facility to be 4.4×10^{-8} . *See id.* ¶2.499.

The Board finds the Applicant's and the Staff's use of the modified NUREG-0800 formula ($P = C \times N \times e \times A/w$) to be appropriate in estimating the probability of jettisoned ordnance directly impacting the facility. The Board finds, however, that the values for N and w should be different from what the Applicant proposes, as will be explained below.

As we determined above in our discussion of the probability of an F-16 crashing into the PFS facility, we find the value of C to be 2.736×10^{-8} (*see* pp. 114-16, 120-21, above) and w to be 6 miles. *See* p. 121, above. Based on the reasoning presented, we find the Applicant's estimation of e and A to be reasonable. As was noted above in Section B, we are satisfied that pilots would be able to maintain control of their aircraft in 90% of crashes (*see* p. 98, above), and it is reasonable that they would jettison their ordnance — one of the first things they are instructed to do, and one that enhances their own safety — on those occasions.⁹⁵ Thus, we find the value of e to be 90%.

With respect to A , the State's expert asserted that the Applicant should have used a "skid area" surrounding the facility to account for jettisoned ordnance potentially skidding into the facility, which it asserted should be based on a skid distance similar to that of a crashing F-16. *See* Resnikoff Post Tr. 8698, at 20. General Jefferson testified, however, that unlike an F-16, which would crash at a very shallow 7-degree angle, jettisoned ordnance would not skid because it would fall and impact the ground at a very steep angle. Tr. at 8869 (Jefferson). Because the sole basis for Dr. Resnikoff's assertion was an undocumented conversation between himself and Lieutenant Colonel Horstman, *see* Tr. at 8801-05 (Resnikoff), we find the Applicant's estimation of the area of the facility reasonable and conclude that A is 0.08763 square mile.⁹⁶

The parties arrived at widely different values for the remaining variable, N . Of the 3 years of data available for the number of F-16s carrying ordnance, the Applicant chose to use the two most recent years of data, FY 1999 and FY 2000,

⁹⁵ We think the jettisoning of ordnance thus involves a different analysis than does avoiding a ground site. The matter need not be explored further, however, for the fewer pilots that succeeded in jettisoning ordnance, the *lower* would be the calculated probability for the accident scenario now under scrutiny — i.e., the risk of *jettisoned* ordnance. In other words, the Applicant's assumption of 100% success in jettisoning ordnance is the most conservative it can make here.

⁹⁶ Although the Staff increased the size of the area calculated by PFS by using the length and width of the CTB at its widest point, the Staff, rather than providing a final value for A , merely asserted that the increase in area would marginally increase the probability, P , by 1×10^{-9} . *See* Staff Findings ¶2.495. Thus, we accept the Applicant's estimation of A .

in calculating the percentage of flights carrying ordnance per year. See PFS Findings ¶ 197. The State, on the other hand, considered only the data from FY 1998, the year with the highest number of flights carrying ordnance. See State Findings ¶ 116. For its part, the Staff took into account data for FY 2000 only, the most recent year available. See Staff Findings ¶ 2.493.

The Board finds that the most appropriate method of determining N is to use all of the data available, that is, data from FY 1998 through FY 2000. Therefore, we find the percentage of flights carrying ordnance through Skull Valley per year to be 8.34%. We arrived at this percentage by dividing the number of 388th and 419th Fighter Wings' flights carrying ordnance over the 3 years for which data were available by the total number of flights: $(866 + 193 + 164)/(4086 + 4586 + 5997) = 0.0834$. See Revised Addendum, Tab HH at 3, 13, 14 n.30. We previously estimated the number of flights along the Skull Valley airway in the future to be 7040. See pp. 116-19, above. Thus, we estimate N to be 587, or 8.34% of 7040.

Based on the above inputs, we calculate the probability of jettisoned ordnance directly impacting the PFS facility as follows:

$$\begin{aligned}
 P &= C \times N \times e \times A \div w \\
 &= 2.736 \times 10^{-8}/\text{mile} \times 587 \times 0.90 \times 0.08763 \text{ sq. miles} \div 6 \text{ miles} \\
 &= 2.11 \times 10^{-7} \text{ per year}
 \end{aligned}$$

For clarity, we display the parties' calculations, and ours, in Table 2, below. As thus indicated, we find that the Applicant has met the Commission's acceptance criterion of 1×10^{-6} per year articulated in CLI-01-22.

TABLE 2
Estimated Probability of Jettisoned Ordnance Directly Impacting the PFS Facility

	Applicant	State	Staff	Board
N	150	1492 or 1063	162	587
C	2.736×10^{-8}	4.10×10^{-8}	2.736×10^{-8}	2.736×10^{-8}
e	0.90	1.0 (no factor)	0.90	0.90
A	0.08763 sq. mile	0.12519 sq. mile	slightly larger than 0.08763 sq. mile	0.08763 sq. mile
w	10 miles	5 miles	10 miles	6 miles
P	3.2×10^{-8}	1.53×10^{-6} or 1.09×10^{-6}	3.5×10^{-8}	2.11×10^{-7}

- (iii) HAZARD POSED BY NEARBY EXPLOSIONS OF ORDNANCE (on Board an F-16 or Jettisoned from an F-16)

The Applicant provided analyses on the potential hazard posed by nearby explosions of ordnance on board or jettisoned from an F-16. *See* PFS Findings ¶¶ 200-203. The State did not challenge any of these findings.

Before adopting the Applicant's findings by default, the Board examined the merits of the underlying analysis; we find it to be logical and reasonable. A detailed description of that analysis is provided in PFS Findings ¶¶ 200-203, and PFS Reply ¶¶ R170-R172, as well as in Staff Findings ¶¶ 2.500 to 2.516. The Applicant's use of an "explosion damage radius" for a 2000-pound ordnance employing overpressure limits for the spent fuel storage cask and the Canister Transfer Building is appropriate, since the 2000-pound ordnance is the largest carried on board an F-16. The Applicant's assumption of a 1% chance of explosion for ordnance jettisoned from, or carried aboard, a crashing F-16 (*see* PFS Findings ¶ 203) is reasonable based on the testimony that Air Force pilots do not arm the live ordnance they are carrying while transiting Skull Valley near the facility. *Id.* ¶ 202. Therefore, the Applicant's estimate of a 1×10^{-10} per year probability of explosion of ordnance sufficiently nearby that the overpressure would impinge on the facility is reasonable.

In summary, the Board finds that the Applicant's analysis is adequate in estimating the hazard probability posed by military ordnance in three of the four respective ways discussed above. The Board's own analysis indicates, however, that a higher hazard probability is more appropriate for that posed by jettisoned ordnance, but the Board's raised estimate, 2.11×10^{-7} per year (relative to the Applicant's value of 3.2×10^{-8} per year), is still within the Commission's 1×10^{-6} per year acceptance criterion.

7. *Cumulative Hazard*

Because of the risk from F-16 flights down Skull Valley alone, the estimated cumulative hazard posed to the PFS facility from aviation activity in the Skull Valley fails to meet the Commission's threshold criterion for credible accidents of less than 1.0×10^{-6} per year. The additional hazard from flights on the MRR and from jettisoned ordnance accidents adds somewhat to the potential excessive risk.

This finding would ordinarily mean that our analysis was for now at an end, and that a grant of the license would not be justified. But the Staff believes that the probability criterion is flexible enough to avoid that result. We consider and reject that argument in Subpart D, below.

D. Compliance with the Commission's Safety Criterion

As has been seen in Subpart C, the Applicant has fallen well short in its attempt to establish that the accidents in question have less than a one in a million per year chance of occurring — we found that the accident likelihood is over four times that high. Rather than have that result be determinative, however, the Staff asserts that the governing Commission criterion (established in CLI-01-22) is not a rigid one, but is flexible in its application. Indeed, the Staff says, through both counsel and a witness, the standard is sufficiently flexible that it is really only intended as an “order of magnitude” guide. *See* Tr. at 3000-01 (Turk); Tr. at 8914 (Campe).

In response to our inquiry, the Staff indicated that it would have that order of magnitude flexibility “bracket” the criterion. Explaining further, the Staff opined that the Commission’s “less than one in a million” really means that a showing of as much as “ 5×10^{-6} ” would still pass muster. *See* Tr. at 3003-06 (Turk); Tr. at 8914 (Campe). In other words, the Staff’s view is that an accident scenario with a probability as high as “one in two hundred thousand” would pass a test that seems to demand “less than one in a million,”⁹⁷ which itself was a (legitimate) markdown (*see* pp. 86-87, above) from “less than one in ten million.”

While there may well be uncertainty in the accuracy of the various estimates now before us for the four factors (*see* Subpart C, above), we find that uncertainty not troublesome if the formula is utilized as it apparently was intended, i.e., as a rough screening device (*see* Tr. at 4127-28 (Campe)).⁹⁸ Indeed, this view is fully in keeping with the thinking of the authors of the formula, at least as expressed in nonadversarial circumstances at the time of the formula’s creation and embodiment in the Standard Review Plan.⁹⁹ At that point, they indicated that use of the NUREG-0800 four-factor formula “gives a *conservative* upper bound

⁹⁷ Because we decide this matter on the legitimacy of the *concept* the Staff is advancing, we do not pause to resolve questions that could be raised about its *details*, such as where the lower end of the order of magnitude “bracket” would most appropriately fall, which depends on whether the probability scale is viewed, for this purpose, as arithmetically based or log based, and might, instead of 5×10^{-6} , be at 2×10^{-6} , or “one in five hundred thousand.” Another more important question would concern why the Staff’s focus was only on the lower end of the so-called “bracket”; if it is truly a “bracket,” it would seem the State could focus on its upper end and argue that a superficially compliant showing (“less than one in a million”) failed for not being as infrequent as, depending on how the scale is interpreted, “one in two million” or “one in five million.”

⁹⁸ The State, for example, called our attention to a Licensing Board decision in another case where the acceptance criterion was 1×10^{-6} per year and yet the Board closely scrutinized crash probabilities of 1×10^{-10} to be sure the criterion was indeed met. *See* note 103, below.

⁹⁹ *Cf. Bowen v. Georgetown University Hospital*, 488 U.S. 204, 212-13 (1998). There, the Court disapproved agency counsel’s attempt to express a position during litigation that was different from the established agency position. Here, even though the changed position was not put forward by agency counsel, but by staff involved in later litigation, we think the principle analogous, in that the new litigating position is inconsistent with that taken in creating the position initially.

on aircraft impact probability if care is taken in using values for the individual factors that are meaningful and *conservative*.” NUREG-0800 at 3.5.1.6-4 (§ III.2, emphasis added).

As we read that text, it indicates clearly that the formula was intended to be applied cautiously.¹⁰⁰ Yet, reformulating the acceptance criterion in the Staff-proposed manner would amount to overriding the conservatism that apparently was deliberately built into the formula.¹⁰¹ We thus disagree with the Staff that in the face of such analytical uncertainty we should create, and rely upon, an order-of-magnitude confidence interval bracketing or surrounding the acceptance criterion.¹⁰² This is particularly true in this instance, given that NUREG-0800 places special focus on “military training routes,” and precludes any waivers of full examination if such routes are “associated with a usage greater than 1000 flights per year” (§ II.1(b)). Here, there are multiple thousands of flights.

In the end, this illustrates the wisdom of using the classic NUREG-0800 formula only to the degree to which it was intended. As we see it, and as the Staff’s Dr. Campe described it during the trial (Tr. at 4126-28 (Campe)), the formula provides an excellent *screening* device for those concerned about unlikely accidents. That is, even when the values for the formula’s four factors are imprecise, the calculation might produce a result not close to the governing criterion. In that circumstance, the formula will have told its user with a reasonable amount of confidence either that (1) the accident being inquired about has so little likelihood of occurring that no further thought need be given it,¹⁰³ or (2) that it has so great a likelihood of occurring that the proposed site may be unsuitable.¹⁰⁴

In sum, it comes down to this: the one-in-a-million “credible accidents” criterion derives from the NRC’s site suitability regulations. The Applicant

¹⁰⁰ As we have adverted to throughout, that conservatism is not meant to deprive an applicant of its desired license. Rather, as we cover in detail in Subpart E, it is intended simply to require an applicant — in order to earn that license — first to take one of several possible steps, or to make one of several possible showings, to demonstrate that (notwithstanding the potential concern identified by the formula) the public health and safety will not be put at risk by an award of the license.

¹⁰¹ It is of no moment to this discussion, of course, that the acceptance criterion mentioned in NUREG-0800 is 1×10^{-7} , while the criterion applicable here is 1×10^{-6} . That difference simply reflects that the formula was initially derived for nuclear power plants and is being used here for a different type of facility. See pp. 86-87, above.

¹⁰² We mention again (See note 97, above), that a troubling question, involving fairness considerations, could arise if this “bracket” — even if otherwise permissible — were for practical purposes to extend, as the Staff seems to intimate, in only one direction.

¹⁰³ See, for example, the decision in Big Rock Point (brought to our attention by the State for another purpose), where the formula gave a result in the 10^{-10} range. *Consumers Power Co.* (Big Rock Point Plant), LBP-84-32, 20 NRC 601 (1984), *aff’d*, ALAB-795, 21 NRC 1 (1985).

¹⁰⁴ Unsuitable, that is, in the sense of the NRC’s site suitability regulations, if the facility is not adequate, or cannot be hardened, to preclude excessive radiological consequences.

selected this site in full knowledge that it was under a busy military training airway. Rather than stretch the one-in-a-million criterion to let the Applicant move forward, the appropriate course is to let that criterion and the screening formula serve their purpose — that of alerting the Applicant and the Staff to a problem so that the Applicant has the opportunity to address it.¹⁰⁵ If, instead, all that happened was to stretch the criterion as the Staff argues — or to alter the basic formulaic result through hypotheses not borne out by the facts as the Applicant proposes — the result would be to look away from, rather than to look more closely at, an identified problem.

In this instance, the Applicant needs to take the next step and address the “consequences” issue (*see* Subpart E, below), either by demonstrating that an F-16 would not penetrate a cask (either as now designed or as it might be hardened), or that, even if it did, there would be no significant radiation impact for the public.¹⁰⁶ If the Applicant can make either of those showings,¹⁰⁷ the NUREG-0800 formula and the “credible accidents” standard will have served their purpose of ensuring that the thousands of military overflights neither render the site unsuitable nor threaten to unleash any significant consequences.

E. Accident Consequences

We indicated earlier in this decision that we had rejected from consideration in the 2002 hearings certain testimony the Applicant had proffered on the “con-

¹⁰⁵ By the same token, the screening purpose for which the formula was created also suggests that, as the “one in a million” criterion is approached, the appropriate response is to look more closely at the problem under scrutiny. For example, if the formulaic calculation indicated that the likelihood of the accident in question was 1.01 per million, would that result truly be any different from one in which the calculation indicated that the likelihood was 0.99 per million? Is there more reason to round down the 1.01 to reach a decision in an applicant’s favor, than there is to round up the 0.99 to reach a decision against an applicant? In such circumstances, rather than the agency’s addressing a marginal proposal by sharpening an analytical pencil, the approach in NUREG-0800 seems to suggest that it would be better to proceed by sharpening an applicant’s focus on identified problematic areas.

¹⁰⁶ As noted earlier, the issue before us involves *accidental* crashes, but it would seem that any studies of aircraft impacts commissioned (after the September 11 attacks on the World Trade Center and the Pentagon) to assess the consequences of *deliberate* crashes, might be found to have a bearing on the analogous issue before us. *See* CLI-02-25, 56 NRC 356; note 4, above, and note 128, below).

¹⁰⁷ Or it can attempt to make arrangements to reduce significantly the likelihood of the accident. In that regard, NUREG-0800 indicates that “past experience has been that military authorities have been responsive to modification of military operations and relocation of training routes in close proximity to” sites in question. NUREG-0800 at 3.5.1.6-5, § III.2. As already noted (pp. 77-78, above), we have no role to play in any such modification and pause simply to note that whether such “military authority responsiveness” will obtain here appears problematic in light of the April 23, 2002 “limited appearance” affidavit submitted on behalf of the Secretary of the Air Force early in our hearing. *See* pp. 77-78, above.

sequences’’ issue. Because that issue may now prove crucial to the eventual outcome of this proceeding, we think it appropriate to provide an explanation of why that testimony was not then entertained, but similar testimony may well now be.

Under the Commission’s site evaluation regulations (covering nuclear reactors and adapted for spent fuel storage facilities), an applicant must show that if a credible accident were to occur, the consequences would not result in the release of radioactivity that would cause doses in excess of 10 C.F.R. Part 100 guidelines. *See* 10 C.F.R. §§ 72.90, 72.94, 72.98, 110.10; NUREG-0800 at 3.5.1.6-2; Campe/Ghosh Post Tr. 4078, at 4-6. As a *legal* matter, then, the ultimate focus is on a unified question, i.e., the probability of an accident that would lead to radiation doses beyond Part 100.

As a *practical* matter, however, the regulatory focus and approach often turn out not to be on that unified question but on one of two separate, subsidiary issues, either of which can be determinative in particular circumstances. Specifically, if it can be shown that the likelihood of the triggering accident is so low that the accident can be discounted as not credible, there is no need for an inquiry into whether the radiation dose consequences would be excessive if the accident were to occur.¹⁰⁸ At other times, the opposite approach is taken — an applicant will assume the accident would occur, but will attempt to demonstrate that even if the event happens there would be no dose consequences. Usually, this would be because the facility’s “design basis” is shown to be such that it can withstand the postulated accident, or mitigate it adequately.¹⁰⁹

Throughout this proceeding, in the pleadings and in Commission and Licensing Board decisions, there was great emphasis on, and full development of, the “probability” issue, involving the likelihood of an aircraft accidentally striking the facility. On the other hand, the “consequences” issue — that of excess dose — emerged not only belatedly, but also obliquely and scantily, in the State’s and Applicant’s proffered pretrial testimony in the form of discussions about the likelihood of cask penetration.¹¹⁰ For related reasons which will be seen, the Staff proffered no testimony on the subject.

¹⁰⁸For example, for purposes of analysis, it can be assumed that the radiological consequences of a direct strike by a large meteor onto a nuclear power plant would be enormous. But because a meteor strike is so unlikely (i.e., in regulatory terminology, “incredible”), nuclear plants need not be designed to withstand them.

¹⁰⁹That result was reached in this proceeding with respect to the lack of any real effect from an impact by a general aviation aircraft. *See* note 18, above.

¹¹⁰In this regard, we note the categorization of the issue regarding cask penetration is a gray area that depends on how the “accident” is defined. Thus, cask penetration was spoken of on a few occasions as constituting part of the “accident probability” question (when the accident is defined as cask *breach* by a crashing aircraft), and on other occasions as part of the “dose consequences”

(Continued)

The validity of the State's proffered testimony was put into play 2 weeks before trial in the form of the Applicant's and the Staff's motions *in limine* to have that testimony excluded on legal grounds.¹¹¹ For its part, the Applicant called our attention to what it perceived as a problem about the scope of this evidence by urging us to exclude the State's proposed testimony on one aspect of the cask penetration issue.¹¹² In this regard, at oral argument Applicant's counsel confirmed the Board's assumption that, in the belief the accidents under scrutiny had less than a one in a million likelihood of occurring, the PFS application had in effect represented to the Staff "don't worry about the military accidents . . . we don't have to design against" them. Tr. at 2986 (Farrar). Counsel indicated that the radiological dose consequences issue was not within the confines of our proceeding and assured us that Applicant would not attempt to litigate that issue. Tr. 2986-87, 2990-91, 2995-96 (Barnett). Instead, as Applicant's counsel explained and its testimony stated,¹¹³ its limited "cask penetration" testimony was offered merely to demonstrate the overall conservative nature of its accident probability calculations. Tr. 2986-87, 2988 (Barnett).¹¹⁴ *See also* proffered Johns Testimony, A7, last sentence; proffered Cole/Jefferson/Fly Testimony, A163, at 112.

For similar reasons, the Staff urged an even broader exclusion of the State's testimony, reaching another aspect of the cask penetration issue. Staff Motion § 4. This position was in harmony with the fact that *the Staff had proffered no testimony whatsoever on the cask penetration and dose consequences matter; its counsel explained that the Staff had taken that approach "because we believe that [given] the probability it does not have to be addressed."* Tr. at 2983 (Marco) (emphasis added).

evaluation (when the accident is defined, as it most often has been here, as cask *impact* by such an aircraft). *Compare* our analysis of the "nearby ordnance" issue in Subparagraph C.6.d(iii), above.

¹¹¹The motions on which we heard oral argument on April 8, the eve of trial, had been filed 2 weeks before the start of the hearing, on March 25, with responses filed a week later, on April 1.

¹¹²Although the Applicant's motion appeared primarily directed at the State's proposed testimony on "dose consequences" for being outside the scope of the proceeding, it also challenged the State's proposed testimony on an aspect of "cask penetration" as lacking any basis. *See* Applicant's Motion to Strike (Mar. 25, 2002), at 4-5.

¹¹³*See* Testimony of Jeffrey Johns on Aircraft Crash Hazards at the PFSF Contention Utah K/Confederated Tribes B [hereinafter Johns Testimony] (Feb. 12, 2002).

¹¹⁴In indicating whether "consequences is part of" this proceeding, Applicant's counsel did draw a distinction between "specific, radiological dose consequences," which it thought *not* before us, and its proffered testimony that "certain impacts . . . would not result in a release of radioactive material," which it had included "to show that our probability calculations were conservative." Tr. at 2986 (Barnett). We discuss that purpose below.

This explanation was repeated a few minutes later, when Staff counsel explained that because the Staff “conservatively assume[s] that the impact of the plane will result in [excessive] consequences,” it “doesn’t get to” the consequences issue and instead “start[s] by looking to see what is the probability of occurrence.” Tr. at 2998 (Turk). This was in keeping with the Staff’s testimony, indicating that, in practice, only the annual probability of occurrence of an aircraft crash is calculated, as if a conservative assumption was made that the crash would cause the Part 100 guidelines to be exceeded. Campe/Ghosh Post Tr. 4078, at 6. In other words, the Staff proceeds initially as if the probability of exceedance is 1. *Id.*

Notwithstanding its position, the Staff did not take directly parallel action against the Applicant in that it did not formally challenge, by way of a separate motion, the Applicant’s testimony on one of the same subjects on which it had challenged the State. The Staff did, however, present an understated challenge by noting in its motion to exclude the State’s testimony that, if that testimony were indeed to be excluded, fairness would dictate that the Applicant’s proposed testimony on “cask penetration” should be excluded as well. Staff’s Motion in Limine (Mar. 25, 2002) at 5 n.4.

For its part, the State was willing to let all the testimony on this subject remain, pointing out that its position — that “consequences” could be a legitimate part of the case — was founded, in part, on a ruling of our predecessor Board on an earlier motion for summary disposition.¹¹⁵ But the State, like the Staff, noted the obvious, i.e., that if the State’s testimony on the “consequences” issue were to be excluded, so should be the Applicant’s (Tr. at 2992 (Soper)).¹¹⁶

That earlier Board ruling does bear on the issue. The Applicant had then urged, as did the Staff in its support of the Applicant’s motion, that in light of the low probability of an aircraft crash accident, “such accidents are not credible and hence the [facility] need not be designed to withstand their effects.”¹¹⁷ Disagreeing, our predecessor Board, chaired by Judge Bollwerk, made it clear

¹¹⁵ State Memorandum in Opposition (Apr. 1, 2002) at 6 (*citing* LBP-01-19, 53 NRC 416, 431 n.5 (2001)).

¹¹⁶ In other words, given the failure of either the State or the Staff to challenge it frontally, a primary reason the Applicant’s proffered testimony on “cask penetration” was subject to exclusion was because the Applicant’s and Staff’s challenge to the State’s testimony had triggered consideration of the overall matter.

¹¹⁷ Applicant’s Motion for Summary Disposition (Dec. 30, 2000) at 9. *See also* Staff Response to Motion to Strike (Feb. 20, 2001) at 1 n.1 (arguing that consequences of an F-16 crash impact accident are beyond the scope of this contention). As we read that argument, the Applicant was at least suggesting at that point that the “penetration” issue was *not* in play by virtue of the State’s contention, for hardening the casks would provide an obvious starting point for avoiding an accident’s untoward consequences.

that there remained room in the proceeding for that issue, and refused to rule it out at that point.¹¹⁸

But even though the door had thus been left open for “consequences” to become part of the case, by the time we came to make our ruling on the Applicant’s and Staff’s *in limine* motions, we concluded that door had since been shut, at least for purposes of the mid-2002 hearing.¹¹⁹ Because our ruling there (Tr. at 3008 (Farrar)), referring to the “way the contention was framed,” was rendered in extremely shorthand fashion in light of the lengthy argument and the other matters still to be addressed at the time, at this juncture we think it worth providing a further explanation of our reasoning.

In short, although the question of accident consequences was touched on from time to time prior to the hearing,¹²⁰ we concluded the issue had not generally been framed with the focus or quantification that would have allowed at the hearing a considered, precise decision on the likelihood either of cask penetration or of exceeding Part 100 dose levels.¹²¹ This lack of focus or quantification was apparent in two respects.

1. The first involved the absence of Staff review of, or a position on, the matter. Whatever may have transpired between the Applicant and Staff during the lengthy application review process,¹²² on this subject the Staff did not put forward

¹¹⁸ LBP-01-19, 53 NRC at 431 n.5.

¹¹⁹ As it turned out, Judge Bollwerk was, for other reasons, present at the April 8 oral argument on the *in limine* motions. Tr. at 2923-24 (Farrar). This Board took advantage of his presence to consult with him on this matter, and he did not disagree with our resolution of it. *See* Tr. at 3007-08 (Farrar).

¹²⁰ We note again in this regard (*see* note 20, above) that a discussion of consequences had arisen in the case during the period when we, and the Commission, were considering what the criterion should be for determining when an accident was credible. In the course of such consideration, distinctions were drawn between what the criterion should be for nuclear power plants and for spent fuel installations, and a key factor in that distinction was the perceived difference between the consequences of an accident at one and an accident at the other. But the consideration of consequences in that context was in a global, generic sense, not in a targeted, specific fashion, and had no bearing on how the case had been pleaded in terms of trial preparation. *See* LBP-01-19, 53 NRC at 429-32.

¹²¹ As is apparent, the proposed consequences testimony we excluded from the hearing was rather sparse compared to the State’s and the Applicant’s thorough, detailed testimony on the likelihood of the accident.

¹²² Early on, as it conducted its internal review triggered by the filing of the PFS application — which presented an analysis of the *likelihood* of crashes into the facility — the Staff had asked pointedly for an analysis of certain crash *consequences*. *See* Commitment Resolution Letter #18 from Applicant to Staff of 10/13/99, reciting the Staff’s earlier conference call question about certain “potential consequences” issues if the Applicant was “unable to show the lack of any credible hazard from aircraft crashes” The Applicant responded, however, that any such analysis was unnecessary. Although the Applicant eventually was more forthcoming (see next paragraph), it appears that that initial Staff-Applicant exchange may have permanently set the tone for how the Staff approached this matter.

(Continued)

its own analysis, either in the Safety Evaluation Report (SER) it produced or in the testimony it proffered to us. *See* SER; Campe/Ghosh Post Tr. 4078.

As a result, we were reluctant to undertake to decide an issue of such potential significance without the benefit of any formal review of it (or presentation of evidence on it) by the Staff. To be sure, the Staff's conclusions based on its safety and environmental reviews — whether contained in the SER and FEIS documents,¹²³ or reflected in witness testimony — are ultimately subject to the same testing in the hearing as those of any other party, and are not given by virtue of their source any more importance than that of any other party.¹²⁴ But under the Commission's time-tested licensing and hearing processes, the Staff's evaluation of an applicant's proposal — reached as it conducts its independent review of the application — is considered an integral part of the record that is developed regarding any contentions challenging what an applicant has put forward.¹²⁵ Even though the Staff's position may not prevail at trial, it is presumed

In Revision 22 of its Safety Analysis Report (SAR), the Applicant on the one hand reasserted at one point that because “aircraft crashes do not present a credible hazard . . . the facility does not need to be designed to withstand the impact of an aircraft crash.” SAR at 2.2-6. The Applicant went on in that same revision, however, to address crash impacts in two not entirely consistent fashions, *viz.*, by (1) pointing out that “*no credit was taken*” in calculating the annual impact probability “for the resistance to the effects of an air crash impact provided by the concrete storage casks” (except where “light general aviation aircraft” were concerned), but (2) urging, based on material it had submitted on that subject, that “[t]his resistance of the casks to penetration further *reduces significantly* the calculated risk . . . from aircraft crashes” SAR at 2.2-22 (emphasis added).

¹²³The NRC's basic rule is that the actual hearing of particular issues (as distinguished from prehearing pleadings and discovery matters related to those issues) is expected to await the Staff's preparation of, respectively, the *Final* SER (not just the *Preliminary* SER) and the *Final* Environmental Impact Statement (EIS) (not just the *Draft* EIS), or the functional equivalent of those documents. In other words, until the Staff is ready to present its *final*, complete analyses, a case is usually deemed not ready to move forward. *Statement of Policy on Conduct of Adjudicatory Proceedings*, CLI-98-12, 48 NRC 18, 20-21 (1998). Here (presumably because of the nature of the Applicant's presentations to it), the Staff had neither conducted nor provided *any* analysis on the issue in question.

¹²⁴It has long been the rule that the Staff “does not occupy a favored position at hearings,” in that Boards “must evaluate the staff's evidence and arguments in the light of the same principles which apply to the presentations of the other parties,” for “the staff's views ‘are in no way binding upon’ the boards . . . [and] cannot be accepted without passing the same scrutiny as those of the other parties.” *Consolidated Edison Co. of New York* (Indian Point, Units 1, 2, and 3), ALAB-304, 3 NRC 1, 6 & n.15 (1976) (footnotes omitted) (quoting *Southern California Edison Co.* (San Onofre Nuclear Generating Station, Units 2 and 3), ALAB-268, 1 NRC 383, 399 (1975)). *See also Texas Utilities Generating Co.* (Comanche Peak Steam Electric Station, Units 1 and 2), LBP-82-87, 16 NRC 1195, 1200 (1982), *vacated on other grounds*, CLI-83-30, 18 NRC 1164 (1983) (describing how the Board and the Staff have different roles in licensing hearings).

¹²⁵While Staff review of a subject may thus be a prerequisite to the conduct of a hearing in ordinary circumstances, we do not mean to exclude totally the possibility that Staff review could be dispensed with in an unusual situation, even in a complex case. In some relatively simpler types of proceedings,

(Continued)

that the development and exploration of a contested issue will benefit from the Staff's analysis and presentation.

2. Additionally, a serious question existed in this instance about whether a comprehensive record on consequences could have been developed, based upon the prefiled testimony offered just before the hearing, that would have allowed us to make an informed decision. As we have just emphasized, the Staff put forward no proposed testimony on either penetration or consequences. The State's proposed testimony simply presented limited material on consequences to illustrate that the accident in question, if it occurred, was a matter significant enough to devote attention to. Nor was the Applicant's prefiled testimony at all extensive.¹²⁶ Rather, the Applicant sought to present limited material on consequences simply to add conservatism to its incredibility calculations, i.e., to reassure the public and the decisionmakers that not only was the accident so unlikely that it need not be guarded against, but that any lingering doubts in that regard could be safely disregarded because of the asserted lack of consequences.¹²⁷

Having sufficient other reason to exclude the testimony, we were pointed in the same direction by the just-described paucity of it. As we listened to the April 8 oral arguments, it became clear that — because of the pendency of the “probability” issue that could moot the need to consider “consequences” — that latter matter had not been fully developed and certainly appeared not ripe for trial.¹²⁸ No party asked us to reconsider our ruling setting the issue aside.

That was the situation on the eve of the evidentiary hearing in Salt Lake. That situation has now changed, with our ruling today indicating that — in connection with the significant presence of F-16 military aircraft in Skull Valley airspace —

the Staff conducts its review but, under NRC Rules, has the option (subject to Board approval) not to participate in any hearing that later takes place. *See* 10 C.F.R. § 2.1213. Here, we were not faced with any such unusual situation, or presented any other reason to take up a subject of this magnitude without benefit of Staff analysis.

¹²⁶The prefiled testimony had indicated that its coverage of the “cask penetration” subject was *qualitative*, not quantitative. *See* Cole/Jefferson/Fly Post Tr. 3061, at 111-12. In short, there has been throughout — perhaps understandably — a degree of vacillation in the Applicant's position, and a degree of ambiguity both in the purpose for which material was being put forward and in the conclusions being urged to be drawn from it. *See* notes 117, 122.

¹²⁷*See* Tr. at 2986-87 (Barnett), the excluded testimony of the Applicant's expert panel (Cole/Jefferson/Fly Post Tr. 3061, at Q&A 163-164), and the excluded testimony of Applicant's expert Jeffrey Johns (Johns Testimony).

¹²⁸Given the time and resources that the Commission has devoted, in the wake of the events of September 11, 2001, to assessing the potential consequences of aircraft striking NRC-regulated facilities (*see* CLI-02-25, 56 NRC at 356), any further proceedings on this subject (whether in open or closed session) may well now benefit from much more detailed evidence than was proffered to us last year.

the Applicant has failed to demonstrate that its proposed facility will meet the applicable cumulative probability acceptance criterion regarding aircraft crashing at or affecting that facility. In light of that ruling, the door is now again open¹²⁹ — at the Applicant’s option — for a “consequences” presentation,¹³⁰ which might include cask penetration and radiation dose issues. In that connection, at the appropriate juncture (*see* note 130, above), the State will have the opportunity to continue to participate (*see* inquiry from State counsel, Tr. at 3007 (Soper)).¹³¹

The question remains as to how further consideration of this issue should proceed. On the one hand, given that all we have held thus far is that the Applicant’s F-16 crash probability showing was inadequate to meet the Commission-endorsed acceptance criterion, it is clear that our decision does not foreclose the Applicant from eventually obtaining a license; further proceedings before us on the consequences issue may thus well be in the offing.

On the other hand, the Applicant may want to seek early Commission review of our decision on the probability issue. Certainly, the steps likely needed to make the necessary further showing on the consequences issue — such as assembling a revised licensing presentation, undergoing Staff review, and participating in possible prehearing and hearing proceedings before this Board — will take some period of time. Thus, even if the Applicant believes it can prevail regarding a further consequences showing, it nonetheless may want to seek reversal of our decision that its showing on the aircraft crash probability issue fell short.

Conscious of the Commission’s instructions that we should adopt case-management techniques that will help move licensing proceedings along as expeditiously as possible,¹³² allowing the Applicant to proceed on parallel tracks before us and before the Commission — rather than forcing it to proceed sequentially — seems likely to best achieve that objective. Indeed, NRC precedent supports just such an approach.

Specifically, in the *Byron* reactor operating license proceeding, the Appeal Board was called upon to consider a Licensing Board decision concluding that, notwithstanding the possibility the applicant might be able to make a further showing that would support a license, the applicant’s initial failure to make its case mandated a final decision denying the license. In reversing that decision, the Appeal Board indicated that the Licensing Board should have retained jurisdiction for the receipt of further evidence, without prejudice to the applicant

¹²⁹ *See* pp. 138-39, above.

¹³⁰ In light of what we have said earlier, we assume that presentation must first go to the Staff, in the form of an application amendment or in some other fashion, for review before reentering the hearing process.

¹³¹ Assuming the State is able to show, in a then-timely fashion, that it meets the procedural and substantive ground rules for such participation, hurdles with which it is thoroughly familiar.

¹³² *Statement of Policy*, CLI-98-12, 48 NRC at 19-20.

seeking “discretionary appellate review of the [Licensing] Board’s appraisal of the existing” record. *Commonwealth Edison Co.* (Byron Nuclear Power Station, Units 1 and 2), ALAB-770, 19 NRC 1163, 1169-70 (1984).¹³³

In the situation before us, there may be some question about whether today’s decision is now appealable as of right, since it may or may not be deemed to dispose finally of a “significant portion of the case.”¹³⁴ Given the significance of our ruling here, and the fact it builds upon a previous Commission determination dealing with this subject, we perceive no reason to put upon the parties the burden of coming before us to debate whether we should refer our ruling to the Commission for its review (and, if we declined, of then asking the Commission to direct us to refer our ruling). Accordingly, pursuant to 10 C.F.R. § 2.730(f), we are referring today’s ruling to the Commission for immediate review.¹³⁵ Of course, whether such review should indeed be undertaken is for the Commission to decide. 10 C.F.R. § 2.786(g).

Although appellate proceedings ordinarily deprive a lower tribunal of jurisdiction over the substance of the matter that was before it, we perceive no fundamental inconsistency between (1) the Commission’s conducting a referred

¹³³To be sure, the Appeal Board in *Byron* indicated it would likely not have taken on such discretionary review in the circumstances before it (an issue concerning the adequacy of the applicant’s quality assurance plan). ALAB-770, 19 NRC at 1170. In contrast, we think prompt review here is fully appropriate and we see nothing in *Byron* suggesting that there cannot here take place simultaneously (1) review by the Commission of the findings on probability underlying our refusal now to approve the license, and (2) consideration by us of a presentation on consequences. The final say here on whether there *should* be expedited discretionary appellate review of the decision and whether we *should* simultaneously retain jurisdiction for further trial proceedings, of course, rests with the Commission; we simply note that the *Byron* precedent would indicate there is no *legal barrier* to proceeding in that fashion.

¹³⁴The applicable section of the rules, 10 C.F.R. § 2.760(a), allows for Commission review of partial initial decisions. NRC jurisprudence prior to the 1991 restatement of that rule suggests, however, that only partial initial decisions that dispose of a “major segment of the case” may be appealed immediately. More recently in this proceeding, the Commission declined an invitation to indicate whether it would adopt that principle, enunciated by the Appeal Board. *See* CLI-00-24, 52 NRC at 354 n.5. Although the Commission has the final word on the applicability of that test in this instance, today’s decision on crash “probability” does appear to us to dispose of a major segment of the case (*cf.* Subpart A, above, first sentence); it certainly does so if the Applicant chooses not to make a presentation addressing consequences.

¹³⁵Ordinarily, we would have given the State, the party prevailing before us, an opportunity to be heard on the immediate referral question before taking that step. But if there can ever be matters that are a foregone conclusion, this is one, and there thus seems little point in putting the State, and the other parties in response, to the effort of briefing that procedural issue. We recognize that in following this course we appear to be violating an important principle — “*audi alteram partem*” (“hear the other side”) — we cited at an earlier stage of this proceeding. LBP-02-8, 55 NRC 171, 201 (2002). That salutary principle is intended to ensure fairness to the parties, and to keep judges from making mistakes, but the circumstances before us appear to justify the risk of its nonobservance here.

review of the *accident probability* matters we have decided today, and (2) our simultaneously undertaking consideration of the matter of *accident consequences* (which we have explained is, as a practical if not a legal matter, a separate issue). Certainly, following such a course appears to be what the Appeal Board in *Byron* had in mind.

Accordingly, we will take that approach (unless the Commission directs us otherwise). To that end, we request that within 20 days of the issuance of this decision, the Applicant, the State (as the Lead Intervenor on the contention that is the focal point of our ruling today), and the NRC Staff provide us with a report that outlines their views, either jointly or separately, as to how they wish to proceed on the matter of accident consequences relative to Skull Valley F-16 aircraft crashes.

II. DETAILED ANALYSIS OF RECORD AND FINDINGS OF FACT

In this part of our decision, we provide the detail that underlies the reasoning expressed in the “Narrative” first part. This “Detailed” Part II contains three subparts, each with its own Table of Contents. Each of the three Subparts is, however, constructed somewhat differently.

The first, Subpart A, beginning on page 145, simply presents the background and contextual matters that set the stage for the major issues covered in the second and third subparts. Most of what it covers was essentially noncontroversial.

As will be explained in the opening of Subpart B (*see* p. 160), which deals with the proposed “*R*” factor, most of that subpart consists of a detailed analysis of the evidentiary record. We take that approach because our ultimate finding there (rejecting the Applicant’s 95% “pilot avoidance” theory) is based less on disagreement with the individual factual threads the Applicant wove into its argument than with our determination — based on our view of the impact of the State’s countering evidence as a whole — that the Applicant’s proposals about the existence of the conditions *necessary* for success do not provide the appropriate framework for deciding the matter. Instead, we find in essence that those conditions are not *sufficient* for success, given the evidence of human error, under stress, leading to failure.

We take a more traditional approach in Subpart C (*see* p. 202). There, we do make the more customary “findings of fact” on the various disputed matters concerning the application of the four-factor formula not only as to the main issue — the risk from F-16 flights down Skull Valley — but also as to the other potential aircraft and ordnance hazards to the facility.

Beyond what is expressed in this Part II, we have carefully considered all of the other arguments, claims, and proposed findings of the parties relative to the matters in dispute. To the extent those party positions are not specifically

addressed herein, it is either because we find them immaterial, without merit, and/or unnecessary to this decision, or because they are subsumed in the rulings we do make.

A. Introduction and Summary

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1. Procedural Background

A.1 In ruling initially on the admissibility of contentions, the Board was faced with several Petitioners having presented similar issue statements. Accordingly, the Board prepared “Contention Utah K/Confederated Tribes B” to consolidate the elements of the separately filed “credible accident” contentions. That new contention read:

CONTENTION: The Applicant has inadequately considered credible accidents caused by external events and facilities affecting the ISFSI and the intermodal transfer site, including the cumulative effects of the nearby hazardous waste and military testing facilities in the vicinity and the effects of wildfires.

LBP-98-7, 47 NRC 142, 253, *recons. granted in part and denied in part on other grounds*, LBP-98-10, 47 NRC 288, *aff’d on other grounds*, CLI-98-13, 48 NRC 26 (1998).

A.2 As required by the Commission’s rules in 10 C.F.R. § 2.714(b), several “bases” in support of the contention were submitted by the Petitioners. In admitting the contention, however, the Board limited the contention’s scope to the following matters: (1) the impact upon the facility from (a) accidents involving materials or activities at or originating from the Tekoi Rocket Engine Test Facility, the Salt Lake City International Airport, Dugway Proving Ground (including the Michael Army Airfield), Hill Air Force Base, and the Utah Test and Training Range, and (b) wildfires occurring in Skull Valley; and (2) the impact upon the Applicant’s Rowley Junction Intermodal Transfer Point (ITP) of activities or materials from the aforementioned facilities, as well as hazardous materials

from other facilities in the area. LBP-98-7, 47 NRC at 190-91, 214, 234-35, 247-48.¹³⁶

A.3 Following the Board rulings on admissibility of contentions, the parties proceeded with discovery on the remaining issues. On June 7, 1999, the Applicant filed a motion for partial summary disposition of Contention Utah K/Confederated Tribes B, arguing that there was no genuine dispute of fact as to those portions of the contention relating to hazards posed by Tekoi; wildfires; the testing and storage of biological, chemical, and hazardous materials at Dugway; ordnance disposal and unexploded ordnance on Dugway; landings at Michael AAF of aircraft carrying “hung bombs”; and the X-33 experimental space plane.¹³⁷

A.4 The Board granted in part, denied in part, and deferred in part the Applicant’s motion. *See* LBP-99-35, 50 NRC 180, *recons. denied*, LBP-99-39, 50 NRC 232 (1999). In light of its ruling, the Board then rewrote the contention to read:

CONTENTION: The Applicant has inadequately considered credible accidents caused by external events and facilities affecting the ISFSI, including the cumulative effects of military testing facilities in the vicinity.

LBP-99-39, 50 NRC at 240. In a subsequent ruling clarifying LBP-99-35, the Board dismissed those portions of contention Utah K/Confederated Tribes B relating to the ITP. LBP-99-39, 50 NRC at 236-38; *See* LBP-99-34, 50 NRC 168 (1999).

A.5 In 2001, pursuant to another Applicant summary disposition motion, the Board dismissed issues pertaining to ordnance usage at Dugway and cruise missile testing on the UTTR. LBP-01-19, 53 NRC at 422-29. As discussed below, in the same order the Board further defined the scope of the issues concerning hazards posed by aviation activities in and around Skull Valley and resolved specific issues concerning all the civilian aviation hazards and some of the military aviation hazards.

A.6 In analyzing aviation-related hazards, the Applicant prepared a comprehensive report on the aviation activities in the vicinity of the site and the specific hazards each activity posed to the facility. *See* PFS Exh. N, Aircraft Crash Impact Hazard at the Private Fuel Storage Facility (Rev. 4) (Aug. 10, 2000) [hereinafter

¹³⁶ As admitted in this proceeding, the contention also included a portion of a contention (Castle Rock 6 — Emergency Planning and Safety Analysis Deficiencies) submitted by former intervenors Castle Rock Land and Livestock, L.C., and Skull Valley Co., Ltd. (Castle Rock/Skull Valley) in the rewritten contention. *See* LBP-98-7, 47 NRC at 214, 247-48. This part was dismissed upon Castle Rock/Skull Valley’s withdrawal from this proceeding in 1999. *See* LBP-99-6, 49 NRC 114, 120-21 (1999).

¹³⁷ *See* PFS Motion for Partial Summary Disposition of [Contention Utah K/Confederated Tribes B] at 2-18 (June 7, 1999).

Aircraft Crash Report]. The report was prepared principally by Brigadier General James L. Cole, Jr., USAF (Ret.), Major General Wayne O. Jefferson, Jr., USAF (Ret.), and Colonel Ronald E. Fly, USAF (Ret.), who served as expert consultants to the Applicant on military and civilian aviation and who eventually testified as witnesses for the Applicant in this proceeding. Their analysis drew upon their broad experience and professional judgment, and incorporated extensive information obtained from the U.S. Air Force.

A.7 The report first assessed the scope of the military and civilian activities in the vicinity of the Applicant's site. It then assessed the aviation traffic associated with each activity and calculated the crash impact probability at the facility for each activity. In calculating the crash impact probabilities, the report determined specific crash rates for each type of aviation activity and accounted for the specific locations and volume of aviation traffic relative to the Applicant's site.

A.8 In assessing the hazard posed by potential F-16 crashes, the report assessed in depth the ability of a pilot to direct a crashing aircraft away from the facility before it struck the ground. That assessment was based on (1) analysis by General Cole, General Jefferson, and Colonel Fly of all of the available Air Force aircraft accident reports concerning F-16 crashes over the 10-year period from Fiscal Year (FY) 1989 to FY 1998 and (2) their professional judgment regarding the ability of F-16 pilots to respond to in-flight emergencies. In the end, the report assessed the cumulative hazard to the proposed facility and concluded that the crash and jettisoned ordnance impact probability was less than 4.17×10^{-7} per year.

A.9 That report, as amended, played a principal role when the remaining issues were litigated in a hearing that began on April 9, 2002, and continued intermittently (along with other unrelated contentions) through July 3, 2002. These issues — all tied to the “inadequate consideration of credible accidents” contention — included: (1) F-16s transiting Skull Valley, including the problems of both aircraft crashes and jettisoned ordnance; (2) aircraft flying on the Moser Recovery Route (MRR); (3) aircraft flying to and from Michael Army Airfield (MAAF) on the flight path designated as IR-420; (4) aircraft conducting air-to air combat training on the UTTR; (5) impact from jettisoned ordnance; and (6) the cumulative hazard to the Applicant's facility from aircraft accidents and ordnance.

A.10 In accordance with timelines we established, the parties submitted prefiled testimony, presented other evidence relevant to their respective positions, and filed extensive post-hearing briefs. Our findings of fact and conclusions of law regarding the credible accidents contention are based upon our review and analysis of all those materials.

2. *Legal Standards*

A.11 The Commission has established criteria for evaluating those characteristics of a proposed site that may directly affect the safety of an ISFSI to be located there. As set forth in 10 C.F.R. Part 72, Subpart E, §§ 72.90, 72.94, and 72.98, proposed sites must be examined with respect to, among other things, the frequency and severity of naturally occurring and man-induced external events that could affect the facility's safe operation, and the existence of manmade facilities and activities that might endanger the proposed facility or affect the facility design.

A.12 The regulations further provide that "design basis" external events must be determined with respect to a proposed facility's site and design. 10 C.F.R. § 72.90(c). Design bases are defined, in 10 C.F.R. § 72.3, in pertinent part, as follows:

§ 72.3 Definitions

....

Design bases means that information that identifies the specific functions to be performed by a structure, system, or component of a facility or of a spent fuel storage cask and the specific values or ranges of values chosen for controlling parameters as reference bounds for design. These values may be restraints derived from generally accepted state-of-the-art practices for achieving functional goals or requirements derived from analysis (based on calculation or experiments) of the effects of a postulated event under which a structure, system, or component must meet its functional goals. The values for controlling parameters for external events include —

....

(2) Estimates of severe external man-induced events to be used for deriving design bases that will be based on analysis of human activity in the region, taking into account the site characteristics and the risks associated with the event.

A.13 In accordance with 10 C.F.R. § 72.24, an application for an ISFSI under Part 72 must include a Safety Analysis Report (SAR) describing the proposed facility, which must contain, among other things, "[a] description and safety assessment of the site on which the ISFSI . . . is to be located, with appropriate attention to the design bases for external events," 10 C.F.R. § 72.24(a) as well as information concerning the facility's design, including identification of the design criteria, design bases, and "the relation of the design bases to the design criteria." 10 C.F.R. § 72.24(c)(2). Further, the design and performance of structures, systems, and components (SSCs) important to safety must be analyzed for those events that are considered to be within the design for the facility, including consideration of "[t]he adequacy of structures, systems, and components provided for the prevention of accidents and the mitigation of

the consequences of accidents, including . . . manmade phenomena and events.’’ 10 C.F.R. § 72.24(d)(2).

A.14 The Commission has established “General Design Criteria” for an ISFSI, as set forth in 10 C.F.R. Part 72, Subpart F. Pursuant to 10 C.F.R. § 72.120(a), an application to store spent fuel in an ISFSI “must include the design criteria for the proposed storage installation,” which “establish the design, fabrication, construction, testing, maintenance and performance requirements for structures, systems, and components important to safety as defined in § 72.3.”

A.15 Minimum requirements for an ISFSI’s design criteria include, among other things, “[p]rotection against environmental conditions and natural phenomena,” 10 C.F.R. § 72.122(b), whereby SSCs “must be designed to accommodate the effects of, and to be compatible with, site characteristics and environmental conditions associated with normal operation, maintenance, and testing of the ISFSI . . . and to withstand postulated accidents,” 10 C.F.R. § 72.122(b)(1) (emphasis added). Events that do not constitute credible accidents need not be included within the design bases of the facility. See CLI-01-22, 54 NRC at 259. As noted above, the Commission specifically approved the use of a 1×10^{-6} annual probability of occurrence standard for design-basis accidents for away-from-reactor ISFSIs. CLI-01-22, 54 NRC at 263.

A.16 In practice, only the annual probability of occurrence of an aircraft crash is calculated, as if a conservative assumption was made that the crash would cause the Part 100 guidelines to be exceeded. Campe/Ghosh Post Tr. 4078, at 6. In other words, the Staff proceeds initially as if the probability of exceedance is 1. *Id.*

3. Testimony Presented

A.17 Prefiled written testimony concerning Contention Utah K/Confederated Tribes B was submitted by the Applicant, the NRC Staff, and the State of Utah. The Applicant’s witnesses appeared first, followed by the Staff’s witnesses, with the State’s witnesses testifying last.

A.18 The Applicant submitted three sets of prefiled testimony, which consisted of the testimony of a total of five witnesses. The witnesses presented in the Applicant’s first set of prefiled testimony were: (1) Wayne O. Jefferson, Jr., a retired U.S. Air Force Major General, who assisted the Applicant with the quantitative calculations and modeling the Applicant performed concerning the probability that a crashing aircraft would impact the facility as well as with the review of relevant F-16 accident reports; (2) James L. Cole, Jr., a retired U.S. Air Force Brigadier General, who assisted the Applicant with the assessment of the aircraft crash hazard to the facility, and whose primary focus pertained to overall aviation safety, general Air Force issues, and certain F-16 operations; and (3) Ronald E. Fly, a retired U.S. Air Force Colonel, who assisted the Applicant in

its assessment of the risk to the facility posed by aircraft crashes and ordnance impacts, and whose primary focus was F-16 operations, F-16 emergency procedures, and flight operations in and around the UTTR. “Testimony of James L. Cole, Jr., Wayne O. Jefferson, Jr., and Ronald E. Fly on Aircraft Crash Hazards at the Facility — Contention Utah K/Confederated Tribes B” [hereinafter Cole/Jefferson/Fly] Post Tr. 3061, at 1-7.

A.19 Applicant witness Wayne Jefferson retired from the Air Force in 1989 with the rank of Major General. He served in the Air Force for over 30 years and has accumulated 4450 flying hours in nine different types of aircraft. General Jefferson served as a B-52 wing commander with the Strategic Air Command and has held other positions of responsibility with the Strategic Air Command. For example, in 1983-1984, he was Assistant Deputy Chief of Staff for Operations, overseeing the entire scope of the Strategic Air Command’s worldwide bomber, tanker, missile, and reconnaissance operations, including training-range development and flight operations. In addition, General Jefferson has been formally trained by the Air Force to serve as an Accident Board president, including management of the investigating team, preservation of the crash site, working with law enforcement officials, and interviewing participants and witnesses.

A.20 Since retiring from the Air Force, General Jefferson has been a consultant in management, management training, and quantitative probabilistic analysis. He holds a master’s degree in operations research from Stanford University and a master’s degree in business administration from Auburn University. Cole/Jefferson/Fly Post Tr. 3061, at 4-5; Jefferson Qualifications at 1.

A.21 General Jefferson has never flown an F-16 fighter aircraft, has never flown through Skull Valley, and has never ejected from any aircraft. Tr. at 3189, 3216 (Jefferson). General Jefferson performed all crash probability calculations for the Applicant. Tr. at 3187 (Cole), 3189 (Jefferson). General Jefferson has no prior experience using NRC guidance document NUREG-0800 nor prior experience in using the DOE Standard for aircraft crash analysis, DOE-STD-3014-96. Tr. at 3193, 3699 (Jefferson).

A.22 We find General Jefferson to be qualified as an expert witness on the subjects of U.S. Air Force aircraft operations, weapons testing and training operations, and probabilistic analysis.

A.23 Applicant witness James Cole retired from the Air Force in 1994 with the rank of Brigadier General. Over his career, he accumulated 6500 total flying hours in seven different types of aircraft, with 3000 flying hours in heavy jet aircraft. General Cole served as Chief of Safety of the U.S. Air Force from 1991 to 1994 and in that capacity directed the entire Air Force safety program. He was responsible for accident prevention and investigation in all aspects of ground and air operations and personally reviewed and approved every Air Force Accident Safety Investigation report for all types of aircraft.

General Cole was also commander of the 89th Airlift Wing, where he directed air transportation for the President of the United States and other senior government officials and foreign dignitaries. He has served as a pilot flight commander, chief pilot, assistant operations officer, operations officer, and squadron commander of a C-141 heavy jet transport squadron. General Cole flew airdrop missions, special operations low-level missions, night-vision-goggle missions, including clandestine approaches to airfields and blackout landings. Cole/Jefferson/Fly Post Tr. 3061, at 1-2; Cole Qualifications at 1-2.

A.24 General Cole has never flown in an F-16 fighter aircraft, has never flown through Skull Valley, and has never ejected from any aircraft. Tr. at 3142, 3158-60 (Cole). General Cole has not previously done a crash impact evaluation or performed a study on the issue of whether an F-16 pilot would be able to avoid a ground site. Tr. at 3156, 3157 (Cole).

A.25 We find General Cole qualified as an expert witness on the subjects of military aircraft operations and aviation safety matters.

A.26 Colonel Fly, who has piloted but never ejected from an F-16, retired from the Air Force in 1998. Cole/Jefferson/Fly Post Tr. 3061, at 6; Tr. at 3125, 3217 (Fly). He served in the Air Force for 24 years as an F-16 pilot, instructor, fighter squadron commander, operations group commander, and wing commander. Cole/Jefferson/Fly Post Tr. 3061, at 1-2. Colonel Fly has approximately 1200 flying hours in the F-16 as a pilot and instructor. Colonel Fly served as Commander of the 388th Fighter Wing at Hill AFB from 1997 to 1998 and has flown F-16s on the UTTR and through Skull Valley. *Id.* He was also Commander of the UTTR when the range was transferred to the 388th Fighter Wing in 1997. *Id.* Colonel Fly routinely reviewed accident reports as a pilot and has experience in strategic planning, operational analysis, international affairs, space operations, and logistical support. *Id.* He is specifically knowledgeable about the operations of military and civilian aircraft that fly in and around Skull Valley, Utah, including military aircraft that fly from Hill AFB and on the UTTR. *Id.* at 6; Fly Qualifications at 1-2.

A.27 We find Colonel Fly to be qualified as an expert witness on the subjects of U.S. Air Force F-16 aircraft operations and training operations, including operations at Hill AFB.

A.28 The Applicant also presented prefiled testimony of two other individuals. They were: (1) Stephen A. Vigeant, a Certified Consulting Meteorologist employed as a Lead Environmental Scientist by Stone & Webster, Inc., who obtained and evaluated information regarding the weather in the region of the Applicant's facility to support an analysis of the impact of weather on aviation activities in the region; and (2) Jeffrey R. Johns, a Licensing Engineer employed by Stone & Webster, Inc., who was responsible for the preparation of the Applicant's Safety Analysis Report pertaining to accident analyses and radiation protection for the proposed facility. "Testimony of Stephen A. Vigeant on Aircraft Crash

Hazards at the PFSF — Contention UtahK/Confederated Tribes B” [hereinafter Vigeant], Post Tr. 3090, at 1-2; “Testimony of Jeffrey Johns on Aircraft Crash Hazards at the PFSF — Contention Utah K/Confederated Tribes B” [hereinafter Johns]; Post Tr. 3205, at 1-2. By stipulation of the parties, Mr. Johns’ testimony was accepted into evidence without cross-examination. Tr. 3204-07 (Johns).

A.29 Applicant witness Stephen Vigeant received a Bachelor of Science degree from Lowell Technological Institute in meteorology and a Master’s degree in meteorology from Pennsylvania State University. Vigeant Post Tr. 3090, at 1; Vigeant Qualifications at 2. Mr. Vigeant has been involved in meteorological aspects of nuclear power plant licensing and environmental impact assessment and licensing for more than 20 years. He has provided consulting services in the areas of climatological analyses, meteorological monitoring, meteorological field studies, and design-basis meteorological investigations. Vigeant Qualifications at 1. However, he is not a pilot, has not flown through Skull Valley, and has not studied the extent to which a pilot can see under various cloud conditions and altitudes. He provided only meteorological data. Tr. at 4047-50 (Vigeant).

A.30 We find Mr. Vigeant to be qualified as an expert witness on the subject of meteorology.

A.31 Applicant witness Jeffrey Johns received a Bachelor of Science degree from Stanford University in Biological Sciences. Johns Qualifications at 2. Mr. Johns has over 20 years of experience in the nuclear power industry and 10 years of experience with the licensing of ISFSIs. Johns Post Tr. 3205, at 1; Johns Qualifications at 1. He has experience in accident analyses for ISFSIs and was responsible for preparation of portions of the Applicant’s Safety Analysis Report. Johns Post Tr. 3205, at 1-2. As a Licensing Engineer for the PFS project, Mr. Johns is familiar with the shielding design provisions of the HI-STORM 100 storage system, confinement design provisions of the canister, and the protection afforded the canister by the HI-STORM 100 storage overpack from postulated events such as tornado-driven missiles and explosions. *Id.* at 1.

A.32 We find Mr. Johns to be qualified as an expert witness on the subject of the susceptibility of the Applicant’s facility design to overpressure produced by an explosion.

A.33 In addition to the above witnesses who prefiled their testimony, the Applicant presented Michael Cosby, who testified individually by telephone regarding his experience as a pilot who had ejected from an F-16. Tr. at 3977-4031 (Cosby). Michael Cosby is an active-duty Colonel in the U.S. Air Force and is presently stationed with the 177th Fighter Wing in Atlantic City, New Jersey. Colonel Cosby is the operations group commander for the Fighter Wing and has been in that position for 3 years. Tr. at 3985 (Cosby). He has over 2500 flight hours in the F-16, with a total of 8900 flight hours in various aircraft. Tr. at 3986 (Cosby). Colonel Cosby has been an F-16 pilot during his entire career in the Air Force and has served as a functional check flight pilot, a four-ship flight lead,

and an instructor pilot. Tr. at 3982, 3984, 3985 (Cosby). He flew 78 combat missions during Desert Storm and flew over 308 combat sorties during Operation Northern Watch and Operation Southern Watch. Tr. at 3984 (Cosby). Colonel Cosby ejected from an F-16 on April 21, 1993. Tr. at 3978-82 (Cosby).

A.34 We find Colonel Cosby to be qualified as an expert witness on F-16 operations, including ejection therefrom.

A.35 The Staff presented a panel of two witnesses concerning this contention. They were: (1) Kazimieras M. Campe, a Senior Reactor Engineer in the Probabilistic Safety Assessment Branch, Division of Systems Safety and Analysis, NRC Office of Nuclear Reactor Regulation, who reviewed the Applicant's Safety Analysis Report (SAR) pertaining to external hazards and participated in the Staff's preparation of the SER; and (2) Amitava Ghosh, a Principal Engineer at the Center for Nuclear Waste Regulatory Analyses, a federally funded research and development center, which is a division of Southwest Research Institute, in San Antonio, Texas. "NRC Staff Testimony of Kazimieras M. Campe and Amitava Ghosh Concerning Contention Utah K/Confederated Tribes B (Inadequate Consideration of Credible Accidents)" [hereinafter Campe/Ghosh], Post Tr. 4078, at 1-3; *see* Staff Exh. C [hereinafter SER]. Dr. Ghosh also reviewed the Applicant's SAR pertaining to external hazards and participated in the preparation of the Staff's SER. Campe/Ghosh Post Tr. 4078, at 1-3; *see* SER.

A.36 Staff witness Kazimieras Campe has 30 years' experience in the NRC (and its predecessor, the Atomic Energy Commission) assessing the risk posed by external manmade hazards with respect to nuclear facilities. Campe/Ghosh Post Tr. 4078, at 1; Campe Qualifications at 1. "As far as looking at the issue of aircraft hazards, along with all other site related hazards," he has "looked at almost every plant in the country." Tr. at 4090; *see* Tr. at 4122 (Campe).

A.37 Dr. Campe was the principal contributor to the document referred to as NUREG-0800, which contains section 3.5.1.6, "Aircraft Hazards," of the NRC's Standard Review Plan. That document is utilized by the Staff in evaluating aircraft crash hazards at nuclear power reactors and other facilities. Campe/Ghosh Post Tr. 4078, at 6. He currently conducts safety reviews of risks posed to nuclear facilities by external manmade hazards, such as aircraft activity, as well as risks posed to other modes of transportation (e.g., railroads, highways, navigable waterways, and pipelines). Campe/Ghosh Post Tr. 4078, at 1-2; Campe Qualifications at 1-2. Dr. Campe, however, has no pilot experience. Tr. at 4116 (Campe).

A.38 We find Dr. Campe to be qualified as an expert witness on the subject of the assessment of risk associated with aircraft activity.

A.39 The second Staff witness, Amitava Ghosh, has over 20 years of experience in conducting both academic and industrial research, consulting, and teaching in mining, geological, and geotechnical engineering. Campe/Ghosh Post Tr. 4078, at 2; Ghosh Qualifications at 1. Dr. Ghosh has experience with respect to probabilistic risk assessments and the design of surface and subsurface

facilities. Campe/Ghosh Post Tr. 4078, at 2; Ghosh Qualifications at 1. Dr. Ghosh is currently the technical lead for preclosure activities of the proposed high-level nuclear waste repository at Yucca Mountain and is currently involved with probabilistic risk assessment, identification of hazards and initiating events, and repository design. Campe/Ghosh Post Tr. 4078, at 2; Ghosh Qualifications at 1. Like Dr. Kampe, Dr. Ghosh has no pilot experience. Tr. at 4116 (Ghosh).

A.40 We find Dr. Ghosh to be qualified as an expert witness on the subject of the assessment of risk and the identification and analysis of hazards posed to nuclear waste facilities.

A.41 In support of its contention, the State presented initially the prefiled testimony of two witnesses. They were: (1) Hugh Horstman, a retired U.S. Air Force Lieutenant Colonel, who has been assisting the State with respect to this contention since 2000; and (2) Marvin Resnikoff, a Senior Associate at Radioactive Waste Management Associates in New York, who performed calculations on behalf of the State regarding the probability and consequences of aircraft crashes at the Applicant's proposed facility. "State of Utah's Prefiled Testimony of Lieutenant Colonel Hugh Horstman (U.S.A.F. Retired) Regarding Contention Utah K/Confederated Tribes B" [hereinafter "Horstman"], Post Tr. 4214, at 1-2; "State of Utah's Prefiled Testimony of Dr. Marvin Resnikoff Regarding Contention Utah K/Confederated Tribes B" [hereinafter "Resnikoff"], Post Tr. 8698, at 1, 4.

A.42 Lt. Colonel Horstman has more than 20 years' experience as a pilot in the U.S. Air Force, including over 2500 hours as a pilot and over 1000 hours as a navigator. Horstman Post Tr. 4214, at 1-2. He has flown over 1800 hours as an F-16 and F-111 fighter pilot. Horstman Post Tr. 4214, at 1-2. He was also an instructor pilot for both the F-16 and F-111 fighter aircraft as well as an instructor navigator. *Id.*

A.43 From October 1997 through June 1999, Lt. Colonel Horstman was the Deputy Commander of the 388th Operations Group at Utah's Hill Air Force Base. *Id.* at 1. In this position, he commanded the F-16 Operations Group and 1500 personnel. *Id.* The Operations Group was responsible for the administration of all 388th Fighter Wing flying activity, including the sorties flown in the Utah Test and Training Range airspace. *Id.* The Operations Group was also responsible for managing the UTTR airspace and for managing the three fighter squadrons stationed at Hill Air Force Base. *Id.* In addition, Lt. Colonel Horstman was responsible for the flight line maintenance of all F-16C aircraft assigned to the 388th Fighter Wing. *Id.*

A.44 Lt. Colonel Horstman has flown over 150 training missions in the UTTR, including air-to-air combat missions, air-to-ground combat missions (e.g., precision ordnance bombing), low-level training missions, targeting pod, and night-vision-goggle missions. *Id.* at 2. While stationed at Hill AFB he was responsible for planning training missions and instructing F-16 pilots. *Id.* He

flew F-16 training missions as an instructor pilot, as a flight lead, and as a mission commander. *Id.* In those capacities he was responsible for assessing individual pilot performance on various tasks, including emergency procedures. *Id.* Lt. Colonel Horstman is intimately familiar with the UTTR land and airspace, including the military operating areas over the area of the Applicant's proposed site. *Id.* He was not trained to serve on accident investigation boards, having served only once briefly as interim board president. PFS Aircraft Findings at 8; Tr. at 8496-97 (Horstman).

A.45 Lt. Colonel Horstman retired from the Air Force in 1999. Horstman Post Tr. 4214, at 1. Lt. Colonel Horstman continues to fly as a commercial pilot of Boeing 737 jets for Southwest Airlines. *Id.*

A.46 We find Lt. Colonel Horstman to be qualified as an expert on the subjects of F-16 aircraft and training operations, including those occurring at Hill AFB and in the UTTR. We have considered the Applicant's challenge to his credibility, based on the changing positions Lt. Colonel Horstman took on the Applicant's multilevel categorization of the accident reports. We find the confusion to have been understandable in light of the manner in which the material was presented, and do not find that, or any other reason, sufficient to cast general doubt on Lt. Colonel Horstman's credibility.

A.47 State witness Dr. Marvin Resnikoff is the Senior Associate of Radioactive Waste Management Associates ("RWMA"), a private technical consulting firm based in New York City. Resnikoff Post Tr. 8698, at 2. He holds a doctoral degree in high-energy theoretical physics from the University of Michigan. *Id.* Dr. Resnikoff has done research on radioactive waste issues for the past 27 years and has extensive experience and training in the field of nuclear waste management, storage, and disposal. *Id.*

A.48 Dr. Resnikoff has done research on technical issues related to the storage of radioactive waste, including spent nuclear power plant fuel, and is familiar with spent fuel storage systems that are now in use or proposed for future use in the United States. *Id.* Dr. Resnikoff's experience includes technical review and analysis of numerous dry cask storage designs. *Id.* Dr. Resnikoff has estimated the probability of accidents regarding air, train, and truck accident rates for the states of New York, Nevada, and Utah. *Id.* at 3.

A.49 Dr. Resnikoff stated that he has no independent expertise concerning hazards posed by aviation activities to facilities on the ground. PFS Findings at 9; Tr. at 8719-20 (Resnikoff). He has no background in aeronautical engineering or in analyzing the performance of military aircraft. Tr. at 8717-18 (Resnikoff). Prior to this case, he has not calculated the probability of an aircraft impacting a particular site on the ground. PFS Aircraft Findings at 9; Tr. at 8719-20 (Resnikoff). Likewise, prior to this case, he has not performed studies or work pertaining to the probability of impacts of external events to facilities. Tr. at 8806 (Resnikoff).

A.50 With respect to Dr. Resnikoff's expertise in the field of probability and statistics, he has not had formal training in statistics, although he considers himself a self-taught statistician and has applied elementary statistics in past assignments. Tr. at 8817 (Resnikoff).

A.51 We consider Dr. Resnikoff to be qualified to testify as an expert with respect to the calculations he performed using the NUREG-0800 equation to derive the probability of aircraft crashes at the Applicant's proposed facility and in the general techniques of mathematical analysis.

A.52 The testimony of Colonel Frank Bernard, USAF (Ret.), was also sponsored by the State of Utah. Tr. at 3880 (Bernard). Colonel Bernard's testimony, like that of Colonel Cosby, was not prefiled but was presented in person and was submitted in response to the Board's inquiry as to conflicting testimony regarding pilot ejections.

A.53 Colonel Bernard served in the Air Force from 1967 to 1972, as well as in the Air Force Reserve from 1972 until 1993. Tr. at 3881 (Bernard). During this time, he accumulated approximately 1200 flight hours in the F-16 and approximately 3500 total aircraft flight hours. Tr. at 3881-82 (Bernard). Colonel Bernard has flown the F-105, the D-29, the D-39, and the F-16. Tr. at 3881 (Bernard). He ejected from an aircraft twice in his career: (1) from an F-105 aircraft that had been damaged in a 1969 midair collision in Southeast Asia, and (2) from an F-16 that suffered an engine failure during a military exercise in Canada in 1986. Tr. at 3882-83, 3888-89 (Bernard). Colonel Bernard is also familiar with Hill AFB because he was stationed there from 1973 until his retirement. Tr. at 3881 (Bernard).

A.54 We find Colonel Bernard to be qualified in the area of F-16 operations, including the ejection experience.

4. Aircraft Operations in Skull Valley

A.55 The Board had before it a comprehensive report on the potential hazards posed to the facility by military aircraft and jettisoned ordnance. The report was submitted as PFS Exhibit N, Aircraft Crash Impact Hazard at the Private Fuel Storage Facility,' Revision 4 (Aug. 10, 2000) [hereinafter Aircraft Crash Report], and PFS Exhibit O, the Revised Addendum to the Aircraft Crash Report [hereinafter Revised Addendum]. The Revised Addendum also contains the Applicant's responses to a series of Requests for Additional Information (RAIs) from the NRC Staff regarding aircraft crash hazards. The report and its addendum were principally prepared by the Applicant's expert witnesses on aviation hazards, Brigadier General James L. Cole, Jr., USAF (Ret.), Major General Wayne O. Jefferson, Jr., USAF (Ret.), and Colonel Ronald E. Fly, USAF (Ret.).

A.56 Aviation activity in the vicinity of the Applicant's site consists of, in addition to civilian commercial and general aviation, military operations associated with the Utah Test and Training Range, an important training range operated by the Department of Defense. *See* LBP-01-19, 53 NRC at 432; State Exh. 41 [hereinafter UTTR Capabilities Guide]; Horstman Post Tr. 4214, at 4-5. This range and the associated airspace, which is even larger than the ground footprint, are used for aircrew training and weapons testing. State Exh. 41. UTTR Capabilities Guide; Horstman Post Tr. 4214, at 4-5. Missions on the UTTR include air-to-air and air-to-ground combat training, both day and night as well as low and high altitude. UTTR Capabilities Guide; Horstman Post Tr. 4214, at 4-5.

A.57 The airspace over the UTTR extends somewhat beyond the range's land boundaries and is divided into restricted areas, in which the airspace is limited to military operations, and military operating areas (MOAs), which are located on the edges of the range, adjacent to the restricted areas. Horstman Post Tr. 4214, at 4-5. The Applicant's site lies within the Sevier B MOA, 2 miles to the east of the edge of the UTTR restricted airspace, and 18 miles east of the eastern UTTR land boundary. *Id.*

A.58 The airspace directly above the Applicant's proposed site, extending from 100 feet to 5000 feet above ground level, is within Sevier B MOA. *Id.* The location of Sevier B MOA relative to the Applicant's site is shown on State Exh. 186. Sevier B is part of the UTTR airspace and various portions of it are used for military low-altitude training, air-to-air combat training, major exercises, and cruise missile testing. Horstman Post Tr. 4214, at 4-5.

A.59 The airspace directly above the Applicant's site also contains an MOA known as Sevier D, extending from 5000 feet to 13,750 feet above the ground. *Id.* at 5. Sevier D is also part of the UTTR airspace and major exercises as well as cruise missile testing are authorized in various portions of this MOA. *Id.*

A.60 Military air operations posing a potential risk to the Skull Valley facility include (1) Air Force F-16 fighter aircraft transiting Skull Valley from Hill Air Force Base to the UTTR South Area; (2) F-16s from Hill AFB returning from the UTTR South Area to the base via the Moser Recovery Route, which runs to the northeast, 2 to 3 miles north of the Applicant's site; (3) military aircraft, comprised mainly of large transport aircraft, flying on military airway IR-420 to and from Michael AAF, which is located on Dugway about 17 miles southeast of the Applicant's site; (4) F-16s from Hill and various other military aircraft conducting training exercises on the UTTR; and (5) jettisoned ordnance from aircraft flying over Skull Valley. LBP-01-19, 53 NRC at 432.

A.61 Civilian aircraft also will be flying in the general area of the Applicant's site, including: (1) aircraft flying on Federal Airway J-56, which runs east-northeast to west-southwest about 12 miles north of the Applicant's site; (2) aircraft flying on Airway V-257, which runs north to south approximately 20 miles east of the site; and (3) other minimal general aviation activity, which has

not been reported but nonetheless could occur in the area. We have previously ruled on the extent of the minimal hazard to the facility posed by commercial and general aviation. LBP-01-19, 53 NRC at 449-52. The cumulative potential hazard to the facility is calculated from the sum of the probabilities of hazards from both civilian aviation and military activity. *Id.* at 452-54.

A.62 During recent years, F-16 fighter aircraft stationed at Hill Air Force Base have regularly transited Skull Valley in a southerly direction through Sevier B and Sevier D MOAs enroute to the UTTR South Area range. Horstman Post Tr. 4214, at 6-8; Tr. at 3455 (Jefferson). Most of the flights through Skull Valley are in Sevier B MOA, and are concentrated in a corridor in the vicinity of the Applicant's proposed site. Horstman Post Tr. 4214, at 6-8; Tr. at 3455 (Jefferson). These F-16s conduct low-altitude training, perform G(ravity) awareness turns, practice terrain masking (radar avoidance), and engage in other training maneuvers while transiting Skull Valley. Horstman Post Tr. 4214, at 8-9.

A.63 The military activity in the Sevier B and Sevier D MOA airspace varies from year to year. The number and type of missions flown as well as the number and type of bombs and other ordnance carried depend on Air Force tactics and training needs, national policy, budgets, and the state of world conflict. *Id.* at 5; Tr. at 3352-55, 3494 (Jefferson). It is difficult to anticipate changes in the level of military training in the UTTR and MOAs. The F-16 fighter has been flying for over 27 years and is scheduled to be replaced by year 2010. Tr. at 3367 (Jefferson), 3372 (Cole). The Board has before it no definitive evidence as to the nature of future Skull Valley training missions or weapon systems after the F-16 is retired.

A.64 The Applicant received information from Hill AFB indicating that F-16 fighter aircraft transiting Skull Valley enroute from Hill AFB to the UTTR South Area typically pass to the east of the facility's site. Cole/Jefferson/Fly Post Tr. at 3061, at 14; Campe/Ghosh Post Tr. 4078, at 9; Tr. at 3397-98, 3402-04 (Cole); *see* Tr. at 3422-24 (Fly). The F-16s typically fly through the Sevier B MOA, between 3000 and 4000 feet above ground level (AGL), with a minimum altitude of 1000 feet AGL.¹³⁸ Cole/Jefferson/Fly Post Tr. 3061, at 14; Campe/Ghosh Post Tr. 4078, at 9; Tr. at 3396-97, 3404 (Cole); Tr. at 4356-57, 4369 (Horstman). A few aircraft fly higher, through Sevier D MOA, between approximately 5000 feet AGL and 14,000 feet AGL. Cole/Jefferson/Fly Post Tr. 3061, at 14. It is unusual

¹³⁸ On August 13, 2002, the Staff notified us that the Air Force had lowered from 1000 feet to 100 feet above ground level the minimum altitude for flights in Sevier B MOA at the location of the Applicant's site. The Applicant's Aircraft Crash Report relied on the previous minimum altitude of 1000 feet AGL over the facility's site. *Aircraft Crash Impact Hazard at the Private Fuel Storage Facility* (Aug. 10, 2000) ("Aircraft Crash Report") (PFS Exh. N) at 6. No party sought to reopen the record or to have us take any other action exploring the significance, if any, of this development. *See also* Staff letter of December 19, 2002, and its enclosures.

for aircraft to fly through Skull Valley at altitudes above 14,000 feet AGL (18,000 feet mean sea level). Tr. at 4372-73 (Horstman). Aircraft fly through Skull Valley at approximately 350 to 400 knots indicated airspeed (KIAS). Cole/Jefferson/Fly Post Tr. 3061, at 14.

A.65 The Applicant asserts that in FY 1999 and FY 2000, an average of approximately 5000 F-16 flights transited Skull Valley per year. *Id.* at 14 & n.10; Campe/Ghosh Post Tr. 4078, at 10. Because 12 F-16s were added to the 69 aircraft stationed at Hill AFB in the third quarter of FY 2001, the Applicant estimated through extrapolation that approximately 5870 flights per year will transit Skull Valley during the life of the facility. Cole/Jefferson/Fly Post Tr. 3061, at 20-21. This estimate was made by increasing the 5000 annual flights by 17.4% to account for the additional F-16s. *Id.* at 16, 20-21. The Applicant's witnesses asserted that the continuing modernization and increased technological capability of newer military aircraft will likely result in fewer aircraft and a reduction in annual sorties over the life of the facility. *Id.* at 22-23.

A.66 F-16s use the airspace above Skull Valley primarily as a transition corridor to the UTTR. *Id.* at 15; Campe/Ghosh, Post Tr. 4078, at 11. Typically F-16s will start a descent after turning south from over the Great Salt Lake and descend below 5000 feet AGL before entering the Sevier B MOA. Cole/Jefferson/Fly Post Tr. 3061, at 15; Campe/Ghosh Post Tr. 4078, at 11. They typically fly in pairs that spread out in a tactical formation which may be 1 to 2 miles across. Cole/Jefferson/Fly Post Tr. 3061, at 15; Campe/Ghosh Post Tr. 4078, at 11. The typical maneuvers that F-16s may undertake while transiting Skull Valley are part of what is referred to as the "normal phase" of flight in that it consists of activities like operations checks (to see if the aircraft is functioning properly), G-awareness turns (to ensure that the pilots' flight suits are functioning properly and to prepare the pilots to take higher G-forces in more aggressive maneuvering on the range (Aircraft Crash Report, Tab FF at 16-17; Tr. at 3523-24, 13,030 (Fly); Tr. at 13,032 (Cole)), and "fence checks" (to simulate flying from friendly airspace into enemy airspace). Aircraft Crash Report, Tab E at 3; Tr. at 3522-24 (Fly). Air-to-air combat training does not take place in Skull Valley itself. Tr. at 4242-43 (Horstman).

5. NUREG-0800 Applicability and Methodology

A.67 A document known as NUREG-0800 contains the portion of the "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" applicable to the review and evaluation of aircraft hazards. Campe/Ghosh Post Tr. 4078, at 5.

A.68 The formula for calculating aircraft crash probability for nuclear facilities is set forth in NUREG-0800 § 3.5.1.6-3 as:

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

C = inflight crash rate per mile for aircraft type,

N = number of flights per year along the airway,

A = effective area of the facility in square miles,

w = width of airway in miles.

Resnikoff Post Tr. 8698, at 5-7; PFS Exh. RRR [hereinafter NUREG-0800].

A.69 As described in NUREG-0800 § 3.5.1.6, “Aircraft Hazards,” the Staff uses probabilistically based screening criteria in determining the acceptability of an aircraft hazard with respect to a nuclear facility site. Campe/Ghosh Post Tr. 4078, at 5-6; *see* NUREG-0800 § 3.5.1.6. The Staff reviews an applicant’s assessment of aircraft hazards to a facility and determines whether those hazards should be incorporated into the facility’s design bases. Campe/Ghosh Post Tr. 4078, at 6; NUREG-0800 at 3.5.1.6-1.

Against this background, we turn in Subparts B and C to the detailed analysis and findings underlying our resolution of the major factual disputes that came before us.

B. Determination of R Factor — “Pilot Avoidance”

In this subpart, we portray in some detail the arguments and evidence that the respective parties put forward. As observed in our Narrative Opinion, this was the most critical issue before us, and we are resolving it essentially on the basis that the Applicant had not carried the burden of proof on its claim of near certain success in human performance under stress-filled conditions.

The reason that claim was unproven was not so much because of any specific showing by the State on a particular, narrow factual issue. Rather, it was because the evidence the State presented — covering a number of different problem areas — created a record wherein the preponderance of the evidence did not support, and indeed substantially undercut, the Applicant’s assertion that pilots would, before ejecting, almost invariably (95% of the time) act affirmatively to guide their aircraft away from striking the PFS facility in the event of an impending crash.

That being the case, in this subpart we do not articulate a Board position on each individual factual issue contested by the parties. Rather, we devote considerable attention to analyzing the record evidence and the parties’ arguments in some detail, then find generally that in view of the totality of the evidence presented by the State, the Applicant has not sustained its claim that pilots will

successfully avoid the site in virtually every instance. The powerful countering evidence about human error, under stress, leading to failure, carries the day.

In some instances, the material related herein covers the same ground as did the Narrative, but in more detail. To the extent that repetition therefore exists, the alternative was to expand the Narrative to include the additional details, at the expense of interfering with the flow of the Narrative's reasoning.

B.1 We begin by restating the issue. The Applicant took the position that a pilot's potential ability to avoid hitting the site in the event of a crash reduced the crash impact probability, determined by the four-factor formula, by 85.5%. Cole/Jefferson/Fly Post Tr. 3061, at 17-18. The probability that a pilot would avoid the site in the event of a crash is equal to the product of (1) the probability that a pilot would be in control of the aircraft with time to maneuver it away and (2) the probability that, given those conditions, the pilot would actually direct the aircraft away from the site before ejecting. Tr. at 3769-70 (Cole); Cole/Jefferson/Fly Post Tr. 3061, at 17.

B.2 In calculating the value for *R*, the Applicant first considered the percentage of accidents that could occur in Skull Valley that would leave a pilot in control of the aircraft after the event. Cole/Jefferson/Fly Post Tr. 3061, at 17. This factor, *R1*, as derived by the Applicant, was estimated to be 90%. *Id.* The Applicant then considered the percentage of the time in which the pilot would indeed direct a controllable aircraft away from the Applicant's facility. This factor, *R2*, as opined by the Applicant, was estimated to be 95%. *Id.*

B.3 The Applicant multiplied *R1* by *R2* to determine the percentage of crashing F-16s that would avoid the facility. *Id.* Thus, the Applicant considered that 85.5% (90% × 95%) of the crashing F-16s would avoid the facility. The calculated crash probability to the facility was accordingly reduced by using a value for the *R* factor in the equation of 14.5% (equal to 100% minus 85.5%). *Id.* at 18.

We provide below an outline of the many subissues involved in reaching our overall verdict that the "95% pilot avoidance" theory was unproven.

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With that outline in place, we set out below the body of evidence and arguments that underlay the decision we reached in the Narrative.

1. Estimate of RI Value

B.4 The factor *RI* represents the fraction of potential accidents in which a pilot would have sufficient time and control of the aircraft to direct the aircraft away from a fixed ground site in Skull Valley. *Cole/Jefferson/Fly Post Tr. 3061*, at 17. The Applicant's analysis indicated that a pilot whose aircraft was experiencing an in-flight emergency would have sufficient time and control to avoid the Applicant's facility approximately 90% of the time. *Id.* This determination was based on the Applicant's expert panel's review of accident reports obtained from the Air Force. *Id.*

B.5 These accident reports were prepared after each aircraft mishap under Air Force Instruction (AFI) 51-503, which directs investigators to determine the cause of the accident, to preserve all available evidence; to provide a complete factual summary for use in claims, litigation, disciplinary actions, adverse administrative proceedings, and for other purposes in accordance with AFI 51-503. *Id.* at 10. The reports follow a set format which describes 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. *Id.* The flight activity section provides relevant information as to pilot actions after the emergency begins. *Id.* Each report may conclude with a statement of opinion by the investigating officer as to the cause of the accident. *Id.* The reports are prepared by an accident investigation board typically chaired by a Colonel and comprised of subject matter experts, including pilots of the relevant aircraft type. Tr. at 3659-60 (Cole); *see* Tr. at 4033-38, 4041-42 (Cole); Tr. at 4038-40 (Fly); Tr. at 4040 (Jefferson).

B.6 The Applicant obtained 126 Air Force F-16 Class A mishap accident reports for the period from FY 1989 to FY 1998. Cole/Jefferson/Fly Post Tr. 3061, at 10. These accident reports consisted of mishaps involving 121 destroyed aircraft. *Id.* at 17. Even though the Applicant reviewed 126 Class A mishap reports, five reports were eliminated from consideration on the basis that only crashes involving destroyed aircraft would be considered, a total of 121. Aircraft Crash Report, Tab H at 3-4. One of the crash reports eliminated was the F-16 flight of December 19, 1991, that disappeared after takeoff and was never heard from. Tr. Part 2, at 27-28 (Fly). PFS witness Fly testified that the F-16 was “probably” destroyed but nevertheless was not considered in the 121 crashes reviewed. *Id.*

B.7 Each of the three Applicant’s experts independently assessed each accident report in accordance with established evaluation parameters. Cole/Jefferson/Fly Post Tr. 3061, at 58. This individual review was followed by a joint review that resolved the few differences that resulted from their individual assessments based on their combined professional judgment. *Id.* at 58-59; Aircraft Crash Report, Tab H at 6-7.

B.8 General Cole, General Jefferson, and Colonel Fly evaluated each destroyed-aircraft accident report to assess and determine: (1) the phase of flight in which the accident occurred, (2) the cause of the accident, (3) whether the pilot had sufficient time and control of the aircraft to be able to avoid a ground site, (4) whether the accident was caused by an event that could have occurred during the operations conducted in Skull Valley (a Skull Valley-type event), and (5) whether the accident occurred under flight conditions representative of the

Sevier B MOA (a Sevier B MOA event). Cole/Jefferson/Fly Post Tr. 3061, at 58. The categorization of the accident reports enabled the expert panel to draw conclusions therefrom. *See id.* at 58-59.

B.9 Following this process, the Applicant's expert panel categorized each accident as (a) one that could or could not have occurred in Skull Valley (i.e., "Skull Valley-type events") and (b) one in which the pilot did or did not have control of his aircraft and time to direct it away from a site on the ground (i.e., "able to avoid"). *Id.* The Applicant's assessment of whether the accident could have occurred in Skull Valley was based on whether the initiating accident event could have occurred in Skull Valley. Aircraft Crash Report, Tab H at 11-12; *see id.* at 14-16; Tr. at 3957 (Fly). Thus, for example, engine failures, in almost all cases, would be Skull Valley-type events. Aircraft Crash Report, Tab H at 8, 11-12. On the other hand, midair collisions during mock dogfighting would not (since such dogfighting does not take place in Skull Valley). *Id.* at 8; Tr. at 3856-60 (Fly).

B.10 The Applicant's assessment of whether the pilot was in control and would have time to direct his aircraft away from the facility was based on the specific information in the F-16 accident reports regarding each accident. Cole/Jefferson/Fly Post Tr. 3061, at 59-60; Aircraft Crash Report, Tab H at 10-11. An engine failure is by far the most likely cause of an accident in Skull Valley and, in every case of engine failure, the Applicant assessed that the pilot would have control and time to avoid a site on the ground. Cole/Jefferson/Fly Post Tr. 3061, at 17; Tr. at 3770 (Cole).

B.11 The Applicant initially found that sixty-one accidents during the 10-year period were Skull Valley-type events and in fifty-eight of them, or 95%, the pilot retained control of the aircraft with time to direct it away from a site on the ground. Tr. at 13,007 (Jefferson); *see* Cole/Jefferson/Fly Post Tr. at 3061, at 81, 88; Aircraft Crash Report, Tab H at 14-20. Nevertheless, the Applicant assumed that the fraction of accidents that would leave a pilot in control of the aircraft and able to avoid a site on the ground was only 90%. Cole/Jefferson/Fly Post Tr. at 3061, at 17; Tr. at 3770 (Cole); Tr. at 3214, 13,007 (Jefferson).¹³⁹ Under the

¹³⁹The Applicant performed an assessment where it evaluated only those accidents that occurred under parameters, such as speed and altitude, at which pilots fly in the Sevier B MOA ("Sevier B MOA flight conditions"). Tr. at 3959 (Fly); Cole/Jefferson/Fly Post Tr. 3061, at 58-60. Those accidents made up a subset of the Skull Valley-type events. The Applicant performed the assessment to evaluate if anything peculiar to the Sevier B MOA flight environment would change its conclusion regarding the fraction of accidents that would leave the pilot in control with the time to attempt to avoid a site on the ground. Nothing did. Tr. at 3959 (Fly); Cole/Jefferson/Fly Post Tr. 3061, at 58-60. The Applicant performed a third assessment in which it assessed all of those accidents that occurred in the "normal" phase of flight (as opposed to special operations, takeoff, and landing), which was also a subset of the Skull Valley-type events, to evaluate whether consideration of the phase of flight

(Continued)

approach taken by the Applicant, this assumption would make room for as many as three more Skull Valley-type crashes in which the pilot was considered not to be in control without affecting the *RI* percentage being advanced.

B.12 The State saw the reports differently. It pointed out that General Jefferson testified that in 42% of the 121 crashes reviewed, the pilot did not have control of the aircraft such that the pilot could avoid the Applicant's site even if he so desired. Tr. at 3817 (Jefferson); PFS Exh. X. Therefore, only 58% of the overall universe of crashes could have resulted in the pilot retaining control of the aircraft.

B.13 The higher percentage (90%) of controllable aircraft used by the Applicant is based on eliminating 60 of the 121 destroyed-aircraft reports which the Applicant "found not to be relevant to Skull Valley." Aircraft Crash Report, Tab H at 8, 15.

B.14 The State asserts that the Applicant excluded many accidents from consideration by incorrectly concluding that the accident could not have occurred in Skull Valley. Horstman Post Tr. 4214, at 31. In this regard, the State contends that the Applicant incorrectly excluded: (1) accidents that occurred at altitudes higher than 5000 feet AGL, (2) accidents that took place while the aircraft was flying under instrument flight rules, (3) accidents caused by midair collisions, (4) accidents caused by G-induced loss of consciousness, (5) accidents caused by bird strikes, (6) accidents caused by lightning strikes, and (7) accidents caused by poor visibility due to cloud cover. Horstman Post Tr. 4214, at 31. During his deposition, the State's witness, Lt. Colonel Horstman, identified six accidents that he contends the Applicant improperly excluded from the Skull Valley-type event category. In his prefiled testimony and at the hearing, the State's witness identified two additional accidents with which he disagrees, for a total of eight accidents. *Id.*; Tr. 4449-51, 4481-83 (Horstman). Five of the eight accidents were discussed during the hearing, and we turn to them now.

a. High Altitude

B.15 First, the State claims that the Applicant improperly excluded high-altitude accidents, such as the March 16, 1990 accident, from the Skull Valley-type event category, on the basis that they occurred above 5000 feet AGL. Horstman Post Tr. 4214, at 31; Tr. at 4449-51, 4481-83 (Horstman). However, the Applicant asserts that it did not exclude the March 16, 1990 accident on the basis of altitude; rather, it was excluded from the Sevier B MOA category. Tr. at 13,091-92 (Jefferson). Colonel Fly explained that the accident was excluded based on: (1)

would change its conclusion regarding the fraction of accidents that would leave the pilot in control with the time to attempt to avoid a site on the ground. It did not. Tr. at 3860-64 (Fly/Jefferson); Tr. at 3958-59 (Fly); Cole/Jefferson/Fly Post Tr. 3061, at 58-60.

an abnormal combination of airspeed (90 knots) and altitude (nearly 27,000 feet AGL) that would not likely occur in Skull Valley; and (2) the engine that failed was an engine that experienced operational abnormalities when flown at high altitudes and low airspeed and is no longer used in F-16s flown today. Tr. at 13,093-95 (Fly).

B.16 Therefore, the Board finds that the Applicant did not exclude this accident from the broader Skull Valley-type event category on the basis that it occurred at high altitude. Thus, we find that the Applicant's exclusion of this accident was reasonable.

b. Instrument Flight Rules

B.17 The State claims that the Applicant improperly excluded accidents that took place under instrument flight rules from those events that could occur in Skull Valley. Horstman Post Tr. 4214, at 31. When questioned on two separate occasions during the hearing, however, the State's witness could not recall which specific accidents the Applicant had excluded on this basis. Tr. at 4423-24, 8510 (Horstman). The Applicant asserts that it did not exclude any accidents simply because they may have occurred while flying under instrument flight rules. Tr. at 13,091-92 (Jefferson).

B.18 We find that the Applicant did not exclude accidents from the Skull Valley-type event category solely on the basis that they took place while the aircraft was flying under instrument flight rules.

c. Midair Collisions

B.19 The State claims that the Applicant improperly excluded accidents involving midair collisions from those events that could have occurred in Skull Valley. Horstman Post Tr. 4214, at 31. In this regard, Lt. Colonel Horstman testified that the September 16, 1997 accident involved a midair collision that occurred after takeoff and while the pilots were preparing for a night-vision-goggle training mission. *Id.* He testified that pilots conduct night-vision-goggle training in Skull Valley, and, therefore, a midair collision similar to this accident could occur in Skull Valley. *Id.* at 32.

B.20 Lt. Colonel Horstman was not aware of any other accidents involving midair collisions that the Applicant improperly excluded. Tr. at 8510 (Horstman). However, to the extent that he took issue with any such evaluation, his disagreement is reflected in Table 1. Tr. at 8510 (Horstman).

B.21 The Applicant reclassified this accident as a Skull Valley-type event accident. Cole/Jefferson/Fly Post Tr. 3061, at 79. Therefore, the State and the Applicant are in accord with respect to the Skull Valley-type event categorization of this accident. The Applicant, however, continues to maintain that the accident

is not a Sevier B MOA event because the accident took place at 14,000 feet AGL. *Id.* at 80; *see* PFS Exh. 195 (accident report). We find that because the accident took place at 14,000 feet AGL, it was properly excluded from the Sevier B MOA event category.

d. G-LOC

B.22 The State also asserts that pilots may suffer loss of consciousness (GLOC) when conducting G-awareness turns in Skull Valley. Horstman Post Tr. 4214, at 17. G-awareness turns can induce loss of consciousness when gravity pulls blood toward the lower extremities, carrying oxygen away from the brain. Tr. at 13,029-30 (Fly).

B.23 The Applicant, however, asserts that G-awareness turns do not present significant risks to pilots. Tr. at 13,030-31 (Fly/Cole).

B.24 The State also asserts that G-induced loss-of-consciousness accidents can occur in Skull Valley due to other maneuvers besides the G-awareness turns. Horstman Post Tr. 4214, at 32. Lt. Colonel Horstman discussed the accident of May 25, 1990, which he asserted was caused by GLOC, in claiming that accidents arising from GLOC could occur in Skull Valley. *Id.* He pointed to no F-16 accidents caused by GLOC, however, that the Applicant improperly excluded from its analysis. Tr. at 4297-99 (Horstman).¹⁴⁰

B.25 The Applicant argues that neither the evidence in the record nor the official Air Force records support Lt. Colonel Horstman's claim that the May 25, 1990 accident was caused by GLOC. Furthermore, Colonel Fly, who has significant experience instructing pilots on the effects of G-forces, testified that he knew of no one who had suffered GLOC in a G-awareness turn similar to those performed in Skull Valley. Tr. at 13,026-31 (Fly). Nor did the Chief of Safety of Air Combat Command. Tr. at 13,031-32 (Cole).

B.26 We find that the evidence in the record supports a finding that G-awareness turns are not high-risk maneuvers, and that it is unlikely that a pilot will lose consciousness during a G-awareness turn. *See* Aircraft Crash Report, Tab F. We find that regardless of whether the May 25, 1990 accident was caused by G-induced loss of consciousness, the Applicant *included* this accident in the Skull Valley-type event category and in the Sevier B MOA category. *See* Cole/Jefferson/Fly Post Tr. 3061, at 63. Since Lt. Colonel Horstman testified that this was the only accident in which G-induced loss of consciousness was at issue, we find that the Applicant's inclusion of this accident as both a Skull Valley-type

¹⁴⁰In this respect, the Applicant included the May 25, 1990 accident in its analysis as a Skull Valley-type event on a different rationale. Cole/Jefferson/Fly Post Tr. 3061, at 63-64. The Applicant assessed the accident as having been caused by the pilot's loss of situational awareness while at low altitude. Aircraft Crash Report, Tab H at 18.

event and a Sevier B MOA event renders the State's concern with respect to this accident irrelevant. Further, we find it highly unlikely that a pilot in Skull Valley would experience G-induced loss of consciousness.

e. Bird Strikes

B.27 The State asserts that the Applicant improperly excluded accidents caused by bird strikes from those accidents which could have occurred in Skull Valley. Horstman Post Tr. 4214, at 31. Lt. Colonel Horstman stated that the F-16 canopy is designed to withstand a bird strike of 4 pounds at 350 knots, but that pilots typically fly at 400 to 450 knots through Skull Valley. *Id.* at 32. The State's expert testified that the May 13, 1998 accident that involved a mishap caused by birds impacting the aircraft (*id.*) was the only accident in which the Applicant improperly excluded an accident on the basis of a bird strike. Tr. at 4531-32, 8512 (Horstman).

B.28 Of the arguments offered by the Applicant, we find the absence of flocks of large birds in Skull Valley near the proposed facility and the history of bird strikes in the area to be the most compelling. Cole/Jefferson/Fly Post Tr. 3061, at 87. On the basis of the absence of flocks of large birds in Skull Valley near the proposed facility (Campe/Ghosh Post Tr. 4078, at 13-14) the history of bird strikes in the area (Cole/Jefferson/Fly, Post Tr. 3061, at 87) and the practice of mission planners at Hill AFB to avoid birds if they are reported (Campe/Ghosh Post Tr. 4078, at 13-14), we find that bird strikes are not reasonably likely to occur in Skull Valley and are not a significant contributor to risk. Therefore, we find that the Applicant's exclusion of the May 13, 1998 accident from the Skull Valley-type event category is acceptable.

f. Lightning Strikes

B.29 The State asserts that the Applicant improperly excluded from the Skull Valley-type event category accidents that occurred due to lightning strikes. Horstman Post Tr. 4214, at 31. Lt. Colonel Horstman testified that it is reasonably foreseeable that a pilot will at some time fly in lightning and that he has personally flown in lightning. *Id.* at 33.

B.30 The Applicant, for its part, asserts that it did not exclude any accidents on the basis that they were caused by lightning strikes. Tr. at 13,092 (Jefferson). In fact, the Applicant notes that the accident of January 15, 1991, was caused by lightning and was included in the Skull Valley-type event category. Tr. at 13,092 (Jefferson); *see* also PFS Exh. X (Table 1).

B.31 We find the Applicant's characterization of this accident to be acceptable.

g. *Cloud Cover*

B.32 The State asserts that the Applicant incorrectly excluded accidents caused by poor visibility due to cloud cover. Horstman Post Tr. 4214, at 31. Lt. Colonel Horstman testified, however, that he could not identify any accident reports that were omitted from the Skull Valley-type events category because of poor visibility due to cloud cover. Tr. at 8519 (Horstman). If there were any such accidents, they would be reflected in his markup of Table 1. Tr. at 8519 (Horstman).

B.33 Our analysis of those accident reports in which the State disagrees with the Applicant's assessment did not reveal any accidents excluded on the basis of cloud cover. The role of cloud cover does, however, become important in our discussion of R2 below.

B.34 Of the remaining crash reports considered by PFS to be Skull Valley events, the Applicant determined that fifty-nine represented crashes where the aircraft remained controllable with sufficient time to avoid a fixed site on the ground. Aircraft Crash Report, Tab H at 20, Table 4. Taking issue with the Applicant's categorization of the crashes, the State points out that in that group of fifty-nine crash reports, five reports show the pilot ejected during an uncontrolled spin or the aircraft was otherwise uncontrollable. PFS Exhs. 113, 118, 124, 145, 147; State Exh. 223 at entries 8, 19, 20, 46, 53. Also within that group of fifty-nine crash reports, argues the State, are eleven reports that show the F-16 was on fire when the pilot ejected. PFS Exhs. 110, 113, 118, 119, 127, 145, 147, 158, 180, 184; Joint Exh. 4; State Exh. 223 at entries 3, 8, 10, 17, 19, 21, 24, 38, 46, 53, 59. The State further argues that the determination of 90% for crashes in which the aircraft is controllable is inconsistent with the evidence that engine failure is the most likely cause of a crash where the pilot retains control and the evidence that only 36% of F-16 Class A accidents are engine failures according to the manufacturer, Lockheed Martin. Aircraft Crash Report at 17b; State Exh. 56; State Findings ¶ 67.

B.35 In response, both the Applicant and the Staff argue that none of the five reports identified by the State represents a situation where the aircraft was uncontrollable. PFS Reply ¶¶ 66-71; Staff Reply ¶¶ 78-84. Both the Applicant and Staff have examined each of the five reports cited by the State and explain in some detail why the aircraft was controllable. *See id.*

B.36 After examining all five reports, we agree with the Applicant and Staff that, although at some point in each of these five accidents the aircraft might have been uncontrolled, in each instance the pilot had control for a sufficient time to take avoidance action. In one instance, the pilot actually turned the aircraft to avoid a building. *See* PFS Exh. 145. In another, the pilot completed his checklist procedures, as well as turned toward an airbase before being forced to eject. *See*

PFS Exh. 118. In a third, the pilot had over 4 minutes in which to maneuver the aircraft after the emergency began. *See* PFS Exh. 124.

B.37 Accordingly, we agree with the Applicant and Staff that the five disputed reports were properly categorized as “in control.”

B.38 As to the eleven reports in which the State asserts that fire was involved (four of which overlap with the five reports involving assertedly uncontrolled aircraft), the Applicant disputes the State’s characterization of these accidents. PFS Reply ¶74. The Applicant described in some detail for each of the eleven reports why it considered the aircraft to still be controllable. PFS Reply ¶¶74-87. For its part, the Staff points out that in several of the eleven accidents in which fire was reported, the pilot took action to avoid a ground object. Staff Reply ¶85. In that regard, the Staff asserts that not all fires would cause an F-16 to become uncontrollable. Staff Reply ¶85.

B.39 We agree with the Applicant and Staff that careful examination of the reports indicates that a plane on fire is not necessarily uncontrollable in the sense being used here. Thus, four of the reports indicate that the pilot had 2 minutes or more in which to steer the plane away from a ground site. *See* PFS Exhs. 110, 119, 158, 180. Moreover, in several instances the pilot steered away from a specific ground site or a populated area before ejecting. *See* PFS Exhs. 119, 145, 158. Our examination of the eleven reports allows us to find that the pilot had enough time in control to take avoidance action. Therefore, we find that the Applicant and Staff properly categorized the above accidents as ones in which the pilot was in control for that purpose. In any event, as many as three of the disputed accidents could be recharacterized as “not in control” without affecting the validity of the Applicant’s 90% *R1* proposal. *See* Finding B.11, above.

2. Estimate of R2 Value

a. Eight-Factor Assessment of Probability of Pilot Avoidance

B.40 Based on their professional judgment as experienced Air Force pilots, rather than on an examination of the accident reports, the Applicant’s panel assessed the value of *R2* — the probability that a pilot in control of his aircraft following an in-flight emergency would actually avoid the site — to be 95%. Cole/Jefferson/Fly Post Tr. 3061, at 17; Aircraft Crash Report at 18-23; Tr. at 3215-16 (Jefferson). The assessment was based on: (1) the time the pilot would typically have based on Air Force data concerning F-16 performance in the event of an engine failure, i.e., one minute or more; (2) the pilot’s ability to fly the aircraft and attempt to restart the engine or otherwise respond to the emergency; (3) the very slight turn required to actually avoid the site; (4) the training that pilots receive to avoid inhabited or built-up areas on the ground; (5) the familiarity of the pilots at Hill AFB with the location of the facility, which will be prominently visible and whose location will be noted, along with other

nuclear facilities, in Defense Department aviation planning guides; (6) the wide open spaces around the facility, to which a pilot could safely direct his aircraft; (7) predominantly good weather and visibility in Skull Valley; and (8) the F-16 flight control computer that will keep the F-16 on a straight course after the pilot ejects. These eight factors are discussed in detail below.¹⁴¹

B.41 The State asserts that the component value of 95% used by the Applicant is a purely subjective determination made collectively by Applicant's witnesses General Jefferson, General Cole, and Colonel Fly. State Findings ¶ 69. The State points out that none of the Applicant's witnesses who determined the component value of 95% have ever ejected from an F-16. Tr. at 3216 (Jefferson), 3217 (Fly). Neither General Cole nor General Jefferson has ever piloted an F-16. Tr. at 3142 (Cole); Tr. at 3189 (Jefferson). In addition, the determination of 95% was made without performing any statistical calculations, and was made prior to reviewing the F-16 accident reports. Tr. at 13,109-10, 13,121-22 (Jefferson).

B.42 The State further posits that this 95% component represents the percentage of time that a pilot will be successful, during an engine failure emergency, in performing emergency procedures including: (1) attempting to restart the engine, (2) locating the Applicant's site which will be 3.22 miles or more away at the time of ejection, (3) directing the aircraft away from the Applicant's site while also directing the aircraft way from any populated areas, and (4) ejecting at or above the minimum altitude of 2000 feet AGL. *See* State Findings ¶ 70.

B.43 Although the Applicant's expert panel based the 95% R2 value on eight contributing factors, the State focused its efforts on challenging the Applicant's assessment of three of those factors, apparently based on General Jefferson's statement that the time available, pilot training, and visibility of the PFS facility were the determining factors. *See* Tr. at 8882 (Jefferson).

(1) TIMING

B.44 The Applicant assessed that in the event of an engine failure, which would be by far the most likely accident leaving the pilot in control of the aircraft, an F-16 pilot transiting Skull Valley would have approximately 1 minute or more to respond to the emergency and potentially avoid a site on the ground before having to eject at the recommended altitude of 2000 feet AGL. Aircraft Crash Report, Tab U at 19c-19e; PFS Findings ¶ 15. All parties agree that in an emergency caused by engine failure leaving the F-16 controllable, the pilot will "zoom" the aircraft, which is a climb to trade speed for altitude, and will discard all fuel tanks, and bombs and other weapons, known as jettison of stores. Horstman Post Tr. 4214, at 15-16; Tr. at 3546-47, 13,080-81 (Fly);

¹⁴¹ The NRC Staff's review of the Applicant's analysis assessed in detail the process the Applicant followed as well as the Applicant's data. Tr. at 8910, 8912, 8917-23 (Campe).

Cole/Jefferson/Fly Post Tr. 3061, at 102; Campe/Ghosh Post Tr. 4078, at 30. Zooming the aircraft provides the pilot with additional time aloft to attempt to restart the engine before the aircraft crashes. Horstman Post Tr. 4214, at 15-16. The zoom is accomplished by raising the nose to establish a 30-degree climb. Tr. at 13,080-81 (Fly). If the pilot had been flying at an altitude of 4000 feet AGL, the zoom would take the F-16 to approximately 7000 or 8000 feet AGL. Tr. at 13,453 (Horstman). In accordance with the F-16 flight manual, upon reaching the airspeed of 250 knots the pilot will end the zoom by “pushing the plane over” and start a descent. Tr. at 13,299-300 (Horstman). The maneuver of pushing the plane over uses some of the F-16’s energy and the aircraft slows to approximately 200 knots. Tr. at 13,300-01 (Horstman).

B.45 Based on data from the F-16 pilot’s manual, the Applicant calculated, for example, that a pilot transiting Skull Valley at 350 knots at 3000 feet AGL would have 1 minute and 16 seconds to perform the zoom and glide maneuver before ejecting at 2000 feet AGL and would have over 2 minutes at 400 knots and 4000 feet AGL. Aircraft Crash Report, Tab U at 3-4. Colonel Bernard confirmed that at 400 knots and 4000 feet AGL, the pilot would have on the order of 2 to 3 minutes to respond to the emergency. Tr. at 3915-16 (Bernard). Graphs from the F-16-1 pilot’s manual show that in the range of speeds and altitudes at which F-16s fly in Skull Valley the pilot would always have over 45 seconds to perform the maneuver. Tr. at 3559-69 (Fly), 8662 (Jefferson); *see* Aircraft Crash Report, Fig. 3 (following page 19c).

B.46 Despite the Applicant’s claim of there being sufficient time for a pilot to respond to an emergency situation over Skull Valley, the State argues that in some circumstances, a pilot in an emergency will focus on the task of restarting a failed engine to the exclusion of performing other emergency procedures, including assessing where the aircraft will impact. *See* Horstman Post Tr. 4214, at 18-19; Tr. at 4030 (Cosby). According to the State, restarting a failed engine, like ejection, would save a pilot’s life and avoid the dangers associated with ejection. Horstman Post Tr. 4214, at 19. Thus, there is an incentive for a pilot to restart the engine and avoid ejection. Tr. at 4010 (Cosby). Moreover, the cost of an F-16 is approximately \$20 million to \$40 million. Tr. at 3339 (Fly). Thus, pilots will take every opportunity to save the aircraft by restarting the engine before ejecting. Tr. at 4010-11 (Cosby).

B.47 Lt. Colonel Horstman interviewed active-duty Air Force pilot Major Tom Smith, who ejected from an F-16 on January 13, 1995. Horstman Post Tr. 4214, at 18 & n.2. Lt. Colonel Horstman and Major Smith were both in the Air Force when Major Smith ejected. Tr. at 8585 (Horstman). Lt. Colonel Horstman was Major Smith’s supervisor at the time and had several conversations with Major (then Captain) Smith concerning his emergency and ejection. Tr. at 8585 (Horstman). Lt. Colonel Horstman recounted the conversation as follows:

Following an engine failure, Major Smith zoomed the aircraft, jettisoned stores, attempted to restart the engine and ejected. Horstman Post Tr. 4214, at 19; PFS Exh. 175. Major Smith said he did not have time to think about where his jettisoned stores would impact or where the F-16 would impact. Horstman Post Tr. 4214, at 19. Major Smith also said his thoughts were focused on his survival, and if he were to again be required to eject given the same circumstances, he would again not consider where the stores or aircraft would impact. Horstman Post Tr. 4214, at 18-19.

The Applicant, however, reviewed the accident report of Major Smith's crash and determined it represented a situation where a pilot would have time to avoid a specific site. Horstman Post Tr. 4214, at 18 n.2; PFS Exh. 100A.

(2) PILOT ABILITY TO RESPOND

B.48 The Applicant asserts that based on the activities that the pilot would have to perform to respond to an engine failure, the pilot would have adequate time during the zoom and glide maneuver to avoid the facility. Aircraft Crash Report at 19c-19d; Tr. at 3546-55 (Fly). The actions required to restart the F-16 engine would take only a fraction of the time available to the pilot before he reached the 2000-foot AGL recommended minimum ejection altitude. Aircraft Crash Report at 19d; *see* Tr. at 3549-51, 3560-62 (Fly). Moreover, pilots are trained at multitasking, so that they are able to perform emergency procedures while simultaneously flying their aircraft. Tr. at 3994-96 (Cosby). Furthermore, it would take 45 seconds after the pilot restarted the engine for it to develop usable thrust. Aircraft Crash Report at 19c, Fig. 3; *see* Tr. at 13,705 (Fly). Thus, according to the Applicant's evidence, at some point in the aircraft's glide before the pilot either resumed flying or ejected, there would be a 45-second period in which the pilot would be able to attend to other matters without interfering with the restarting of the engine. Tr. at 13,704-05 (Fly); *see* Aircraft Crash Report at 19c.

(3) SLIGHT TURN TO AVOID SITE

B.49 The Applicant further argues that to avoid any ground site visible at 2000 feet, the turn the pilot would have to make would be slight, on the order of 4 degrees (assuming that the pilot turned just before he ejected at 2000 feet AGL), and easily made in the time available to him while he was gliding toward the ground. Aircraft Crash Report at 22-23; Tr. at 3094-96 (Fly), 3910 (Bernard), 4023-25 (Cosby); *see* Tr. at 8527 (Horstman). The Hill AFB staff corroborated in its meeting with the NRC Staff that such a turn would not be difficult. *See* Tr. at 4186-88 (Campe). In his accident, Colonel Cosby turned 180 degrees to avoid an apartment complex and then maneuvered his aircraft further to avoid another

aircraft on the ground. Tr. at 3980-81 (Cosby). Colonel Bernard also agreed that in a controllable situation it would “not be difficult at all” to direct an F-16 away from the Applicant’s facility prior to ejection. Tr. at 3910 (Bernard).

(4) PILOT TRAINING

B.50 The Applicant posits that pilots would turn to avoid the site because they are trained to avoid inhabited or built-up areas on the ground. Aircraft Crash Report at 19-19a; Tr. at 3898 (Bernard), 3989-93 (Cosby).

(a) *Air Force Instruction Manuals*

B.51 The Applicant notes that the instruction manual for the first aircraft on which Air Force pilots are trained instructs pilots prior to an emergency ejection to “turn aircraft toward uninhabited area.” Aircraft Crash Report, Tab S. In addition, the F-16 manual states that “if time permits” the pilot should “direct the aircraft away from populated areas.”¹⁴² Colonel Bernard and Colonel Cosby both stated that the objective of that instruction is to minimize damage and risk to people or property on the ground by, for example, directing the aircraft into a river or a lake. Tr. at 3920 (Bernard), 3990-91 (Cosby). Dr. Campe testified that based on the NRC Staff’s meeting with the Hill AFB staff, avoidance of built-up areas on the ground if the aircraft was in control was “something that is . . . in every pilot’s mind, attitude [and] training to consider that.” Tr. at 4188 (Campe). Moreover, the fact that the facility will be a storage facility for nuclear material would also likely reinforce the pilot’s desire to avoid it. Tr. at 3921 (Bernard).

B.52 Regarding the emergency procedure of ejection, the F-16 flight manual provides the following reference:

Ejection (Time Permitting)

If time permits, descend to avoid the hazards of high altitude ejection. Stow all loose equipment and direct the aircraft away from populated areas. Sit with head against headrest, buttocks against back of seat, and feet on rudder pedals.

1. IFF MASTER knob — EMER.
2. MASTER ZEROIZE switch (combat status) — ZEROIZE.
3. Loose equipment and checklist — Stow.
4. Lapbelt and helmet chin strap — Tighten.

¹⁴²State Exh. 150. Lt. Colonel Horstman suggested that the manual cited by the Applicant was different with respect to emergency procedures than the manual for the F-16s currently flown at Hill AFB because the manual cited by the Applicant was for a block of aircraft that assertedly had different engines. Tr. at 13,628-29 (Horstman). In fact, the Block 30 and the Block 40 F-16 have the same engines, Tr. at 13,632-33 (Fly), and the manuals have identical language regarding the direction of the aircraft away from populated areas, Tr. at 13,637 (Farrar).

5. Night vision devices — Remove (if appropriate).
6. Visor — Down.
7. Throttle — IDLE.
 Slow to lowest practical airspeed.
8. Assume ejection position.
9. Ejection handle — Pull.

Aircraft Crash Report at 19a n.16A; PFS Exh. PPP at 3-43.

B.53 The State asserts that there is only one line in the pilot’s manual for the F-16 that instructs pilots to direct their aircraft away from populated areas before ejecting, State Findings ¶73, and claims that the Air Force only intends for pilots to avoid “a large geographical area, not a specific site or targets on the ground,” State Findings ¶74. Of the approximately 10,000 pages of directives and procedures for the F-16, the State notes that the only reference to directing the aircraft before ejecting is found embedded in the above provision: *If time permits . . . direct the aircraft away from populated areas.* Tr. at 8551 (Horstman). Except for a similar one-sentence reference in flight manuals for other aircraft, there are no other Air Force documents that refer to training a pilot to avoid populated areas. Tr. at 3251-52 (Jefferson), 13,532 (Horstman).

B.54 The State makes the following arguments about pilots avoiding ground sites. The Air Force does not teach pilots to look for specific sites on the ground in an emergency. Tr. at 8550-51 (Horstman). There is no Air Force training or guidance to avoid a house, a facility, or other specific ground site and pilots do not have the tools for such a task. Tr. at 13,464-65 (Horstman). Directing the aircraft away from a populated area refers to a large geographical area, not a specific site or targets on the ground. Tr. at 13,531-32 (Horstman). F-16 pilots will make the decision as to whether they can steer away at a distance of at least 3.22 miles and possibly as far away as 5 miles from where the F-16 will impact. Tr. at 13,612-13 (Horstman). The task of directing an F-16 away from a populated area before ejecting requires the pilot to determine if the impact area, 3.22 or more miles in front of the aircraft, is a populated area. Tr. at 13,612-13, 13,624 (Horstman). It is relatively easy to determine if a city is within the crash impact area, because its size makes it easy to locate. Tr. at 13,470-71 (Horstman), 3290 (Fly). Conversely, the State points out that a pilot may not be able to see smaller specific ground sites as well as larger areas. Tr. at 13,470-71 (Horstman). It points out that the Applicant’s site covers only 0.13 square mile and consists mostly of open space and concrete casks and does not appear to be a populated area. Aircraft Crash Report, Tab R; Horstman Post Tr. 4214, at 17-18. Lt. Colonel Horstman testified that the fact that the PFSF will be a “facility,” as opposed to a “populated area,” would make it less likely that a pilot would avoid the site, in that the pilot’s manual for the F-16 instructs pilots to turn the aircraft away from

“populated areas” before ejecting. Horstman Post Tr. 4212, at 18; Tr. at 13,532, 13,465 (Horstman).

B.55 To support its position, the State points out that the crash report of July 11, 1996, shows the pilot turned “towards what he perceived to be a less congested area” yet the impact destroyed two houses killing a child and injuring her mother. Joint Exh. 10; State Exh. 223, No. 14. In addition, the crash report of August 31, 1992, shows the pilot turned toward “what appeared to be an uninhabited area” yet impacted 150 yards from two inhabited dwellings. PFS Exh. 140; State Exh. 223, No. 7. These mishap reports, according to the State, demonstrate the level of a pilot’s ability to turn away from large populated areas, and the inability to locate and avoid specific ground sites. State Findings ¶ 75.

B.56 The State also argues that the notion of directing the aircraft away from a populated area also includes the notion that a pilot would not direct the aircraft away from one area at the risk of impacting a more populated area. Tr. at 13,613 (Horstman). The decision to turn away from a populated area requires the pilot to assess the impact area of where the F-16 is pointed and alternative impact areas to turn toward. *See* Tr. at 13,613 (Horstman). A pilot in Skull Valley would not direct an F-16 toward the Goshute Indian Village in an effort to avoid the Applicant’s facility. Tr. at 13,613 (Horstman); State Exh. 222. Lt. Colonel Horstman suggested that a pilot whose crashing aircraft was going to hit the Hoover Dam might not try to avoid it because the dam was not, strictly speaking, a “populated area,” despite the fact that damaging the dam could potentially cause great harm to many people. Tr. at 13,559-60 (Horstman).

(b) Situational Awareness

B.57 Air Force pilots are taught three general principles pertaining to in-flight emergencies, which are reinforced throughout their careers: maintain control of the aircraft, analyze the situation and take appropriate actions, and land as soon as conditions permit. Aircraft Crash Report at 19. In addition, Air Force pilots are trained from the beginning of their careers to develop and maintain constant situational and positional awareness, so that regardless of where they are flying and where they are headed, they are cognizant of their surrounding environment. Tr. at 3103-04 (Cole). General Cole described situational awareness as “an active and engaged cognizance” of a pilot’s location, direction, airspeed, track, and terrain features, among other things. Tr. at 3591 (Cole). Air Force pilots begin to learn and develop situational awareness from their first flights in pilot training, and pilots continue throughout their careers to improve their situational awareness skills in maintaining it. Tr. at 3591-92 (Cole). Situational awareness is integrated into pilot training through flight simulator exercises in which various emergencies are presented and through actual flight time, check rides, and flight drill instruction. Tr. at 3593-98 (Cole/Fly/Jefferson), 3334-35 (Fly). Situational

awareness is also discussed as part of mission briefings and debriefings. Tr. at 3595 (Fly). Hence, loss of situational awareness is minimized as a result of training.

B.58 PFS argues that the extensive training Air Force pilots receive with respect to the development of situational and positional awareness relates to a pilot's success in avoiding structures on the ground during an emergency. Tr. at 3598-99 (Cole). General Cole explained that while addressing an emergency situation, a pilot will generally be aware of what is in front of and behind the aircraft and will have a sense of the location of a structure on the ground, before a pilot would have to act to avoid it. Tr. at 3599 (Cole). A pilot will know where the aircraft is going to land and will adjust the heading of the aircraft to ensure that the aircraft will not hit a ground structure before the pilot ejects. Tr. at 3103-04 (Cole).

B.59 The State's witness, Lt. Colonel Horstman, agreed that pilots are trained in aspects of situational awareness and are trained to know their location. Tr. 13,334-35 (Horstman). He agreed that pilots have situational and positional awareness when flying and that, generally speaking, a pilot would not look out of the aircraft for the first time at the onset of an emergency to determine the aircraft's location, because the pilot should already be aware of it. Tr. at 8606 (Horstman).

(c) Ejection Training

B.60 The State observes that during Air Force training, responding to engine failures is practiced only on simulators. *See* State Findings ¶ 76. Air Force training does not include practicing engine failure emergencies where the F-16 engine is failed for training purposes. Tr. at 3555-56 (Fly). If an engine fails, the pilot will for the first time be in that emergency situation. Tr. at 3556 (Fly). Engine failures are practiced only on flight simulators. Tr. at 3333-37 (Fly/Cole). Nor does Air Force training include practicing ejections from an aircraft. Tr. at 3335-36 (Fly). Pulling the ejection handle in a flight simulator merely causes the simulator to go blank and stop. Tr. at 3335 (Fly). Until a pilot actually ejects from an aircraft during an emergency, the pilot has never fully experienced that sensation nor made decisions relating to where the aircraft will impact. Tr. at 3556 (Fly).

B.61 In response, PFS argues that simulator training is thorough and realistic. Tr. at 3333-34 (Fly). The simulator looks like an F-16 cockpit and contains functioning instruments. Tr. at 3333-34 (Fly). It enables a pilot to practice navigation, flying in bad weather, air-to-air combat, and some bombing missions. Tr. at 3334 (Fly). The simulator can also simulate the failure of any of the aircraft's systems. Tr. at 3334 (Fly). "There are literally hundreds of emergencies that the F-16 simulator simulates, and they put the pilot through real-time stresses and radio calls . . . , those kinds of extraneous and external inputs to the pilot, so that the

pilot can focus on the task at hand and solve whatever he is presented with. . . .” Tr. at 13,260 (Horstman). Thus, PFS asserts, a pilot can practice responding to an engine flameout by going through all of the emergency procedures up to and including pulling the ejection handles if the engine fails to restart. Tr. at 3334, 3810 (Fly). Pilots rehearse emergency procedures extensively and are regularly tested on them in the simulator. Tr. at 3330-31 (Cole), 3811 (Fly), 13260 (Horstman). Colonel Cosby testified that this thorough training enables a pilot to respond automatically or instinctively to emergency situations and that part of the pilot’s instinctive response includes the pilot knowing where he is and what he might wish to avoid hitting on the ground. Tr. at 3988-90 (Cosby).

B.62 The Applicant further maintains that Air Force training provides pilots with a sense of what ejection feels like by putting them through a simulated ejection in an ejection seat that actually shoots them into the air. Tr. at 3335-37 (Fly). Simulated ejections are practiced twice per year. Tr. at 4015 (Cosby). Colonel Fly testified that with the combination of training and the simulated ejection, “the Air Force does everything they can to make you as prepared as you can possibly be so that when you’re faced with that decision [to eject], you will make the correct one.” Tr. at 3338 (Fly). The avoidance of areas on the ground is discussed during emergency procedures training. Tr. at 3810 (Fly).

(d) Emergency Stress and Pilot Error

B.63 The State further argues that pilots are under great physical and emotional stress during inflight emergencies, which causes their performance to deteriorate. Horstman Post Tr. 4214, at 20; Tr. at 3252-54 (Jefferson). A pilot’s primary concern upon realizing the aircraft is about to crash is for the pilot’s survival, which is dependent on ejection. Horstman Post Tr. 4214, at 17-21. Ejection from an F-16 is a violent and dangerous procedure which can cause severe injury or death. *Id.* at 17; Tr. at 3900 (Bernard). U.S. Air Force publication *Flying Safety* reports that through September 2000, 6.8% of F-16 ejections have resulted in fatal injuries. *Flying Safety* at 11-13; Tr. 3255, 3270-71 (Jefferson). Colonel Bernard, who ejected from an F-16 during a training mission, testified that the greatest stress levels by a “significant measure” faced by a pilot occur during the moments before ejection. Tr. at 3897-98 (Bernard). Colonel Bernard testified that you have a period of divided attention during an emergency that “completely becomes focused on what you need for your survival.” Tr. at 3897-98 (Bernard).

B.64 The Air Force Chief of Safety sends out messages known as ALSAFECOMs to distribute critical safety information to Air Force commands. Horstman Post Tr. 4214, at 20-21. During 1996, the Air Force Chief of Safety sent out ALSAFECOM 002/1996, one of only four ALSAFECOMs sent out that year. Horstman Post Tr. 4214, at 20-21; State Exh. 57, U.S. Air Force, ALSAFECOM

002/1996 [hereinafter ALSAFECOM 002/1996]. It advised of significant pilot errors in emergency situations, including 73% of ejections in the previous 6 months occurring below the published minimum altitude of 2000 feet due to futile attempts to restart failed engines. *Id.* at 1. It further advised that incorrect assessment of airborne situations and timely ejections had become a problem, and that erroneous assumptions and poor airmanship flourished in emergency situations. *Id.* at 2-3. It concluded that crew members confronted with inflight emergency-induced stress may need external intervention to alter inappropriate actions. *Id.* at 3. The State notes that F-16 manufacturer Lockheed Martin has determined that 52% of Class A F-16 accidents have been caused by pilot error. Horstman Post Tr. 4214, at 20; State Exh. 56.

B.65 As an example of pilot error during an emergency situation, the State points to the testimony of volunteer witness Colonel Michael Cosby, who ejected from an F-16 after his aircraft's engine failed during a 1993 training mission. Tr. at 3978-80 (Cosby). Colonel Cosby testified that he spent too much time and attention trying to restart the failed engine. Tr. at 3980 (Cosby). The board that investigated Colonel Cosby's accident determined that if he had spent less time focusing on restarting the engine, he would probably have avoided the crash and been able to successfully land. Tr. at 4008 (Cosby).

B.66 The State presented the testimony of volunteer witness Colonel Frank Bernard, who ejected from an F-16 after the engine failed during a 1986 training mission. Tr. at 3888-89 (Bernard). Colonel Bernard testified that it was error on his part to use all his time trying to solve his failed engine problem, which drove him to eject at only 170 feet AGL. Tr. at 3895-96 (Bernard). Video recordings are routinely made during F-16 flights. Tr. at 13,133-36 (Horstman). The Air Force used the actual video recording taken from Colonel Bernard's F-16 during his ejection emergency to produce a safety training video for F-16 pilots. Tr. at 13,135-37 (Horstman); *see* State Exh. 220, Videotape: Late Decision To Eject (U.S. Air Force 1986) [hereinafter Bernard Video]. The video shows a portion of the training mission that is generally representative of flying conditions that normally occur in Skull Valley. Tr. at 13,435-38 (Horstman); *see* Bernard Video. Following disengagement from the mock battle training, the circumstances represented in the Bernard training video are representative of any F-16 with a failed engine. Tr. 13,690-91 (Fly); *see* Bernard Video. Colonel Bernard, a most experienced pilot, ejected only seconds prior to the aircraft impacting the ground. Tr. at 13,435-38 (Horstman). This was Colonel Bernard's second ejection. Tr. at 13,438 (Horstman). The State claims that Colonel Bernard's accident supports its notion that a pilot who suffered an engine failure in Skull Valley would be too distracted to avoid the facility. *See* State Findings ¶ 81.

B.67 In response, the Applicant argues that, as Colonel Fly explained, "[i]f you had taken Colonel Bernard and put him in a typical Skull Valley position and he had the same engine problem, he would have wound up with much more time

to analyze the situation and to act accordingly.’’ Tr. at 13,692 (Fly). In Skull Valley, a pilot would be at approximately 3000 to 4000 feet AGL and 350 to 400 knots. Cole/Jefferson/Fly Post Tr. 3061, at 14. In contrast, Colonel Bernard did not pull himself away from his combat training mission and began to focus on his emergency until he was at 170 feet AGL. *See* Bernard Video.

B.68 From reviewing F-16 crash reports for the 10-year period 1989 through 1998, the Applicant determined that fifty-eight reports represented crashes where the aircraft remained controllable with sufficient time to avoid a specific ground site. The State points out, however, that in that group of crash reports, twenty-nine reports (50%) show the pilot ejected below the published minimum altitude of 2000 feet AGL. State Exh. 223.

B.69 The Applicant responds by arguing that merely because the pilot ejected below 2000 feet does not mean that he would not have been able to avoid the facility. PFS Findings ¶¶ 123-124, 162. The Applicant argues that pilots in the reports, including Colonel Cosby, did in fact avoid sites or areas on the ground even though they ejected below 2000 feet. *See id.* ¶ 123. The Applicant argues that according to the evidence in the record, ejection at below 2000 feet is not related to a pilot’s ability to avoid a site on the ground. *See id.* It also points out that in a number of cases, the pilots specifically delayed their ejection below 2000 feet in order to take additional actions for the express purpose of avoiding sites on the ground and were commended for doing so. *Id.* ¶ 124. Further, PFS argues, the accident reports refer to the 2000-foot limit as “minimum recommended ejection altitude” and not as “rule” or “regulation.” *See, e.g.,* Joint Exh. 1 at 2; Joint Exh. 6 at 4; Joint Exh. 9 at 16; PFS Exh. 205 at 17. The Applicant points out that some pilots have been specifically commended for delaying their ejection below 2000 feet AGL in order to avoid something on the ground. *See* Joint Exh. 9 at 16; PFS Exh. 205 at 17.

B.70 After reviewing the accident reports offered into evidence by the Applicant, the Board identified forty instances in which pilot error was listed as either the confirmed or suspected cause of an F-16 crash. Relevant excerpts from these forty reports are set forth below:

PFS Exh. 80. *Collision with ground.* Potential pilot error attributed to two fatalities (one pilot and one civilian) as no equipment failure was found and no ejection was attempted.

PFS Exh. 103. *Collision with ground.* Mishap pilot “inadvertently pulled his power back to idle,” and after “recognizing his error,” took corrective actions. The plane impacted the ground with no attempted pilot ejection, but the mishap pilot suffered no serious injury.

PFS Exh. 106. *Live bombs dropped.* Four “deviations” were cited: (1) mishap pilot “overflowed manned sites . . . with live ordnance on board and with their Master Arm switch in the ‘ARM’ position”; (2) mishap pilot “expended six MK-82 AIR

general purpose bombs on an unauthorized target”; (3) mishap pilot “did not place required navigational data . . . on his low level map”; and (4) flight “used non standard radio transmissions.” Six live bombs were dropped and detonated near a manned site, and four civilians were affected.

PFS Exh. 107. *Midair collision*. One pilot fatality and one successful pilot ejection in midair collision of two F-16s. Four “known or suspected deviations” are: (1) “no air-to-air academic are documented”; (2) one pilot did not meet minimal training requirement; (3) one pilot’s video showed “at least four instances, not including the collision, where his aircraft was closer than 1,000 feet to “the other aircraft, where 1,000 feet was established by USAFER 55-79 as minimum separation distance; (4) and one instance of activation of the low speed signal, where “no knock it off or terminate call was given even though safety was compromised.”

PFS Exh. 109. *Midair collision*. One pilot fatality. “All pilots in the squadron did not have the same interpretation of the leader/wingman responsibilities in MCM 3-3 and MCM 3-1,” and “[t]here were also differences of opinion on whether the flight member engaging had to specifically call ‘engaged’ when he was assuming the role of the ‘engaged fighter.’ ”

PFS Exh. 120. *Midair collision*. One pilot fatality and one safe pilot ejection. Pilot training deficiencies were cited as “demonstrated deficiencies during initial qualification that were documented on the phase grade sheets.” Deficiencies were noted in the report.

PFS Exh. 122. *Collision with ground*. Potential pilot error as no equipment failure was found and there was no attempted ejection. Pilot was fatally injured.

PFS Exh. 130. *Crash into sea*. Three training deficiencies noted: (1) mishap pilot was “not an experienced pilot in the F-16 as required by AFR 60-1”; (2) “no waiver was approved” for a crew member who was not a rated crew member; and (3) “G-straining maneuvers were not briefed,” which was required by AFR 60-1 and PACAFR 55-7.

PFS Exh. 131. *Collision with ground*. Potential pilot error as there was no attempted ejection. Fatal injury to the pilot.

PFS Exh. 132. *Collision with mountain ridge*. One cited deviation as mishap actions were “outside of the MOA” while training should be conducted within designated airspace. Two pilot fatalities in this accident.

PFS Exh. 135. *Collision with ground*. Potential pilot error in that “[t]he mishap pilot and flight lead both believed that sufficient cloud clearance would be available when the attack was initiated.” The plane crashed and was destroyed.

PFS Exh. 136. *Midair collision*. One pilot fatality. Potential pilot error.

PFS Exh. 139. *Collision with ground*. Pilot fatality because “ejection was initiated out of the design envelope of the ejection system.”

PFS Exh. 142. *Collision with ground.* Pilot using piddle-pack caused the plane to become uncontrollable.

PFS Exh. 149. *Landing accident.* Cited factors causing accident: (1) had the pilot “adhered to these published altitude restrictions this accident would not have occurred”; (2) pilot “failed to follow T.O. 1F-16C-1”; and (3) “pilot distraction.”

PFS Exh. 151. *Collision with ground.* Pilot fatality due to following potential causes: (1) the time allotted for mission brief was “insufficient to adequately cover a detailed game plan”; (2) pilot training “did not involve high G, visual Air-to-Air maneuvering”; and (3) pilot’s “low situational awareness . . . placed him in a high task environment.”

PFS Exh. 152. *Collision with ground.* Pilot ejection at 620 feet AGL during a contractor acceptance check flight, leading to fatal injury. “Momentary complacency . . . provided the only reasonable explanation for this accident.”

PFS Exh. 153. *Midair collision.* Safe pilot ejection. Pilot “misperception” and “disorientation” were cited.

PFS Exh. 154. *Collision during landing.* Control tower controller deficiency noted. Pilot “operated his aircraft in violation of Air Force Regulation 60-16” and pilot’s “demonstrated lack of flight discipline” was cited.

PFS Exh. 155. *Collision with ground.* Potential pilot error due to pilot “delayed his recovery from a near vertical dive.” Pilot was fatally injured.

PFS Exh. 159. *Midair collision.* Pilot’s “failure to follow established guidance for required actions” was cited.

PFS Exh. 161. *Collision with ground.* Pilot fatality. Pilot “misprioritizing his tasks for a very short period of time while maneuvering at low altitude” was cited.

PFS Exh. 165. *Collision with ground.* Potential pilot errors committed in 360-degree spiral. “Distraction/preoccupation” and “inattention/complacency” were discussed as potential causes.

PFS Exh. 168. *Midair collision.* Collision between F-16 and C-130 caused 23 fatalities and 100 injuries to Fort Bragg Army personnel who were paratroopers in preparation for a jump. A minor pilot error was cited as “AFR 60-16 [paragraph] 4-4b was not adhered to by the F-16 pilot.”

PFS Exh. 169. *Collision with ground.* Engine failed. Accident investigator found that “accident was the result of pilot error. The mishap pilot failed to follow two of the three basic rules in T.O. 1F-16C-1 which apply to all emergencies.”

PFS Exh. 171. *Crash on takeoff.* Accident investigator found that the aircraft “crashed because it was not properly trimmed for takeoff.” The most likely reason for incorrect trim was found to be “the pilot’s failure to return the TRIM/AP (trim/autopilot) switch to the NORM position during the after start checks and failure to check the trim in the center position prior to take off.”

PFS Exh. 172. *Collision with ground*. Accident investigator found six deviations from directives or publications by mishap crew members or others involved in the mission after bird strike occurred. “For an unknown reason, [pilot] descended through 6000 feet mean sea level, the assigned and published base of the [operating area] and leveled off at approximately 1000 feet above the ground. . . . There is no evidence to show that . . . the designated element lead, made any attempt to prevent or correct the deviation from the assigned airspace.”

PFS Exh. 178. *Midair collision*. Investigator found that cause of accident was “loss of situational awareness in the traffic pattern.”

PFS Exh. 187. *Collision with ground*. Investigator found the pilot “failed to monitor his aircraft’s position and flight path relative to the ground [T]his mishap was caused by human factors. . . . [P]reparation [and] experience . . . can be overridden by a momentary lapse into ‘seat-of-the-pants’ flying due to some form of distraction. . . . [H]uman factors continue to be the ongoing limitation to perfect results.”

PFS Exh. 190. *Midair collision*. Investigator found that pilot failed to maintain sight of lead aircraft and he could no longer ensure safe separation between his aircraft and aircraft 257. Pilot “engaged the auto pilot for the second photo pass, in order to provide . . . a more stable platform from which to fly [A]uto pilot [tolerances] must be closely monitored.”

PFS Exh. 193. *Collision with ground*. Investigator found that “mishap was caused by human factors.” Pilot “was unprepared for the degree of G tolerance reduction following his unloaded extension [E]ven with the most thorough preparation and capability, the human factor continues to limit perfect success.”

PFS Exh. 195. *Midair collision*. Investigator found that “[b]y clear and convincing evidence, the midair collision] . . . was caused by pilot errors by all three pilots involved.” Two pilots “failed to effectively communicate, prioritize tasks, and control aircraft performance parameters to avoid collision. In simpler terms, they lost situational awareness.”

PFS Exh. 197. *Midair collision*. Investigator found that there were numerous deviations from training rules. There was “failure to use proper ‘see and avoid’ techniques to ensure a clear flight path.” Human factors cited include decreased situational awareness secondary to task saturation, task misprioritization, channelized attention, misperception of speed/closure rate.

PFS Exh. 200. *Collision with ground*. Investigator found that pilot “channelized his attention on some aspect of the attack and descended below the briefed recovery altitude, became spatially disoriented and impacted the terrain.”

PFS Exh. 204. *Aborted takeoff*. Accident investigator found that “pilot failed to execute the abort procedure properly.” There was a failure to deploy the SAFE-BAR Arresting System. Had the system been deployed “it would have prevented the mishap aircraft from departing the overrun.”

PFS Exh. 206. *Collision with ground.* Investigator found accident was caused by “G-induced loss of consciousness (GLOC).” The cause of “the GLOC was the mishap pilot’s failure to execute a proper AGSM while initiating the conversion turn during the mishap intercept.”

PFS Exh. 207. *Collision with ground.* Investigator found that “this mishap is the result of the combined effects of several errors made by the mishap pilot.” Pilot “did not maintain proper spacing from and visual contact with” other aircraft.

PFS Exh. 218. *Landing gear collapse on landing.* Investigator found that pilot failed “to properly control his descent rate during landing. . . . [A]ircraft was descending in a slight left bank at around 23 ft/sec, well above the 10 ft/sec design limit.” (reference omitted)

Joint Exh. 8. *Collision with ground.* Investigation found that “[mishap pilot] failed to recognize . . . mechanical malfunction in a timely manner.” When engine failed, mishap pilot “did not take command of the flight. . . . descended rather than maintain his altitude . . . did not request assistance . . . did not complete all the steps recommended by the flight manual checklist to correct [fuel situation].”

Joint Exh. 10. *Collision with ground.* Pilot attempted to avoid populated area after engine failed. Ejected at 209 feet; aircraft crashed into populated area destroying a house and killing a child.

We do not suggest any statistically valid inferences can be drawn from the reports just mentioned. But we do find that the reports provide powerful evidence concerning the many ways human error leads to failure. And while the errors recounted therein did not take place during the “ground-site avoidance” phase of flight, they nonetheless demonstrate that errors take place in many other phases of flight. That demonstration provides us good reason not to accept the notion that in the particularly stress-filled phase of flight in which we are interested (and after the accident scenario has been initiated), near-flawless performance in ground-site avoidance will result.

(5) PILOT FAMILIARITY WITH SITE

B.71 The Applicant stresses that pilots flying in Skull Valley will know where the facility is because it will be prominently visible. Lt. Colonel Horstman agreed that it would be one of the largest built-up areas and would have perhaps the tallest structure in Skull Valley and would be of “fairly unique” appearance. Tr. at 13,510-11 (Horstman). The restricted area will have 130-foot light poles around its boundary to provide illumination 24 hours a day. Cole/Jefferson/Fly Post Tr. 3061, at 66 n.80; Aircraft Crash Report at 22. Pilots will see the site as they fly over it from week to week, even as it is being constructed. Tr. at 3600-01 (Fly). Observing their surroundings is something pilots constantly do while they are flying their aircraft. Tr. at 3551-53 (Fly), 3599 (Cole).

B.72 Further, as the Applicant discussed in its proposed findings, in addition to its visibility, because of the nature of the facility, the location of the facility within the middle of the Valley will be well known to the pilots who fly through Skull Valley. PFS Findings ¶97. From the time the pilot enters Skull Valley about 25 miles to the north of the facility he will have mountains on both sides and a road down the center of the Valley. *See* SER at 2-3 to 2-5. He will also have a flight plan developed, a flight map of the area, and will know his course of flight in relation to these prominent landmarks, including the facility. Tr. at 8417-19 (Horstman), 13,049-52 (Fly) (discussing pilots' use of landmarks and instruments in the event of reduced visibility due to weather).

B.73 In addition to the pilot's own personal awareness and familiarity with the Valley from flying F-16s, the Applicant argues that the site's location will be noted, along with other nuclear facilities, in Defense Department aviation planning guides. Aircraft Crash Report at 90-91; *see* also Tr. at 3519-20 (Cole), 13,114 (Fly). The Department of Defense's Area Planning Guide provides guidance to planners of military training routes regarding location and avoidance of radioactive waste facilities and is updated every 56 days. Campe/Ghosh Post Tr. 4078, at 21.

B.74 Finally, PFS asserts, if pilots at Hill AFB determine to use the Applicant's facility regularly as a primary visual reference point, the facility will be known to those pilots. Cole/Jefferson/Fly Post Tr. 3061, at 42. In that event, pilots would be able to see or at least be aware of the location of the Applicant's facility in Skull Valley. *Id.* Along with other sensitive areas beneath the airspace of the UTTR, such as the chemical and biological laboratories on Dugway Proving Ground, the facility would be depicted on aviation maps and its location published in Air Force instructions for the UTTR. Tr. at 13,114 (Fly). Pilots also receive orientation with respect to safety hazards when they come to a new base which would make them further aware of the facility, assuming that the Air Force instructs pilots as to the potential hazard of hitting the facility. Tr. at 3781-82 (Cole), 3783 (Fly).

(6) OPEN SPACE SURROUNDING SITE

B.75 In Skull Valley, the Applicant's proposed facility would be the largest structure in the area. Tr. at 3600. Skull Valley itself is sparsely populated and on the Skull Valley Band Reservation, near the proposed facility, there are two tribal homes approximately 2 miles southeast of the proposed site, additional residences about 3.5 miles east-southeast of the site, and off the Reservation, two private farm residences located approximately 2.75 and 4.0 miles northeast of the site. *See* SER at 2-4. Generally, the area surrounding the proposed facility is characterized by open space and is undeveloped with mostly limited grazing and agricultural uses. *See* FEIS at 3-41. In addition, the Applicant notes that there

are no residences or structures of any kind to the west of the site. Aircraft Crash Report at 22. From these facts, the Applicant claims that a pilot flying down the middle of the Valley in the general direction of the site could divert to the west to avoid crashing into people, but would have to be cognizant of the restricted airspace. Tr. at 13,703-04 (Jefferson). Similarly, says the Applicant, an F-16 following the predominant route east of the site could be somewhat east of the other structures in the general vicinity and could, before ejection, continue the same direction, or make a slight turn toward the Stansbury Mountains, to ensure site avoidance. Tr. 13,700-01 (Fly).

B.76 In rebuttal to the Applicant's claims, the State points out that two F-16 accident reports presented by the Applicant show that a pilot would have difficulty avoiding the facility. See State Findings ¶75 (citing accidents of July 11, 1996, and August 31, 1992). The July 11, 1996 accident (in which the aircraft struck a house) occurred after an engine failure during an attempted emergency landing at the Pensacola Regional Airport. See Joint Exh. 10. At the point the pilot realized he could not make it to the runway, "[t]here were houses everywhere he looked below him." Joint Exh. 10 at 5. The pilot nonetheless continued maneuvering the airplane to avoid structures on the ground up to the very last moments possible. In the August 31, 1992 accident, the pilot did not hit anything. The accident report stated that the aircraft impacted approximately 150 yards from two inhabited dwelling structures. PFS Exh. 140 at 4. The land on which the aircraft impacted was a "wooded area," *id.* at 2, that "contained primarily trees and underbrush," *id.* at 4.

(7) GOOD WEATHER AND VISIBILITY

B.77 The Applicant argued generally that the lack of cloud cover over Skull Valley and a pilot's ability to maintain positional awareness in cloudy conditions through visual identification of landmarks and the use of navigational tools would assist pilots in avoiding the PFS facility in an emergency ejection situation.

(a) *Presence of Cloud Cover*

B.78 According to the Applicant, the weather in Skull Valley is generally excellent. PFS Findings ¶99. Actual ceiling data based on 30 years of climatological data from Michael AAF show that 70.5% of the time there is no ceiling at any altitude combined with a visibility greater than or equal to 7 miles. Vigeant Post Tr. 3090, at 4. Because Michael AAF is close to the proposed facility site in Skull Valley and because the data were specifically collected by the Air Weather Service to support aviation operations at Dugway Proving Ground, the ceiling and visibility data would be closely representative of that for the facility site. *Id.* at 6.

B.79 The Applicant also contends that cloud cover in Skull Valley that would affect a pilot’s ability to see the facility at the altitudes flown by the F-16s would be very uncommon. The same 30 years of climatological data from Michael AAF shows there is no ceiling below 5000 feet AGL (where the F-16s mostly fly) and 7 or more miles of visibility 91.5% of the time. Cole/Jefferson/Fly Post Tr. 3061, at 53; Vigeant Post Tr. 3090, at 4. Because a ceiling as defined by the FAA is indicative of a pilot’s ability to maintain sight of a point on the ground for a sufficient length of time to land an aircraft without using instrument procedures, Tr. at 13,458-59 (Horstman), these data show that more than 90% of the time clouds would not impair a pilot’s ability to see and avoid the facility while flying through Skull Valley. Further, specific cloud cover data from Salt Lake City show that 79% of the time there would be no clouds (or fog) below 5000 feet AGL whatsoever. Tr. at 13,061 (Fly); PFS Exh. 245. Applicant witness Vigeant collected surface weather observations from Salt Lake City International Airport for calendar year 2001. See Tr. at 13,055-56 (Vigeant); PFS Exh. 245. The information presented gives the amount of cloud cover at various layers and includes the altitude of each cloud layer. Tr. at 13,056 (Vigeant). The data show that out of 108 observations, only 23 had any clouds reported at altitudes below 5000 feet AGL — the elevation threshold of the Sevier B MOA. Tr. at 13,059 (Fly); PFS Exh. 245. Thus, in 79% of the time, there were no clouds observed. Tr. at 13,061 (Fly). The data for observations reported at altitudes below 5000 AGL¹⁴³ are set forth below:

Overcast (100% cloud covered)	9% of the time
Broken (5/8 to 7/8 cloud covered)	3% of the time
Scattered (3/8 to 4/8 cloud covered)	6% of the time
Few (2/8 or less cloud covered)	4% of the time

PFS Exh. 245.

B.80 Based on the data collected by Mr. Vigeant, the State posits that the cloud coverage for Skull Valley represents a ceiling at 5000 feet 12% of the time. State Findings ¶ 86. The State also asserts that a pilot’s view of the Applicant’s facility will be obstructed when cloud coverage is 50% or greater and there is a high probability it will be obstructed when the sky is 25% cloud covered. Horstman Post Tr. 4214, at 21-24; Tr. at 8377-84 (Horstman). As a result, it

¹⁴³Between 5000 feet AGL and less than or equal to 14,000 feet AGL, the threshold elevation of the Sevier D MOA, the data collected by Mr. Vigeant showed that there were thirty-one observations of no clouds, twenty-one instances observed of few clouds, eighteen instances of scattered clouds, fourteen instances of broken clouds, and eleven instances of overcast conditions. Tr. at 13,060 (Fly); PFS Exh. 245. Some of the entries in the chart involved multiple layers of clouds at different altitudes. Tr. at 3060 (Fly); see, e.g. PFS Exh. 245 at 1 (Jan. 15, 2001, 0900 entry).

points out that a pilot will not be able to see the Applicant's facility at least 12% of the time and may not be able to see the facility up to 21% of the time. *See* State Findings ¶ 86. The State presented its own table, "Air Weather Service — Climatic Brief," that the State contends shows that there is greater than 50% cloud cover in Skull Valley 46% of the time at or below 12,000 feet AGL. *See* Horstman Post Tr. 4214, at 22; *see also* State Exh. 59 (Climatic Brief table).

B.81 In response, the Applicant contends that the State incorrectly interpreted the cloud data contained in the Climatic Brief table. Vigeant Post Tr. 3090, at 7. Mr. Vigeant testified that the Climatic Brief table relied on by the State indicates that there is greater than 5/10 cloud cover 46.3% of the time on an annual basis, but that it does not provide the altitude of the various cloud layers, and it does not state whether the cloud cover constitutes a "ceiling." *Id.* Ceiling height is the height of the lowest sky cover that results in cumulative opaque sky of more than half. *Id.* at 8. In contrast, sky cover is the amount of sky covered by clouds — whether transparent or opaque. *Id.* Therefore, according to Mr. Vigeant, the Climatic Brief table, in referring to sky cover, does not provide any information regarding the frequency of occurrence or extent to which the sky in Skull Valley would be covered by opaque clouds. *Id.* at 9. Rather, the cloud cover observations were not made with respect to altitude, but, instead, were made on the basis of total sky coverage expressed in tenths. Thus, 2/10 sky cover at 1000 feet AGL would be reported the same as 2/10 cloud cover at 20,000 feet AGL. *Id.* at 8.

B.82 For its part, the Staff argues that the data provided by the Applicant provide information regarding the fraction of the sky covered by opaque clouds and the altitude at which those clouds are located and, therefore, is more appropriate for an analysis of whether a pilot flying through Skull Valley would be able to locate visually a ground structure than the information provided by the State in its Climatic Brief table. *See* Staff Findings ¶ 2.381. Furthermore, the Staff believes the Applicant's ceiling versus visibility chart supports a finding that the annual percentage of occurrence of "no ceiling" at or below 5000 feet AGL, combined with a visibility of greater than or equal to 7 miles, is 91.5%. *See* Staff Findings ¶ 2.381.

(b) *Pilot Ability To Maintain Positional Awareness*

i. *Pilot Ability To See in Cloud Cover*

B.83 The Applicant argues that the presence of clouds, whether they constituted a ceiling or not, would not necessarily obstruct the pilot's view of the facility. That would depend on the relative positions and altitudes of the clouds, the pilot, and the facility. Cole/Jefferson/Fly Post Tr. 3061, at 52-55; Tr. at 13,032-36, 13,038-42, 13,095-96 (Fly). The Applicant's testimony showed in graphic form that where there is a ceiling, a pilot below the ceiling (and in some cases a pilot above) could see the facility with no difficulty. Cole/Jefferson/Fly

Post Tr. 3061, at 53-55; Revised Addendum, Tab FF, Figs. 9-1 to 9-12. In fact, one of the accident reports describes how the pilot purposefully glided down through an overcast cloud layer, spotted farms on the ground, avoided them, and then ejected. *See* Tr. at 13,579-80 (Horstman); Joint Exh. 9 at 2, 13-14. Thus, the Applicant argues that even total cloud cover below a pilot might not prevent him from ultimately seeing the facility before he ejected. PFS Findings ¶ 131.

B.84 During the course of the hearing, the Licensing Board was presented with three visual demonstrations regarding the impact of cloud cover on the ability of a pilot to see objects on the ground. *See* Tr. at 8377-85 (State demonstration); Tr. at 13,033-53 (Applicant demonstration); Tr. at 13,420-29 (second State demonstration). With respect to the first demonstration, Lt. Colonel Horstman placed Scrabble tiles across the top of a tablet of paper to depict clouds. Tr. at 8378 (Horstman). He covered 25% of the tablet with the Scrabble tiles to demonstrate scattered cloud coverage. Tr. at 8379 (Horstman). He testified when looking directly down from the top, a fairly significant portion of the tablet is visible, but when viewing at a 10-degree angle, a small portion is visible. Tr. at 8380 (Horstman). The State argues that because clouds have vertical development and because a pilot's view of the ground is at an angle, a sky that is 25% cloud covered may completely block the pilot's view of the ground. Tr. at 8377-84 (Horstman). It points out that clouds are generally dense enough that they cannot be seen through. *See* State Findings ¶ 24. Even clouds referred to as "transparent" cannot be seen through by a pilot viewing the ground at an angle. Tr. at 8575-76 (Horstman). The State further argues that a single cloud may be positioned at any given time to preclude a view of the Applicant's site. Revised Addendum, Tab FF.

B.85 The Applicant's witness, Colonel Fly, disagreed that the State's demonstration with the Scrabble tiles accurately replicated what a pilot would see if flying over clouds in Skull Valley. Tr. at 13,032 (Fly).¹⁴⁴ He stated that cloud layering is an important consideration in seeing the ground. Tr. at 13,032-33 (Fly). To demonstrate cloud layering, Colonel Fly placed cardboard rectangles on clear plastic columns of varying heights. Tr. at 13,034-35 (Fly). He demonstrated conditions of cloud cover ranging from 25% to 75%. As an airplane moves, due to the different cloud heights, a pilot would be able to see a feature on the ground and would be able to see different parts of roads, buildings, and terrain features coming in and out of the pilot's view. Tr. at 13,036-41 (Fly). These reference features serve to update the pilot as to his physical location. Tr. 13,041 (Fly). The

¹⁴⁴ Because the tiles were laid directly upon the notepad, the demonstration did not accurately reflect the height of the clouds above the ground or the height of the aircraft attempting to observe the facility. *See* Tr. at 13,041-43 (Fly). Because the notepad was blank, the Applicant argues that the demonstration did not capture the landmarks on the ground that a pilot could use to orient himself with respect to the facility even if he could not observe it directly. *See* PFS Findings at 113 n.102.

Applicant argues that cloud cover — even at 75% — does not preclude a pilot's general positional awareness of the area. Tr. 13,048 (Fly).

B.86 The State's witness agreed with respect to his demonstration that a pilot would have general situational awareness under conditions of 25% cloud coverage. Tr. at 8417 (Horstman). A pilot would be able to see portions of Skull Valley road and would be able to see portions of a rail line to the proposed facility. Tr. at 8417-18 (Horstman). Thus, Lt. Colonel Horstman agreed that generally speaking, a pilot flying above 25% cloud cover would have an idea of the location of the Applicant's site. Tr. at 8418 (Horstman).

B.87 With respect to the State's second demonstration, Lt. Colonel Horstman placed large styrofoam cups on top of plastic columns to demonstrate that cloud cover can be very difficult to see through. Tr. 13,420-21 (State second demonstration). Even in such a circumstance, however, Lt. Colonel Horstman agreed that a pilot would have a general idea of the location of the Applicant's facility. Tr. at 13,457 (Horstman). He further agreed that if 8/8 cloud cover is present below 5000 feet AGL, the overcast would likely be too thick to fly under, and therefore, pilots would tend to fly above the clouds in the Sevier D MOA. Tr. at 13,456-57 (Horstman).

B.88 General Jefferson noted that training activities would likely not take place if heavy, floor-to-ceiling cloud cover were present, and, therefore, pilots would not be flying under those conditions. Tr. at 13,097-98 (Jefferson).

B.89 Lt. Colonel Horstman acknowledged that cloud cover above the pilot would not affect his ability to see the facility. Tr. at 8374-75, 13,456 (Horstman). The State asserts that a pilot flying beneath cloud cover, however, would not zoom the aircraft into clouds in the event of an emergency, a procedure used to gain more time, but, instead, may be forced to eject immediately depending on the altitude of the aircraft. Horstman Post Tr. 4214, at 21. The State points out that sky conditions above 5000 feet through 14,000 feet in Skull Valley are overcast or broken (5/8 to 100% cloud covered) 23% of the time. PFS Exh. 245.

B.90 Lt. Colonel Horstman also testified, however, that a pilot would be able to zoom up to a point under the clouds. *See* Tr. 8425 (Horstman). Thus, if the clouds were at 3500 feet AGL, a pilot flying at 2500 feet AGL at 425 knots would zoom to 3400 feet and would have sufficient time to avoid the Applicant's facility. Tr. at 8423, 8426 (Horstman). Further, even if a pilot could not zoom, a pilot may nonetheless have time to avoid the Applicant's facility. In this regard, if cloud cover is present at 3500 feet, a pilot flying at 3000 feet should have approximately 15 seconds to glide from 425 knots to 200 or 225 knots without zooming. Tr. at 8403-04 (Horstman).

B.91 On a related matter, the State asserts that based on the Applicant's cloud layering data, if a pilot zoomed to the top of the Sevier D MOA, a significant amount of clouds would likely be below the aircraft that would impact the visibility of objects on the ground. Tr. at 13,418, 13,434-35 (Horstman).

B.92 In addition to cloud cover, the State asserts that the presence of ground fog may affect the ability of a pilot to avoid the Applicant's facility in an emergency. Horstman Post Tr. 4214, at 24. In this regard, the State claims that Utah often experiences severe ground fog in the wintertime. Horstman Post Tr. 4214, at 24.

B.93 In response, the Applicant argues that ground fog typically occurs in the morning hours and subsequently burns off. Tr. at 13,075 (Vigeant). Further, ground fog is a function of season, such that there are more occurrences of ground fog in the wintertime than in the summertime. Tr. at 13,113-17 (Vigeant). The weather data for Michael Army Airfield show that the frequency of occurrence of ground fog is 2.5% of the observations on an annual basis. Tr. at 13,075 (Vigeant).

B.94 In the event that ground fog is present in Skull Valley, the Applicant points out that it could rise to heights in the tens of feet or the hundreds of feet, depending on the degree of cooling and the availability of moisture. Tr. at 13,111-12 (Vigeant). Thus, a pilot would be able to fly above the fog in the Sevier B and Sevier D MOAs. In such a case, a pilot would be able to maintain situational awareness by reference to the mountains, which would be visible above the fog, and would be able to use the F-16's onboard navigation systems. Tr. at 13,079-80 (Fly).

ii. Ability To Maintain Positional Awareness Through Landmarks

B.95 In addition, the Applicant asserts, even clouds that obstructed a pilot's view of the facility would not deprive him of knowledge of his position relative to the facility. Tr. at 3288-90 (Fly). That knowledge is what the pilot needs to avoid the site. Tr. at 13,711 (Jefferson). He could use landmarks such as Skull Valley Road, the Applicant's railroad, and the Stansbury and Cedar Mountains to see where he was relative to the Applicant's site. Tr. at 13,038-41, 13,044-52 (Fly). Colonel Fly performed a demonstration at the hearing in which he showed that even with as much as 75% cloud cover, a pilot could see landmarks that would enable him to determine his position relative to the location of the facility. Tr. at 13,044-48 (Fly). Thus, the Applicant argues, pilots would be aware of the relative position of the PFS facility during an emergency due to the pilot's positional awareness maintained during the flight prior to an emergency or prior to a decision to eject. Cole/Jefferson/Fly Post Tr. 3061, at 53.

B.96 The State's witness, Lt. Colonel Horstman, asserts that use of the Stansbury or Cedar Mountains as reference points is unlikely to assist pilots in avoiding the Applicant's facility. Horstman Post Tr. 4214, at 25. In this regard, the State claims: (1) that it is improbable that a pilot could determine the location of the Applicant's facility in Skull Valley by reference to the mountain ranges and that, even if the location could be initially estimated, the location of the facility

relative to the aircraft would be in constant change; (2) that a pilot would not attempt to head toward the mountains during an emergency because they are not safe places to eject; and (3) that the mountains themselves may be obscured by clouds and unavailable as visual reference points. Horstman Post Tr. 4214, at 25.

B.97 PFS witness Colonel Fly testified that a pilot would not necessarily have to be able to see the ground in order to avoid a site on the ground. Tr. at 3288-89 (Fly). Thus, the Applicant asserts, if a pilot can see a terrain feature, such as a mountain peak, the pilot will be generally aware that if he points the aircraft toward the mountain range, he will be clear of what he wants to avoid. Tr. at 3289-90 (Fly). With respect to Skull Valley, Colonel Fly testified that in cloud cover, the mountains in the vicinity of Skull Valley would give a “good general feel” for where the Applicant’s facility was located and would be available as a guide even if the aircraft is operating under a completely solid undercast. Tr. at 3601 (Fly). Moreover, in order to use the mountains as a steering reference, according to the Applicant, a pilot would only need to make a small turn toward them. Tr. at 13,701-02 (Fly). Turning a few degrees toward either the Stansbury or Cedar Mountain ranges would be sufficient to miss the Applicant’s site. Tr. at 13,700-02 (Fly).

B.98 With respect to Lt. Colonel Horstman’s assertion that a pilot would not attempt to head toward the mountains during an emergency because they are not safe places to eject, PFS counters that a pilot would be able to use the mountains as a general situational awareness aiming point and would be able to eject in Skull Valley shortly after placing the aircraft on a glide path that would direct it into the mountains. *See* Tr. at 13,701 (Fly) (a pilot would use the mountains for positional awareness in order to avoid a ground site). Lt. Colonel Horstman agreed that if a pilot was pointing the aircraft at the mountains prior to ejection, it would be possible for the pilot to eject before the aircraft reached the side of the mountain and that the pilot would not have to wait until directly over the mountain peaks to eject. Tr. at 13,508 (Horstman).

B.99 With respect to the State’s assertion that the mountains themselves may be obscured by clouds and unavailable as visual reference points, the Applicant notes that the evidence regarding clouds in Skull Valley indicates that such an occurrence in which all mountain ranges as well as the facility site would be obscured by clouds would be rare. *See* Revised Addendum, Tab FF. *See also* PFS Exh. W (describing the UTTR as having “excellent” weather and visibility). As described in more detail below, however, the Applicant points out that pilots flying under such conditions would rely on navigational aids to maintain positional awareness.

iii. Ability To Maintain Positional Awareness Through Navigational Tools

B.100 In addition to landmarks, the pilot would have available his navigational instruments, map, and flight plan to assist in determining his position relative to the location of the facility. Tr. at 13,049-52 (Fly).¹⁴⁵ According to the Applicant, even above a complete undercast, as he flew down the Valley the pilot would be using instruments and his map and could refer to features like the mountain ranges, if visible, to maintain awareness of his position. Tr. at 3288-90, 13,052-53, 13,079-80 (Fly); Tr. at 8479-80 (Horstman). These onboard navigation aids are: the Inertial Navigation System (INS); the Tactical Air Navigation System (TACAN); the Horizontal Situational Indicator (HSI); and, for those planes so equipped, the Global Positioning System (GPS). Cole/Jefferson/Fly Post Tr. 3061, at 51. During typical missions, pilots will use both visual references and onboard navigation systems together to maintain positional awareness. Revised Addendum, Tab FF at 28.

B.101 Inside the cockpit, the different instruments are physically mounted in a box, the glare shield. Tr. at 3114 (Fly). The heads-up display (HUD) is mounted on top of the glare shield and consists of a thick piece of glass. Underneath the HUD, a projector generates symbology — electronic green markings and images — up from the bottom of the glare shield onto the HUD. A pilot can see through the symbology and glass HUD and out of the aircraft. Tr. at 3114 (Fly). The target detection (TD) box is a green square that is projected onto the HUD and surrounds the selected steer point, a selected set of latitude and longitude coordinates. Tr. at 3114-15 (Fly). *See* Revised Addendum, Tab FF at 28. The TD box assists the pilot in finding the next geographical point on the planned route of flight for navigational purposes. Tr. at 3115 (Fly). Each steer point is programmed into the onboard INS, and the pilot selects which steer points he wants to use during a flight. Tr. at 3115, 13,049 (Fly) (steer points determined as part of mission planning). The INS can be used to navigate to or from the steer point or can be used to maintain awareness of the location of the steer point. Revised Addendum, Tab FF at 28. Colonel Fly noted that a pilot in Skull Valley would have a steer point programmed into the INS somewhere in the vicinity of the narrow neck of Skull Valley and would be able to figure out bearing and distance with respect to that point. Tr. at 3602 (Fly).

B.102 The F-16 is also equipped with the TACAN, which provides bearing and distance information from a selected ground station. Revised Addendum, Tab FF at 28. TACAN detects radio signals transmitted from different radio stations around the country, such as from Hill AFB, and will provide the pilot with the distance of the aircraft to the transmitting ground station. Tr. at 3289 (Fly). Thus, a

¹⁴⁵The relevant navigational instruments continue to show relative bearing and the distance to the preselected point after an engine failure. Tr. at 13,053-54 (Fly).

pilot may know at any given time his position relative to Hill AFB. *See* Tr. at 3289 (Fly). In addition, some models of the F-16 are equipped with a GPS receiver, which uses the satellite navigation constellation to maintain positional awareness and makes the INS more precise. Revised Addendum, Tab FF at 28. The F-16 is also equipped with an onboard HSI, which displays distance and bearing to selected navigational steer points. Tr. at 13,050-51 (Fly). A pilot can use this equipment to maintain a ground track of the flight. Cole/Jefferson/Fly Post Tr. 3061, at 51; Campe/Ghosh Post Tr. 4078, at 23. As Colonel Fly explained, the HSI would enable a pilot to determine the aircraft's location relative to a visible course line that connects the various steer points. Tr. at 13,050-51 (Fly).

B.103 In any event, the Applicant points out that the route of flight would be thoroughly planned beforehand with turn points along the way that the pilot could use as a reference to determine his position. Tr. at 13,049-51 (Fly).

B.104 The State argues that a pilot cannot rely on navigation instruments to locate the Applicant's facility during an emergency. Horstman Post Tr. 4214, at 24. In this regard, the State asserts that during an engine failure, the precision of the navigation system is reduced, and the instruments will work on and off for short periods of time as the electrical system switches to the backup systems. *Id.* Lt. Colonel Horstman testified that once the emergency power unit (EPU) comes up to speed, it takes more time to power the bus, which is "not instantaneous." Tr. at 8484 (Horstman). He also stated that once the HUD returns, some of the information available to pilots does not come back. *Id.* He agreed, however, that the HUD would continue to display the steer points. *Id.* at 8486.

B.105 The Applicant counters that the HUD shuts down when the main generator shuts down and comes back as soon as the standby power system comes on line. Tr. at 3118-19 (Fly). The time in which the HUD is off during this time is approximately 2 seconds, which is "a very short period of time." Tr. at 3124, 3590 (Fly). The F-16 operating manual states that the emergency power unit is designated to operate automatically for main and standby generator failure "or if the engine is shut down in flight." Technical Order 1F-16C-1, at 1-94 (PFS Exh. 000). Further "[a]fter receiving any start command, the EPU requires approximately 2 seconds to come up to speed." *Id.* Colonel Fly also testified that the INS would still show the relative bearing and the distance to the selected turn point in the event of an engine failure. Tr. at 13,053-54 (Fly).

B.106 The Applicant maintains that the area around the facility is wide open so the pilot would not have to have a highly precise picture of its location in order to avoid it. Tr. at 13,711 (Jefferson) As discussed above, the only other buildings present near the facility are the Goshute village, about 3.75 miles east of the site, and two ranches, located 2.75 and 4.0 miles northeast of the site, and Tekoi (no longer in operation) 2 miles to the southeast. There are no structures of any kind to the west of the site. Aircraft Crash Report at 21-22.

(c) *Pilot Ability To See Site During Emergency Procedures*

B.107 In addition to cloud cover potentially limiting a pilot's ability to see the PFS facility, the State asserts that during an emergency zoom, a pilot's vision will be partially blocked so that he is unable to clearly see the facility. State Findings ¶96. The State asserts that a pilot flying straight and level in an F-16 can see only 11 degrees below the horizon before the nose of the aircraft obstructs the pilot's view. *See* State Findings ¶91. Therefore, a pilot flying through Skull Valley at 425 knots and 4000 feet AGL would not be able to see the ground for a distance of over 4 miles in front of the aircraft. Tr. at 13,639-40 (Fly). Assuming a Skull Valley emergency caused by an engine failure, the State asserts that the task of a pilot includes the following events:

B.108 Upon realizing the engine has failed, a pilot will zoom the aircraft, trading speed for altitude to prolong the time aloft before crashing. Horstman Post Tr. 4214, ¶61. During the zoom, the aircraft nose will be pointed 30 degrees nose high, blocking the view of the ground in front of the aircraft. Tr. at 13,080-81 (Fly). If the pilot had been flying at an altitude of 4000 feet AGL, the State estimates the zoom would take the F-16 to approximately 7000 or 8000 feet AGL. Tr. at 13,453 (Horstman). In accordance with the F-16 flight manual, as the State points out, upon reaching the airspeed of 250 knots the pilot will end the zoom by "pushing the plane over" and start a descent. Tr. at 13,299-300 (Horstman). The maneuver of pushing the plane over uses some of the F-16's energy and the aircraft slows to approximately 200 knots. Tr. at 13,300-01 (Horstman).

B.109 The State estimates that the F-16 will then begin a glide at the speed of 200 knots with approximately a 6-degree angle of descent. Tr. at 13,301 (Horstman); *see also* Tr. at 13,641-42 (Fly). If the emergency occurred in the general area of Skull Valley, the State asserts the pilot would then turn the aircraft toward Michael Army Airfield, the designated emergency airfield and attempt to restart the engine during the glide. Tr. at 8576-79, 8601-05, 8625-27 (Horstman). It points out that during the glide descending at 6 degrees, the pilot's view will be obscured in front of the aircraft for a distance of approximately 5500 feet for every 1000 feet of altitude. *See* State Findings ¶94. According to the State, as the aircraft continues on this glide path, the pilot will not be able to see ground terrain closer than 22,000 feet (4.16 miles), in front of the aircraft at the altitude of 4000 feet AGL, nor closer than 13,750 feet in front of the aircraft at an altitude 2500 feet AGL. Tr. at 13,639-42 (Fly).

B.110 The State asserts that upon reaching the altitude of 2500 feet AGL, the pilot will slow the F-16 to the slowest possible speed in preparation for ejection. *See* State Findings ¶95. According to the State's witness, slowing the F-16 for ejection is done by raising the nose of the aircraft up to as much as 20 degrees above the horizon, at which point the nose of the aircraft will block the pilot's view of the ground in front of the aircraft for 10 miles. Tr. at 13,303 (Horstman).

The F-16 will remain at as much as 20 degrees nose high until the pilot ejects. Tr. at 13,303 (Horstman). As a result, the State calculates that at the minimum ejection altitude of 2000 AGL, the F-16 will be 3.22 miles from the crash impact site. Tr. at 13,612-13, 13,624 (Horstman).

B.111 The State further argues that after the pilot ejects, assuming the aircraft was correctly aimed, the aircraft would have to travel for over 3 miles without changing direction in order to crash at the selected site. However, if the pilot ejects at a slight bank, the aircraft's computer will hold that bank which will generate a turn in the F-16's heading. Tr. at 8525-26 (Horstman). Even if the aircraft is not initially in bank, an F-16 gliding from 4000 feet AGL may roll and bank, causing it to deviate 10 to 20 degrees from its initial heading. Tr. at 4016-17 (Cosby). Simple trigonometry shows that an F-16 aimed at a ground site from 3.2 miles away that deviated off course by 10 degrees would miss its target by over one-half mile. In such a case, an aircraft aimed to crash one-half mile away from the Applicant's site may in fact hit the site.

B.112 The Applicant disagrees with the State's claim that during the zoom and glide maneuver that a pilot would execute in response to an engine failure in Skull Valley, his view of the ground in front of the aircraft would be "substantially impaired." PFS Reply ¶ 144. First, PFS argues, the pilot would know where he was relative to the facility immediately prior to suffering the engine failure. Tr. at 13,053-54 (Fly). Second, during the entire glide descent, the pilot will be able to see the ground in front of the aircraft sufficiently far ahead to see where the aircraft would hit if the pilot did not turn it. Tr. at 13,642-44 (Fly). Furthermore, the pilot has a larger field of view just to each side of the nose of the aircraft. Tr. at 13,640-41 (Fly). Thus, the pilot's view of sites on the ground that the aircraft might hit would not be obstructed.

B.113 PFS also contends that there is no requirement for a pilot to raise the nose of the aircraft 20 degrees above the horizon prior to ejecting. PFS Reply ¶ 145. According to the Applicant, the ejection procedures in the pilots' operation manual make no mention of raising the nose above the horizon. PFS Reply ¶ 145. The prescribed emergency procedure tells the pilot to eject at the "lowest practical airspeed." PFS Exh. PPP at 3-42, 3-43. Finally, a pilot would turn to avoid the facility before he ejected, so even if he were to raise the nose of the aircraft, by the time he was doing so, he would no longer be pointed at the facility. Tr. at 3921 (Bernard), 3776-78 (Cole/Fly/Jefferson), 4026-27 (Cosby).

(8) FLIGHT CONTROLS

B.114 According to the Applicant, avoidance of the site would also be facilitated by the F-16 flight control computer, which keeps the F-16 on a straight

course after the pilot ejects.¹⁴⁶ Aircraft Crash Report at 21; Tr. at 3507 (Jefferson), 3996-98; *see* Tr. at 4016-17 (Cosby). The computer will attempt to keep the aircraft flying at a constant altitude by increasing the angle of attack of the aircraft as it decelerates. Once the aircraft reaches a programmed angle of attack, the computer will hold that attitude and heading as the aircraft descends while maintaining that angle of attack. Aircraft Crash Report at 21. The aircraft will most likely impact the ground at a velocity between 170 and 210 knots at a point along the straight-ahead flight path from the point of pilot ejection. Aircraft Crash Report at 21; Tr. at 3096-99 (Fly). The aircraft may roll slightly about its longitudinal axis after the pilot ejects, but the flight path along the ground would remain basically unchanged. Tr. at 4019-20, 4025-26, 4029-30 (Cosby). This would be the case even with the aircraft canopy gone after the pilot ejects. Tr. at 3527 (Fly).

(9) APPLICANT'S CONCLUSION

B.115 Based on the above eight factors, the Applicant's expert panel concluded that "a pilot who remained in control of the aircraft after the event precipitating the crash would invariably take action to have the crashing F-16 miss the site." Aircraft Crash Report at 23; *see* Cole/Jefferson/Fly Post Tr. 3061, at 17. They found further support for this conclusion in the "F-16 accident investigation reports, which show that pilots do, when relevant, maneuver [the] aircraft to avoid sites on the ground." Nevertheless, to account for possible unforeseen circumstances they determined that a pilot in control of a crashing aircraft would be able to direct the aircraft away from the facility not all the time, but only 95% of the time. Cole/Jefferson/Fly Post Tr. 3061, at 17.

b. Evaluation of Accident Reports for Probability of Pilot Avoidance

(1) APPLICANT'S METHODOLOGY

B.116 As discussed above, based upon its eight-factor evaluation of the time and circumstances involving likely emergencies that might occur while transiting Skull Valley, the Applicant's expert panel determined that "a pilot who remained in control of the aircraft after the event precipitating the crash would invariably take action to have the crashing F-16 miss the site." Aircraft Crash Report at 23; *see* Cole/Jefferson/Fly Post Tr. 3061, at 17. In addition, the Applicant's expert panel relied upon the accident reports for confirmation of their professional assessment. Cole/Jefferson/Fly Post Tr. 3061, at 17. The Applicant asserts that the accident reports showed that pilots in control of a crashing aircraft do in

¹⁴⁶The computer operates on backup power sources after an engine failure. Tr. at 3525-26 (Fly).

fact take necessary action to avoid sites on the ground after an accident-initiating event. *Id.* In addition, it points out that the accident reports showed no cases in which a pilot failed to take steps to avoid or minimize damage to facilities or populated areas on the ground. *Id.* Based on their review of the accident reports, the Applicant's panel believed that the percentage of pilots in control who would avoid the facility could reasonably be set at 100%. *Id.* Nevertheless, to account for possible unforeseen circumstances, they determined that a pilot in control of a crashing aircraft would be able to direct the aircraft away from the facility only 95% of the time. *Id.*

B.117 In response to questions from the Board, the Applicant's expert panel undertook a more formal evaluation of the accident reports for information concerning pilot avoidance. Tr. at 8662-63 (Jefferson). The evaluation focused on the F-16 accident reports for the fifty-eight accidents that the expert panel initially determined were Skull Valley-type events in which the pilot retained control of the aircraft. *See* PFS Exh. 100A. Because many of the accidents occurred in military training areas with little or no civilian population, many of the accident reports do not contain any discussion of pilot avoidance because of the lack of populated or built-up areas that would require avoidance. Tr. at 13,107 (Jefferson). Therefore, in addition to direct evidence of steps a pilot may have taken or not taken to avoid populated or built-up areas, the Applicant's expert panel also looked at a pilot's maneuvering of the aircraft as indicating that he had situational awareness and knew where he needed to go, as well as the absence of actual damage on the ground caused by the impact as indicating that the pilot did not fail to take action to avoid a site or structure on the ground. *See, e.g.,* Tr. at 13,106-07, 13,117 (Jefferson); Tr. at 13,099-103 (Jefferson/Fly).

B.118 The Applicant's expert panel conceded that its evaluation of the accident reports was not a statistically based evaluation. Tr. at 13,109-10, 13,121-22 (Jefferson). Rather, it was a qualitative evaluation of information in the reports relevant to the issue of pilot avoidance. Tr. at 13,118-24 (Jefferson/Cole). The Applicant argues that what is highly significant in this respect is that the reports show no instance in which a pilot failed to take steps to avoid or minimize damage to facilities or populated areas on the ground. PFS Findings ¶ 145.

B.119 The expert panel's evaluation of the fifty-nine Skull Valley events in which the pilot retained control of the aircraft showed seventeen instances where specific actions were taken by the pilot to avoid areas or structures on the ground after an accident-initiating event. Tr. at 8662-63 (Jefferson). In addition, the Applicant points out that the accident reports showed twenty-nine cases in which the pilot turned toward an emergency airfield or took some other action indicating that he had situational awareness and knew where he needed to go. *Id.* Finally, the remaining thirteen accident reports showed no cases where the pilot had the opportunity to avoid a facility or populated area on the ground but failed to do

so; in other words those reports showed no harm to people or structures on the ground. *Id.*¹⁴⁷

B.120 The Applicant asserts that the accident reports clearly confirm a key fact that all pilots have testified to in this proceeding — that time and circumstances permitting, a pilot will avoid populated and built-up areas. PFS Findings ¶ 147. For example, a number of the reports show that the mishap pilot maneuvered the aircraft in order to avoid populated areas or particular structures and built-up areas that were directly in their flight path. *Id.* The clearest example of this is the accident report involving Colonel Cosby as amplified by his personal testimony. The accident report succinctly states that: “Noticing a residential area in [his] flight path, [Colonel Cosby] made a 2-G left turn” PFS Exh. 79, Bates No. 57619. The Board heard Colonel Cosby’s testimony in particular that he saw an apartment complex in front of him and made a hard 180-degree turn to the left in order to avoid it. Tr. at 3980-81 (Cosby). The Applicant argues that a 180-degree turn reversing direction is clearly much more than would be required for a pilot to turn and avoid the facility. PFS Findings ¶ 147. In addition, as Colonel Cosby was attempting to land he saw another plane on the taxiway on which he was trying to land and again maneuvered his aircraft (“put[ting] the airplane off in the infield”) to avoid the plane. Tr. at 3980-81 (Cosby).

B.121 The Applicant argues that in addition to the reports stating explicitly that the pilot avoided an area on the ground, twenty-nine other reports showed cases in which the pilot turned toward an emergency airfield or took some other action indicating that he had situational awareness and knew where he needed to go. Tr. at 8663 (Jefferson). Those cases show that the pilots knew where they were and acted accordingly in the event of an emergency, whether turning toward an emergency airfield, away from a populated area, or both. Tr. at 13,102 (Fly). In the June 7, 1996 accident, the report specifically states that the pilot made an “instinctive” turn back toward his home base when the incident began. Joint Exh. 9 at 2. In the April 18, 1991 accident, “[t]he mishap pilot immediately zoomed the aircraft, turned toward home base and initiated engine airstart procedures.” PFS Exh. 127, Bates No. 57137. In the September 11, 1993 accident, “During a pull up after the third bombing pass, Bronco 3 experienced a momentary airframe vibration which stopped, then reappeared moments later on the base turn. [He] terminated the bomb pass and began a climb towards the emergency divert field.” PFS Exh. 158 at 1. According to PFS, these are just a few examples in the reports

¹⁴⁷ While the reports are required to indicate any damage or injuries on the ground, they are not required to report pilot avoidance actions. Tr. at 3661 (Cole). Thus, a case with no damage but no mention of pilot avoidance might or might not have been a case in which the pilot avoided something; the only thing such a case indicates is that the pilot did not fail to avoid something. Tr. at 3661, 3663-64 (Cole); Tr. at 3670 (Jefferson).

that clearly show that the pilots have an awareness of where they are and what needs to be done in the event of an emergency.

B.122 Finally, the Applicant points out that, although the remaining thirteen accident reports did not state whether the pilot maneuvered, they reported no harm to people or structures on the ground, i.e., they showed no cases where the pilot had the opportunity to avoid a facility or populated area on the ground but failed to do so. *See* Tr. at 8663 (Jefferson); *see also* PFS Exh. 100A.¹⁴⁸ While this last group of reports contains less explicit information than the first two, the Applicant says the point they stand for is important. Arguing that if the probability of failure is defined as one minus the probability of success, the Applicant posits that because the reports show no cases of failure to avoid, they support a finding that the probability of successful avoidance is 100%. Tr. at 13,117 (Jefferson); Aircraft Crash Report, Tab H at 28 n.22.

B.123 The Applicant also indicates that the accident reports highlight the assistance provided the accident pilot by his wingman (or in one case, air traffic control) in terms of directing the aircraft away from structures and facilities on the ground and other aspects of responding to the emergency. PFS Findings ¶ 154. Colonel Fly testified that he would expect other flight members to alert a pilot of an aircraft with a problem to the location of the facility or any other area to avoid. Tr. at 13,658-59 (Fly). His testimony is supported by the accident reports describing flight members (and in one case, air traffic control) helping pilots respond to their emergencies and avoid areas on the ground.¹⁴⁹ Therefore, because F-16s typically transit Skull Valley in flights of two or four aircraft, there is additional reason to believe that a pilot would be able to avoid the facility in the event of an accident.

(2) STATE CHALLENGE

B.124 With respect to the Applicant's review of 126 U.S. Air Force F-16 mishap reports for the 10-year period 1989 through 1998 and the 58 reports identified in PFS Exh.100A, the State argues that even before reviewing the reports, the Applicant had already concluded that 95% of pilots would be able to avoid the Applicant's site, Tr. at 3967 (Jefferson), and that the reports were reviewed and PFS Exh. 100A was prepared to justify the 95% component of the "R" factor. Tr. at 13,100 (Jefferson).

¹⁴⁸ Accident reports must cover damage or injuries on the ground. *See* note 147, above.

¹⁴⁹ *See, e.g.*, Joint Exh. 3, Bates No. 57126 (assistance with location of emergency airfield); Joint Exh. 5 at 2 (assistance with location of airfield); Joint Exh. 10 at 3-4 (location of airfield, safe location to jettison fuel tanks); Joint Exh. 11 at 3 (vector to clear area from air traffic control); Joint Exh. 14 at 3 (altitude and navigation assistance); Joint Exh. 15 at 3 (assistance clearing impact area of boats).

B.125 The State further challenges the use of the reports on the basis that Air Force mishap reports are not prepared for the purpose of determining if the pilot avoided a ground site or could be counted on to avoid a ground site, a fact that the Applicant acknowledges. Tr. at 13,118 (Jefferson). Air Force regulations requiring when and how mishap reports are prepared do not include guidance on the subject of the pilot's avoidance of a ground site. Tr. at 13,119 (Jefferson); State Exh. 60, Ch. 8.

B.126 The same fifty-eight crashes shown in PFS Exh.100A as examples of where "the pilot retained control and had enough time to avoid a specific site" were reviewed extensively by Lt. Colonel Horstman. Tr. at 13,362-66 (Horstman). Contrary to the Applicant's findings, Lt. Colonel Horstman's review of those fifty-eight crashes shows that in no case did a pilot identify a specific ground site from the minimum ejection altitude of 2000 feet and take some maneuver to avoid it. State Exh. 223,¹⁵⁰ Tr. at 13,370-92, 13,407-10, 13,445-47 (Horstman). According to the State, the pilot task contemplated by the Applicant's avoidance factor, the identification of a ground site from a distance of 3.22 miles or more, and turning away from that sight did not happen a single time during the 10-year period reviewed by the Applicant. *Id.*; State Exh. 223.

As may be seen from the above, the Applicant made a commendable attempt to demonstrate that there were no insurmountable obstacles to pilots succeeding in the site avoidance behavior upon which the Applicant's case depends. But the Applicant's showing could not overcome the State's countering showing that, first, in some circumstances obstacles would exist, and that second — and more important — accident experience, recognized in Air Force directives and memorialized in crash reports, establishes beyond doubt that human beings, under stress, fail even though the conditions for success exist.

Accordingly, we cannot find otherwise than that the Applicant's claim of near certain success in human performance under stress-filled conditions was simply not proven. As we said at the outset of this Subpart, we find that in light of the whole of the evidence the State presented — covering a number of different problem areas and pointing to Air Force acknowledgment of pilot error — the Applicant failed to carry its burden on its assertion that pilots would, before ejecting, almost invariably (95% of the time) act affirmatively to guide their aircraft away from striking the PFS facility in the event of an impending crash. In short, in view of the totality of the evidence presented by the parties, the Applicant has not sustained its claim that pilots will successfully avoid the site in virtually every instance.

¹⁵⁰ Entries No. 11 and No. 31 are the same mishap, making a total of fifty-eight mishaps shown on State Exh. 223.

C. Four-Factor Formula

In this final Subpart, we address the many disputes among the parties as to the values that should be used for the standard factors that make up the classic NUREG-0800 formula. Again, a central message is that for three of those factors, the data that exist are largely not directly on point, and the values for the factors have to be derived indirectly from such data. Many of the disputes, then, turn on what is the most appropriate way to conduct those derivations.

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1. Background

C.1 In accordance with the review guidelines described in NUREG-0800 § 3.1.5.6, “Aircraft Hazards,” the Staff reviews all potential aircraft activity in the vicinity of a nuclear facility, such as a reactor or an away-from-reactor spent fuel storage site. Campe/Ghosh Post Tr. 4078, at 7. This review includes the consideration of general, commercial, and military aviation. Campe/Ghosh Post Tr. 4078, at 7. The review covers specific aviation aspects such as nearby airways and airports, taking into account aircraft types, air traffic density, and specific airway and airport characteristics. *Id.*

2. *Formula*

C.2 The formula for calculating aircraft crash probability for nuclear facilities is

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

where P is the annual probability of an aircraft crash and the four factors represent, respectively, the Crash rate (per mile), the Number of flights (per year), the Area of the facility (in square miles), and the width of the airway (in miles). There is no dispute among the parties — apart from that over the R factor — that this formula is an appropriate method for calculating the aircraft crash hazard for the proposed facility. The governing Commission criterion, established in this case, allows a facility like this one to be licensed if the calculated probability of an aircraft crash on the site is less than one in a million (1×10^{-6}) annually.

3. *Basic Disagreements*

C.3 The State disputes the numerical values the Applicant and the Staff would assign to three of the four factors required by the NUREG-0800 equation. The disputed factors are crash rate (C); number of aircraft (N); and width of airway (w). According to the State, both the Applicant and Staff have selected values for these parameters that are incorrect and result in estimates of annual crash probability on the PFS site that are low.

C.4 There is no dispute among the parties regarding the fourth factor, which specifies the effective area of the PFS site. All parties accept the area determined by the Applicant (1.337 square miles) as the appropriate value. The Board has reviewed that determination and we accept it as reasonable.

4. *Input Values*

a. *Crash Rate per Mile (C)*

C.5 The Applicant believes the crash rate of F-16s to be 2.736×10^{-8} per mile for normal in-flight mode. Cole/Jefferson/Fly Post Tr. 3061, at 16. In deriving this number, the Applicant took an average of the crash rates for the F-16 in normal in-flight operations over the 10-year period from FY 1989 to FY 1998. *Id.*

C.6 The Applicant derived its F-16 crash rate by combining the data obtained from a DOE study with the mishap rates obtained from the Air Force. Campe/Ghosh Post Tr. 4078, at 11. The DOE study is entitled, “Data Development Technical Support Document for the Aircraft Crash Risk Analysis Methodology (ACRAM) Standard,” Kimura *et al.* (1996) (ACRAM Study). The ACRAM Study provides F-16 crash rate data for the period from 1975 through

1993. ACRAM Study at 4-1. *See* Campe/Ghosh Post Tr. 4078, at 11. The ACRAM Study categorizes the crash rate data according to four modes of flight — takeoff, landing, normal in-flight, and special operation. ACRAM Study at 4-4. After reviewing the four different modes of flight, the Applicant concluded that normal in-flight mode was the category that best represented the conditions in which F-16s transit Skull Valley. Campe/Ghosh Post Tr. 4078, at 11-12. Normal in-flight includes “climb to cruise, cruise between an originating airfield and an operations area, if applicable, and cruise descent portions” of flight. ACRAM Study at 4-5. According to the ACRAM Study, the per-mile crash rate for F-16 normal in-flight is 3.86×10^{-6} . ACRAM Study, Table 4.8.

C.7 Because the ACRAM Study did not contain crash rate data for the years after 1993, the Applicant turned to data obtained from the Air Force to provide crash rate data for the second half of its 10-year period. *See* Aircraft Crash Report at 8-11; SER at 15-52. The Air Force maintains mishap rates categorized in terms of the number of crashes per 100,000 hours of flight for each type of aircraft. SER at 15-52. The Applicant used the Air Force mishap rates for 1994 to 1998 to update the data for the ACRAM Study in order to create a complete data set for the 10-year period from 1989 to 1998. Aircraft Crash Report at 9.

C.8 Because the NUREG-0800 formula requires an in-flight crash rate per mile and the Air Force mishap data are expressed per 100,000 hours of flight, the Air Force data must be converted to a crash rate per mile to be used in the formula. PFS used the data set forth in the ACRAM to obtain an average flight speed to be used for this conversion. Aircraft Crash Report, Tabs C, D. The ACRAM document contains mishap data and the estimated mileage and number of flight hours for F-16s during years 1975 through 1993. Aircraft Crash Report at 10, Tabs C, D. Using these ACRAM data, PFS divided the total miles by the total hours to obtain an average flight speed of 471.85 miles per hour flown by F-16s during years 1975 through 1993. Aircraft Crash Report, Tab D.

C.9 The Air Force mishap data are also not separated into the various phases of flight, i.e., takeoff, landing, special operations, and normal flight. Therefore, the Applicant was forced to further manipulate the Air Force data to ensure that only “normal flight” data were used in its crash rate calculation. To do so, the Applicant estimated the percentage of all mishaps occurring during “normal flight” and applied that percentage to the Air Force data. Aircraft Crash Report at 11-14, Tab D. The Applicant based its estimate on the ACRAM data that contain both Class A and Class B mishaps from 1975 through 1993, separated into the four phases of flight: takeoff, landing, normal flight, and special operations. Aircraft Crash Report, Tabs C, D. The Applicant divided the number of mishaps shown in the ACRAM data for “normal flight” by the total mishaps for all F-16 flights, obtaining 15.09% as the percentage of F-16 mishaps occurring in “normal flight” during years 1975 through 1993. Aircraft Crash Report, Tabs C, D. Similarly, the Applicant estimated the flight miles occurring during normal flight by dividing

the number of “normal flight” F-16 miles shown in the ACRAM data by the total F-16 flight miles, obtaining 47.18% of flight miles occurring during the “normal” phase of flight. Aircraft Crash Report, Tabs C, D at 1.

C.10 The Applicant used the average speed of 471.8 miles per hour, 15.09% as the percentage of mishaps occurring during “normal flight,” and 47.18% of all flight miles occurring in the “normal” phase to derive a “normal flight” crash rate per mile from the Air Force mishap data. Aircraft Crash Report, Tabs C, D at 2. The Applicant calculated a crash rate using Air Force F-16 mishap data for the 10-year period 1989 through 1998, obtaining a crash rate of 2.736×10^{-8} per mile. *Id.* at 11, Tab D. The Applicant chose this particular 10-year period because, given the downward trend in crash rate demonstrated by the data, it believed that the data for this time period best represented the actual crash rate. *Id.* at 11.

C.11 The State argues that the mishap data for the 10-year period used by the Applicant produces the lowest 10-year average crash rate in the history of the F-16. Resnikoff Post Tr. 8698, at 15. Further the State points out that the years 1995 through 2001 show an increasing trend in F-16 crash rates. *See* State Findings ¶34 (*citing* State Exh. 155). In that regard, the State insists that no objective basis is given by the Applicant as to why the years 1989 to 1998 were chosen as the basis for a crash rate; rather, the decision was admittedly subjective. Thus, the State insists that it is neither reasonable nor conservative to base the F-16 crash rate on data from the 10-year period 1989 through 1998. *See* State Findings ¶34.

C.12 According to the State, the annual crash rate for the F-16 has varied substantially from 1975 through 2001. The State believes that the initial years of service through 1983 show a period of comparatively high accident rates. Furthermore, the State contends that every fighter aircraft the Air Force has ever had shows the phenomenon of higher crash rates in initial years. Moreover, the State also asserts that the Applicant’s Aircraft Crash Report shows higher crash rates for single-engine fighter aircraft even after they have been in service for 100,000 hours. *See id.* ¶35. The F-16 is expected to be replaced in 2010, and the replacement aircraft is expected to also have a higher startup crash rate. Tr. at 3371-72 (Cole), 3367-68 (Jefferson). During the most recent 7 years for which data are available, the State argues that there is an increasing trend in F-16 crash rates. *See* State Findings ¶35 (*citing* State Exh. 155; Tr. at 8944-45 (Campe); Resnikoff Post Tr. 8698, at 11-12). According to the State’s experts such a trend is common, because crash rates for fighter aircraft are typically higher at the beginning and at the end of an aircraft’s service life. Thus, the State argues that using the mishap data for all available years that an aircraft has been in service is the best predictor of the aircraft’s future crash rate. Horstman Post Tr. 4214, at 13-14. The State argues that even in the case of an apparent trend of decreasing crash rates, which is not the case here, it would not be reasonable to limit the database, and all years of data should be used. *See* State Findings ¶35. In that

regard, the State points out that the database used for the ACRAM technical support document used all years of crash history and did not attempt to select or omit certain years of crash history for the F-16 or other aircraft. Resnikoff Post Tr. 8698, at 9. Thus, the State insists that the most realistic estimate of future F-16 crash rates is obtained by using the entire F-16 crash history for all years available. *See* State Findings ¶ 35.

C.13 Using the average flight speed of 471.85 miles per hour, the ratio of 15.09% mishaps occurring in “normal flight” and the ratio 47.18% of miles flown in “normal” phase of flight, but using the Air Force F-16 Class A and B mishap data for years 1975 through 2000, the State derives a crash per mile for normal flight of 3.39×10^{-8} . Resnikoff Post Tr. 8698, at 15; State Exh. 76. Furthermore, the State notes that by adding the F-16 Class A and B mishap data for 2001 shown on State Exh. 154, i.e., 22 mishaps and 337,315 flight hours, to those same calculations increases the crash rate per mile for normal flight to 3.44×10^{-8} . Therefore, the State argues that at a minimum using a value for C, in-flight crash rate per mile for aircraft using airway, of less than 3.44×10^{-8} crashes per mile is not realistic. *See* State Findings ¶ 36.

C.14 The State also attacks the Applicant’s decision to include only the normal flight phase of flight in its crash rate calculation. The State begins by claiming that during the years 1975-1993, the time period of the ACRAM data, a greater percentage of Class B mishaps (which are not actual aircraft crashes) occurred in flight phases other than the normal phase of flight (i.e., takeoff, landing, or special operations). The State calculates a fraction of destroyed aircraft accidents in the normal phase of flight for the period FY 1989 to FY 1998 of 22.3%, using PFS’s assessment in Tab H of the Aircraft Report of the number of F-16s that were destroyed during the normal phase from FY 1989 to FY 1998. The State compares that fraction (22.3%) to the fraction of total F-16 mishaps (Class A and Class B) occurring in the normal phase of flight from 1975 to 1993 as assessed in the ACRAM Study (15.09%) and concludes that in the period considered by the ACRAM Study a greater fraction of Class B mishaps occurred in phases other than the normal phase of flight. *See* State Findings ¶ 30.

C.15 Furthermore, the State argues that the problems with the Applicant’s crash rate are compounded by its use of the ratio of 15.09% of all Class A and B mishaps to determine the number of mishaps occurring in “normal” flight. Aircraft Crash Report, Tab D. According to the State, this ratio of 15.09% was derived from ACRAM data which divided mishaps into the four phases of flight without indicating whether a mishap was a Class A or B mishap. *Id.*, Tabs C, D. The State contends that a second ratio for normal flight mishaps was obtained when the Applicant analyzed 121 destroyed F-16 crashes during the 10-year period 1989 through 1998, and determined that 27 of those crashes (22.3%) occurred in the “normal” phase of flight. Resnikoff Post Tr. 8698, at 15 (*citing* Aircraft Crash Report, Tab H at 12). Because of the unknown distribution of Class

A and B mishaps between the various phases of flight in the ACRAM Study, and because of its comparatively older data, the State argues that the ratio indicating that 22.3% of all destroyed aircraft are destroyed in the normal flight phase, when applied to the number of total destroyed F-16s, is the best evidence on which to base an estimate of F-16 mishaps occurring in the “normal” flight phase. *See* State Findings ¶ 37.

C.16 Therefore, using the average flight speed of 471.85 miles per hour, the ratio of 22.3% for destroyed F-16s occurring in “normal flight,” and 47.18% of all flight miles occurring in the “normal” phase of flight, the State has determined the crash rate per mile for normal flight based on lifetime F-16 mishap data¹⁵¹ is 4.10×10^{-8} . This value was obtained as follows:

$$6,644,260 \text{ hours} \times 471.85 = 3.135 \times 10^9 \text{ miles,}$$

$$3.135 \times 10^9 \text{ miles} \times 47.18\% = 1.479 \times 10^9 \text{ miles in normal flight,}$$

$$272 \text{ destroyed aircraft} \times 22.3\% = 60.66 \text{ destroyed F-16 mishaps during normal flight,}$$

$$60.66 \text{ mishaps} / 1.479 \times 10^9 \text{ “normal” flight miles} = 4.10 \times 10^{-8} \text{ crashes per mile.}$$

Thus, the State insists that the realistic crash rate for the F-16 to be used as the value for C, the “inflight crash rate per mile for aircraft using airway,” is 4.10×10^{-8} . *See* State Findings ¶ 38.

C.17 We do not accept the State’s crash rate. It is higher than the F-16 lifetime crash rate for normal operations of 3.86×10^{-8} per mile through 1993 set forth in the DOE ACRAM Study, which both PFS’s expert panel and Dr. Resnikoff used as the starting point for their calculations. State Exh. 51, Table 4.8; *see* Aircraft Crash Report, Tab D; Resnikoff Post Tr. 8698, at 14-15. Further, both the Applicant’s expert panel and Lt. Colonel Horstman agree that the overall crash rate for the F-16 was higher in its initial years than now, as one would expect, but that the crash rate has been lower and approximately level for the last 15 years or so. *See* Cole/Jefferson/Fly Post Tr. 3061, at 27-31; PFS Exh Q; Tr. at 4376-77 (Horstman). Therefore, even assuming the use of a lifetime rate were appropriate, the current lifetime rate should be lower than that calculated based on the data through 1993, not higher as the State now argues for the first time.

C.18 We find the State’s claim regarding the distribution of Class B mishaps is unsupported for two reasons. First, the ACRAM data do not indicate what fractions of Class A mishaps, Class B mishaps, and destroyed aircraft accidents (which are a subset of Class A mishaps) occurred in each phase of flight. The ACRAM Study provides a breakdown only of total mishaps by phase of flight.

¹⁵¹ Mishap data from U.S. Air Force mishap report 1975-2001, State Exh. 154, second page.

See Aircraft Report Tab C, Table 4.8. Thus, ACRAM does not state that a higher fraction of Class B mishaps occurred in phases of flight other than the normal phase. Second, the State is comparing ACRAM data for the period 1975 to 1993 to PFS's assessment of destroyed aircraft for the period FY 1989 to FY 1998. Since ACRAM looked at Class A mishaps and Class B mishaps together and the Applicant's assessment looked only at destroyed aircraft, a comparison of ACRAM data to the Applicant's assessment does not show whether or how the fractions of Class A mishaps, Class B mishaps, and destroyed aircraft accidents occurring in each phase of flight changed between the period ACRAM considered and the period PFS considered.

C.19 Further, we find no support for the State's reliance upon the ratio for destroyed aircraft used by the Applicant in Tab H of the Aircraft Crash Report (22.3%) to derive what it believes is a conservative crash rate. The State's approach is incorrect because the Applicant's assessment of the phase of flight of the accidents in Tab H of the Aircraft Report was not intended for the calculation of a crash rate. The Tab H calculations were intended for the specific purpose of assessing pilot avoidance in accidents that could possibly occur in Skull Valley. To be conservative, the Applicant for this purpose included some borderline accidents as being in the normal phase of flight (e.g., the accident of May 25, 1990), which increased the number of normal-phase accidents at the expense of the other categories. If the Applicant's assessment were used to calculate a crash rate, this conservatism would cause the normal-phase rate to increase and the rates for special operations and takeoff and landing to decrease. The ACRAM Study, on the other hand, was focused on accident rates in all phases of flight. It could not skew crash rates toward (or away from) the normal phase because the study results might be used to calculate special operations rates or takeoff and landing rates, depending on the scenario or the facilities for which risk was being calculated. Therefore, the ACRAM fraction of mishaps occurring in the normal phase of flight is appropriate to use here. *See* Aircraft Crash Report, Tab H.

C.20 In sum, we find the State's new crash rate, of 4.10×10^{-8} , to be inappropriate for the following reasons. First, as noted above, this is higher than the lifetime crash rate for the normal phase of flight as of 1993 of 3.86×10^{-8} , which is illogical for the reasons explained. Second, as also discussed above, when it calculated the fraction of F-16s destroyed in the normal phase of flight from FY 1989 to FY 1998 (22.3%), the State included accidents that could not have occurred in Skull Valley.

C.21 Further, we find the State's suggestion that the Applicant had chosen the "lowest" 10-year crash rate ever for the F-16, e.g., Tr. at 8843-44 (Soper), as a basis for its crash rate to be unfounded. A careful review of the data demonstrates that inclusion of the crash rate data for subsequent years (FY 1999 to FY 2001) would have practically no effect on the crash rate. Tr. at 3726-33 (Jefferson); PFS Exh. UUU. Focusing just on Class A mishaps, as of FY 1998, the 10-year

average crash rate was 3.54 mishaps per 100,000 flight hours. The 10-year Class A mishap rate went up slightly to 3.67 and 3.62 for the 10 years ending with FY 1999 and FY 2000, respectively. However, for FY 2001, the 10-year Class A mishap rate fell to 3.53, slightly below that for the 10-year period used by the Applicant. Cole/Jefferson/Fly Post Tr. 3061, at 27. Similarly, the most recent 10-year crash rate for destroyed aircraft (3.37 per 100,000 flight hours) is slightly below that for the 10-year period used by the Applicant (3.46 per 100,000 flight hours). PFS Exh. UUU. Taking an average for the last 13 years, the rates for both Class A mishaps and destroyed aircraft are within 2% of the rates for the 10-year period used by the Applicant. PFS Exh. UUU. Thus, the inclusion of more recent data (created after the Applicant computed its crash rate) would have little or no impact on the analysis.

C.22 The State claimed that the crash rate relevant to Skull Valley will go up in the future because the F-16 crash rate is going up due to the “bathtub effect” related to the aging of the aircraft. *See* Resnikoff Post Tr. 8698, at 9; Tr. at 8788 (Resnikoff). While State witness Dr. Resnikoff claimed that the F-16 was exhibiting the “bathtub effect” and that its crash rates were going up, it was shown on cross-examination and in the NRC Staff’s rebuttal testimony that Dr. Resnikoff chose a period of analysis in a highly selective manner that improperly found an upward trend in rates. *See* Tr. at 8750-77, 8782-88, 8806-13, 8817-18 (Resnikoff); Tr. at 8886-92, 8899-8903 (Campe/Ghosh). Furthermore, even Lt. Colonel Horstman admitted that accident rates appeared to have been level over time since the mid-1980s and that the F-16 was not currently exhibiting an end-of-life bathtub effect. Tr. at 4376-77 (Horstman); State Exh. 52.

C.23 In fact, careful examination of F-16 crash rates, in particular that of the F-16A, which is the first of the F-16 models to be retired from service, as well as the crash rates of other recently retired fighter aircraft at the ends of their service lives, shows no end-of-life bathtub effect. The crash rates have remained the same near end of life or decreased with time. Tr. at 3376-77 (Jefferson); Cole/Jefferson/Fly Post Tr. 3061, at 28-31; PFS Exhs. Q, R, S, T, U, V.

C.24 Particularly instructive is the end-of-life crash rate for the F-16A. The F-16A was the first model of the F-16. Most of them have now been retired. Over the past 5 years, the 5-year and 10-year average accident rates for the F-16A have remained flat. Cole/Jefferson/Fly Post Tr. 3061, at 28-29; PFS Exh. R. Thus, the F-16A is not exhibiting a bathtub effect and there is no reason to believe that other models of the F-16 will exhibit a bathtub effect. Cole/Jefferson/Fly Post Tr. 3061, at 29.

C.25 The State’s experts also claimed that the crash rate for the aircraft that will replace the F-16 in the future, most likely the F-35 Joint Strike Fighter (“JSF”), will be higher in the beginning of its lifetime. Thus, Lt. Colonel Horstman argued for the use of the lifetime crash rate of the F-16, including the early years when the crash rate was very high, as a surrogate for the presumed

high early crash rate for the JSF. Horstman Post Tr. 4214, at 14. However, the Applicant's expert panel convincingly explained why the JSF's crash rate, assuming it were to come to Hill AFB, would be significantly lower than the crash rate of the F-16 early in its lifetime.

C.26 First, over the history of the Air Force, the aggregate crash rate has steadily decreased over time. Tr. at 8656 (Fly); PFS Exh. 82. For example, Air Force-wide destroyed aircraft rates in 1998 were one-fourth of what they were 35 years ago. *See* PFS Exh. 82. Lt. Colonel Horstman acknowledged in this respect that "typically every few years" the Air Force crash rate goes down because "they build better planes." Tr. at 4398-99 (Horstman). In addition, better pilot selection and training, better maintenance practices and procedures, and better analytical tools and better technology are further factors that have resulted in the continual reduction of military aircraft crash rates over time. Cole/Jefferson/Fly Post Tr. 3061, at 32.

C.27 Second, approximately 35 years will elapse from the introduction of the F-16 in 1975 to the planned introduction of the JSF in 2010. The increased skill and technology in designing better aircraft, the improved maintenance practices and procedures, and the better pilot selection and training over these 35 years should result in a lower crash rate for the JSF than for the F-16. Tr. at 3369 (Jefferson); Tr. at 3370-71, 3377-78 (Cole); Tr. at 4398-4401 (Horstman). This expectation is strongly supported by the history of single engine jet fighter aircraft, which shows that initial crash rates for single-engine jet fighters have steadily decreased over time. Tr. at 3370-71 (Cole).

C.28 Third, it would be particularly inappropriate to use the lifetime crash rate average for the F-16, including the early years when the crash rate was very high, as a surrogate for the presumed high early crash rate for the JSF, because the F-16 was originally a technology demonstration program, which led to higher initial crash rates than one would expect from a more traditionally managed program like the JSF. Tr. at 8657 (Fly).

C.29 Fourth, Hill AFB would not receive the first JSF aircraft, which would be expected to experience the somewhat higher initial crash rates of a new aircraft. The Marine Corps will receive the JSF before the Air Force, and the first Air Force JSFs will likely be deployed elsewhere than at Hill AFB. Tr. at 8656-57 (Fly); *see* Tr. at 3372 (Cole). Furthermore, initial crash rates are based on fewer accidents and lower numbers of flying hours, both of which would translate into lower numbers of flights through Skull Valley. Cole/Jefferson/Fly Post Tr. 3061, at 32.

C.30 We are relatively confident in relying on existing F-16 crash rates because long-term trends are indicating a downward trend and no break-in flights will take place in Skull Valley, with other branches of the service to take delivery before the Air Force does. In any event, we note that use of the lifetime crash rate average for the F-16, excluding the early years when the break-in crash rate was

very high, would yield a value reasonably consistent with the 10-year crash rate the Applicant put forward.

b. Number of Flights (N)

C.31 The dispute between the parties about the proper value for *N*, the “number of flights per year along the airway,” involves two principal issues: (1) whether, as the State says, F-16s that fly through Sevier D should also be included in the value for *N*; and (2) whether, as the Applicant says, a 2-year average for the number of F-16s traversing Skull Valley should be used for *N*, as opposed to using only the most recent year’s data, as the State would do.

C.32 The Applicant projected the future number of flights per year along the airway, *N*, to be 5870 flights. That number is derived from an average of the annual number of F-16 sorties through the Sevier B MOA for FY 1999 and FY 2000, increased proportionately for additional aircraft stationed at Hill AFB beginning in FY 2001. *See* Cole/Jefferson/Fly Post Tr. 3061, at 18.

C.33 The State and the Staff, however, have obtained a different result by utilizing the most recent sortie data from FY 2000 only, as well as using all of the flights occurring in both Sevier B and D, which is how the data are reported by the Air Force.

C.34 The Applicant used Sevier B MOA usage reports because, according to the Air Force, they are representative of the number of F-16 flights through Skull Valley. Revised Addendum at 2-5 & n.7. Based on these usage reports, the Applicant contends that in FY 1999, 4250 F-16s transited Skull Valley and in FY 2000, 5757 F-16s transited Skull Valley. Cole/Jefferson/Fly Post Tr. 3061, at 18. This is a 2-year average of approximately 5000 flights annually. *Id.*

C.35 The Applicant claims that the number of F-16 flights through Skull Valley in FY 1999 and FY 2000 reflects current Air Force operations and the normal fluctuations in the number of sorties flown annually. Cole/Jefferson/Fly Post Tr. 3061, at 18-20. It points out that there are several reasons for the higher number of Skull Valley sorties in FY 2000. First, the Air Force experienced fewer overseas deployments of aircraft (which take them away from their home bases) in FY 2000. The Air Force formally adopted the Air Expeditionary Force (“AEF”) concept, which began a new policy for overseas and other deployments of Air Force units away from their home bases, and initially implemented it in October 1999 (FY 2000). *Id.* The AEF’s purpose is to make more equal and regular the ongoing deployment of Air Force units from their home bases of operations which reduces the amount of time spent away from the home base of operations. *Id.* at 19. The net effect relevant here was to generally increase the amount of training time available for units at their home bases when they are not deployed relative to what they had prior to FY 2000. PFS Findings ¶ 56. In addition, the Applicant notes that fewer aircraft were deployed overseas in FY 2000 because deployments

to areas like Bosnia, Kosovo, and the Persian Gulf tapered off toward the end of FY 1999. Cole/Jefferson/Fly Post Tr. 3061, at 19. Thus, the Applicant argues that the average sortie counts for FY 1999 and FY 2000 provide a reasonable baseline for estimating future sortie counts in Skull Valley. *Id.* at 20.

C.36 To project the future number of annual flights, the Applicant used the average of the FY 1999 and FY 2000 sortie counts of 5000, increased proportionately to 5870 flights to reflect the authorized increase in the number of F-16s at Hill AFB in FY 2001. The combined number of F-16 aircraft (active plus reserve) assigned to Hill AFB has increased in FY 2001 from sixty-nine to eighty-one, for an increase of 17.4%. *Id.* at 20-21. Assuming the same Skull Valley sortie rates per F-16 as determined above, the twelve additional F-16s would also increase the number of F-16 sorties through Skull Valley by 17.4%. *Id.*

C.37 The Applicant asserts that FY 2001 data on the number of flights through Skull Valley support the foregoing approach for projecting future sortie counts. According to the Sevier B MOA usage report for FY 2001, 5046 flights transited Skull Valley. Tr. at 13,017-19 (Cole). If that total were adjusted to account for the effect of the additional F-16s at Hill being there the entire year (as opposed to the half year they were present), the total would have been 5435. Tr. at 13,019-20 (Jefferson). This is below the Applicant's projection of 5870. Tr. at 13,017 (Cole), 13,020 (Jefferson). The Applicant argues that the unreasonableness of using the atypically high sortie rate of FY 2000 as the basis for future projections is demonstrated by the FY 2001 sortie count which was somewhat below the average of the FY 1999 and FY 2000 sortie counts. Tr. at 13,020-21 (Jefferson).

C.38 The Applicant also argues that it would be unreasonable to use the combined Sevier B and Sevier D sortie counts as the basis for future projections as argued by Lt. Colonel Horstman. As discussed above, the Air Force has stated that the Sevier B sortie count is representative of the traffic through Skull Valley. The Sevier D MOA airspace does lie directly above Sevier B. Because the Sevier B and Sevier D MOAs extend to the far southern edge of the UTTR, nearly 100 miles from the facility, however, both Sevier B and D MOA sortie counts include aircraft entering the UTTR from the south, such as bombers and aircraft conducting cruise missile tests, that never enter Skull Valley. Revised Addendum at 4; Tr. at 3355-56 (Jefferson). The Sevier D counts are small, approximately 5.7% of the Sevier B counts. Revised Addendum at 4. Thus, the Applicant asserts that taking Sevier B to be representative of Skull Valley accounts for the small number of aircraft that use the Sevier MOAs but never enter Skull Valley. *See* PFS Finding ¶ 65.

C.39 The State disagrees with the Applicant's analysis. *See* State Finding ¶ 49. It points out that the Air Force does not keep records showing specifically the number of F-16 flights in Skull Valley, but does report the usage of Sevier

B and Sevier D MOAs for all aircraft in those MOAs, most of which are F-16s transiting Skull Valley. Revised Addendum at 3-4, Tab HH at 2. It points out that only F-16 aircraft are required to transit Skull Valley. Aircraft Crash Report at 8 n.7. In addition, some F-16 flights through Skull Valley are not reported on the usage reports for Sevier B and D MOAs because the flights are above both MOAs. *See* Horstman Post Tr. 4214, at 11-12.

C.40 In FY 2000, the total number of flights reported in the Air Force usage reports for Sevier B and D MOAs was 5997. Applicant Exh. O at 4. In addition, twelve additional F-16s were assigned to Hill AFB in April of 2001, raising the total number of F-16s stationed at Hill AFB from sixty-nine to eighty-one, an increase of 17.4%. Cole/Jefferson/Fly Post Tr. 3061, at 18-20; Horstman Post Tr. 4214, at 12. The State argues that it is reasonable to assume that the number of F-16 flights transiting Skull Valley would increase by this same percentage. The number of flights in Sevier B and D MOAs for FY 2000, 5997, increased by 17.4% representing the additional F-16s assigned to Hill AFB in 2001, gives a total of approximately 7040 estimated annual F-16 flights through Skull Valley. Both the State and the Staff have in this manner estimated the future number of flights through Skull Valley to be approximately 7040. Campe/Ghosh Post Tr. 4078, at 10; Horstman Post Tr. 4214, at 12.

C.41 The State highlights the fact that the Applicant's estimate of 5870 future flights is based only on Sevier B MOA usage reports. *See* State Findings ¶50. The Applicant excluded flight counts from Sevier D usage reports on the basis that they may contain flights other than Skull Valley flights and may therefore "overcount" the number of F-16 flights through Skull Valley. Tr. at 3356-57. The State argues, however, that the Air Force has informed the Applicant that the majority of flights going through Sevier D MOA are F-16s transiting Skull Valley. *See* State Findings ¶50.

C.42 The Staff estimated the value for *N* by using the Air Force upper-bound data — the 2000 data for the combined flights in the Sevier B and D MOAs (5997) — and increased it by 17.4% to account for the additional F-16 assignments at Hill AFB. Campe/Ghosh Post Tr. 4078, at 10. Thus, the Staff, taking the same approach as the State, estimated the annual number of flights to be 7041. Campe/Ghosh Post Tr. 4078, at 10.

C.43 We find the State and the Staff estimate of 7040 future flights per year over Skull Valley to be a reasonable estimate for the value of *N* in the NUREG-0800 calculation. First, the number of flights occurring in Sevier B and D is more representative of the number of F-16 sorties and, to the extent it might overcount the true number of flights, it is consistent with the NUREG-0800 demand for conservatism. Second, we find the use of FY 2000 to be a better indicator of the present situation for flight numbers over Skull Valley, which data were also used by the Staff in arriving at its estimate of 7040 annual flights.

Adhering to the NUREG-0800 admonition to employ conservative values, the Board agrees with the appropriateness of that number.

C.44 The Staff reduced that value for *N*, however, to account for those aircraft in formation flights that it says do not pose a threat to the Applicant's facility. Campe/Ghosh Post Tr. 4078, at 10-11. The Staff recognized that F-16 aircraft transiting Skull Valley fly in either a two-ship or a four-ship formation. Campe/Ghosh Post Tr. 4078, at 11. (Solo flights occur occasionally, for example, when a pilot's departure on a sortie is delayed.) In terms of aircraft flight path distribution, the Staff considered a four-ship formation as two formations of two aircraft each — one formation flying a few miles behind the first, with either a left or a right offset. There is approximately a 9000-foot lateral separation between the leader and the wingman in a two-ship formation. *Id.* Consequently, according to the Staff, at least one of the aircraft in a two-ship formation will not be in a position from which it can strike the Applicant's facility in the event of a crash. *Id.* See also State Exh. 48 (depicting F-16s in formation on cross section of MOA).

C.45 Therefore, the Staff considered that approximately half of the flights have a negligible potential for striking the Applicant's facility. This was not reflected in the Applicant's analysis, but was accounted for by the Staff in the SER by reducing the number of flights by a factor of 2. SER at 15-67 & n.2; Campe/Ghosh Post Tr. 4078, at 11. The Staff argues that this approach adequately accounts for the fact that flights in Skull Valley take place in formations of two or four ships and that half of those aircraft are far enough east so as not to pose a hazard to the Applicant's facility. Thus, the number of flights, 7041, divided by 2, or 3520 flights, is the Staff's estimate for *N*. See Staff Findings ¶ 2.119.

C.46 We disagree with the Staff's analysis that divided the number of flights through Skull Valley in half. The Staff reasons that only one of the ships could fly directly over the Applicant's site and be in a position to strike the Applicant's site, and accordingly divided the number of flights to reflect this reduced risk. Campe/Ghosh Post Tr. 4078, at 10-11. For the reasons set out in the Narrative portion of this opinion, we find, however, that this is mathematically and logically inappropriate — if half the aircraft are to be disregarded, so must the portion of the airway in which they are flying. Thus, the Board finds the number of flights cannot be reduced on this reasoning, and selects 7040 as the appropriate number for *N*.

c. Effective Area of Facility (A)

C.47 The Applicant asserts that the effective area of that portion of the facility where the storage casks will be located (including the Canister Transfer Building) is 0.1337 square mile. This calculation took into account the flight characteristics and dimensions of the F-16 and the angle at which it might approach the facility, and assumes a facility at full capacity with 4000 spent fuel storage casks on

site. Cole/Jefferson/Fly Post Tr. 3090, at 16. This effective area accounts for the possibility that an aircraft impacting in front of the facility could skid into it and the possibility that an aircraft that would otherwise impact just beyond the facility would hit an elevated structure at the facility. *See* PFS Findings ¶38. The State does not contest the effective area put forward by the Applicant. *See* State Findings ¶52. We find that the value for *A*, effective area, has reasonably been calculated by the Applicant to be 0.1337 square mile. The Board has reviewed this analysis and finds it reasonable.

d. Width of Airway (w)

C.48 The major dispute among the parties regarding this factor of the NUREG-0800 equation centers on where pilots actually fly in taking F-16 aircraft down Skull Valley. The dispute arises because of the physical contours of the Valley and the location of artificial delineations of the airspace. Below we describe the geographical relationship between these features, and why the parties differ in their calculations of the Skull Valley airway width.

C.49 Skull Valley is located between two mountain ranges, the Stansbury Mountains to the east, and the Cedar Mountains to the west. On the west side, Air Force Restricted Airspace intrudes into the Valley. Because of the configuration of the Mountains, Skull Valley varies in width — it is approximately 17 miles at the northern tip but narrows to 7 miles at the southern tip. SER at 15-62.

C.50 The Applicant took the position that the width available to pilots flying in Skull Valley is the actual width from the edge of the restricted airspace intruding in the west to the Mountains on the east, that being 10 miles at the point where the facility is proposed to be built. The Staff agrees with that argument. The State, on the other hand, believes that pilots fly only in a narrower effective area that takes account of the need to observe certain buffer zones. The State asserts that, when all adjustments of this nature are taken into account, this distance is 5 miles near the proposed position of the facility.

C.51 We have previously described the way airspace is divided into “Military Operating Areas” (MOAs). Approximately 96% of the F-16 flights through Skull Valley are in Sevier B MOA. Resnikoff Post Tr. 8698, at 15; Tr. at 3396 (Jefferson). F-16s may fly through any part of Sevier B MOA but commonly fly at 3000 to 4000 feet AGL. Aircraft Crash Report at 5; Tr. at 3396-97 (Cole). F-16s fly through Skull Valley in two-ship or four-ship formations. Horstman Post Tr. 4214, at 5-6. According to the Air Force, it would be an exception for a solo flight to transit Skull Valley. Campe/Ghosh Post Tr. 4078, at 11.

C.52 In a two-ship formation of F-16s, the wingman would fly 1.5 to 2 miles abreast of the flight leader at a position 0 to 10 degrees aft of the leader. In a four-ship formation of F-16s, a wingman would similarly fly 1.5 to 2 miles abreast of the flight leader. Those two aircraft (lead and wingman) comprise the

“lead element.” Two additional aircraft with spacing similar to that of the lead element would follow 2 to 15 miles behind. One of the aircraft in the back element will be located somewhere between the horizontal spacing of the lead element. A four-ship formation thus may vary from just over 1.5 to just under 4 miles in horizontal width and over 2 to 15 miles long. Horstman Post Tr. 4214, at 6.

C.53 A cross section of Sevier B MOA, looking north from the latitude of the proposed site, is shown in Aircraft Crash Report, Figure 1. Tr. at 3395-3401 (Jefferson). The site is identified as “PFSF” and located at “0” on the “statute miles” scale along the bottom of Figure 1. The Applicant’s site is located at 4500 feet mean sea level as indicated by the scale along the right side of Figure 1, which is also ground level or 0 AGL. Tr. at 3405 (Jefferson). The Sevier B MOA is bounded on the west by a restricted area located 2 miles to the west of the Applicant’s site. Tr. at 3400 (Jefferson). The blacked-out area on Figure 1 labeled “GROUND” represents mountainside terrain of the Stansbury Mountains, which prevents aircraft from flying to the eastern boundary of the MOA. Tr. at 3401 (Jefferson). State Exh. 156B shows Figure 1 with the airspace between 3000 and 4000 feet AGL shaded. *See* State Exh. 156B.

C.54 F-16 flights transiting Skull Valley maintain a “buffer” distance of 1 mile or more from the western boundary of Sevier B MOA to prevent straying into restricted airspace west of the MOA. Horstman Post Tr. 4214, at 7. Aircraft must avoid flying in this restricted area or the pilot may incur very serious sanctions. Tr. at 3407 (Jefferson). Colonel Bernard, a former F-16 pilot with experience in flying through Skull Valley, testified when flying in Skull Valley he would maintain a comfortable (buffer) distance of 2 to 3 miles from the restricted airspace at the western boundary of the Sevier B MOA. Tr. at 3924 (Bernard). The Applicant’s witness Colonel Fly testified that most flights are down the middle to the eastern side of Skull Valley because of the restricted airspace to the west. Tr. at 3415-16 (Fly). Colonel Fly further testified that he generally flew well clear of a 1-mile buffer zone from the restricted airspace west of Sevier B MOA. Tr. at 3424 (Fly). In light of this information, the State asserts that F-16 pilots maintain a distance of at least 1 mile from the western boundary of Sevier B MOA at the latitude of the Applicant’s site to prevent entering restricted airspace. *See* State Findings ¶43.

C.55 The State argues that F-16 formations generally fly down the middle of Skull Valley with part of the formation over or near the Applicant’s site. Horstman Post Tr. 4214, at 6. The formation leader will select a flight path to allow the furthest-west aircraft to maintain a distance of at least 1 mile from the western boundary of Sevier B MOA, beyond which is restricted airspace. *Id.* at 7. The flight leader will also select a flight path to allow the furthest-east aircraft to maintain a sufficient distance from the Stansbury Mountains, generally 2 miles, placing the furthest-east aircraft at least 5 miles from the eastern border of Sevier B MOA. *Id.* The width of the Sevier B MOA that is actually used by F-16 formations would thus extend from 1 mile east of the western MOA boundary to

5 miles west of the eastern MOA boundary, or a width of approximately 6 miles. *Id.* at 6.

C.56 Within this 6-mile width of usable airspace, F-16s fly in two- or four-ship formations which are from 1.5 to just under 4 miles wide. *Id.* at 7. With one ship in the formation flying at either the eastern or western edge of the usable airspace, the remaining ships in the formation would be inward from the edges. *Id.* Accordingly, the majority of F-16 flights in Skull Valley, argues the State, would therefore be within a corridor less than 5 miles wide within the 6-mile width of usable airspace. *Id.* The usable 6-mile airspace and formations positioned at the outer edges of that airspace are shown on State Exh. 48. *Id.*; State Exh. 48.

C.57 The Applicant asserts, however, that the Air Force has consistently advised that the predominant or preferred route of flight for F-16s transiting Skull Valley is approximately 5 miles to the east of the proposed facility site. *See* PFS Findings ¶42 (*citing* Cole/Jefferson/Fly Post Tr. 3061, at 16; Tr. at 3397 (Cole)). This stated preference is consistent with Colonel Fly's testimony that he typically flew about 4 miles east of the site in a south-southeasterly direction. Tr. at 3415-24 (Fly). This preferred route is said to be a logical result of the natural configuration of the MOA and the restricted airspace to its west which serve to naturally funnel the F-16 traffic in Skull Valley toward the eastern side of the Valley and the narrow 7-mile-wide neck in the MOA southeast of the facility site. Cole/Jefferson/Fly Post Tr. 3061, at 16; PFS Exh. P.

C.58 The Applicant asserts that it assumed for purpose of its calculations that the Sevier B MOA could be treated like an airway and that the F-16s were evenly distributed across the width of the Sevier B MOA, from the Stansbury Mountains in the east to the edge of restricted airspace in the west. *See* PFS Findings ¶43. The width, *w*, of this hypothetical airway was chosen to be 10 miles based on the useable airspace in the Sevier B MOA through which the F-16s could fly at the latitude of the facility. Cole/Jefferson/Fly Post Tr. 3061, at 16.

C.59 For F-16s flying above the Sevier B MOA (i.e., above 9000 feet MSL/4400 feet AGL), the width of the useable airspace would be the full 12 miles. *See* Tr. at 3795 (Jefferson). The Applicant therefore asserts that using an airway width of 10 miles for the purpose of analysis is conservative. Tr. at 3443-52 (Jefferson).

C.60 The determination of the width of the airway to be used in calculating probability of aircraft crashes at the Applicant's site turns on the evidence of the type and flight patterns flown by F-16s stationed at Hill AFB. No evidence was presented as to the type of training missions, flight altitudes, or routes that will be flown by the replacement aircraft. The Board has been presented with no reason to find that the width of the airway would change for a replacement aircraft.

C.61 We base our finding as to this issue on where pilots fly as a routine practice, which establishes the effective width of the airway. We agree with the State's assertion that F-16s transiting Skull Valley observe buffer zones on both

sides of the MOA such that aircraft would stay 1 mile east of the restricted area to the west of the facility and up to 3 miles west of the Stansbury Mountains or the MOA's boundary to the east. Horstman Testimony at 6-7; Tr. at 8571, 8613-14 (Horstman). We find the State's position to be persuasive because State Exhibit 148B demonstrates that even though Applicant's 10-mile distance is theoretically possible at 3000 to 4000 feet AGL, pilots are more likely to be conservative and thus allow for as great a buffer zone on the Stansbury side and the UTTR side as possible. But the State's proposed 5-mile distance is too narrow — the evidence demonstrates that 6 miles is the appropriate width of the airway as it is used in practice.

5. *Calculated Probability*

C.62 As we found in the narrative portion of our decision, the probability of an F-16 impacting the facility is 4.29×10^{-6} (see p. 122, above.) Consequently, the Applicant's proposal fails to meet the acceptance criterion the Commission articulated in CLI-01-22.

6. *Other Skull Valley Operations*

a. *Moser Recovery Route*

C.63 Most aircraft returning to Hill AFB from the UTTR South exit the northern portion of the range and proceed north or fly over the Great Salt Lake. SER at 15-80. Some aircraft returning to Hill AFB from the UTTR South, however, may use the Moser Recovery Route (MRR). Cole/Jefferson/Fly Post Tr. 3061, at 11. The MRR runs from the southwest to the northeast to the north, and passes approximately 2 to 3 miles north of the Applicant's site. SER at 15-80. The MRR is only used during inclement weather conditions or at night under specific wind conditions. See Cole/Jefferson/Fly Post Tr. 3061, at 11.

C.64 The Applicant estimates that approximately 5% of the F-16 flights on the UTTR return to Hill AFB via the MRR. *Id.* at 97. This estimate is supported by conversations between General Cole and the Vice Commander of the 388th FW at Hill AFB, and an air traffic controller in the Salt Lake City Air Traffic Control Center. Tr. at 3456-58 (Cole). Thus, based on FY 1998 UTTR sortie data, the Applicant estimated 286 flights used the MRR in FY 1998. Cole/Jefferson/Fly Post Tr. 3061, at 97. The Applicant defined the MRR as having an airway width, w , of 11.5 miles (equal to the width of military airway IR-420). *Id.* The other factors the Applicant used in its calculation were the same as those used to calculate the hazard to the facility from F-16s transiting Skull Valley: the crash rate, C , was equal to 2.736×10^{-8} per mile; the effective area of the site, A , was 0.1337 square mile; and 14.5% of the calculated crashes would impact the site

because the pilot could not direct the aircraft away from the facility (the *R* factor). *Id.*

C.65 Because the Air Force does not keep precise data as to the number of flights per year that occur on the MRR, all parties had to look elsewhere to derive estimates of annual MRR flights. Tr. at 3455-59 (Cole); *see* Cole/Jefferson/Fly Post Tr. 3061, at 96-97. In order to estimate the number of flights, the Applicant assumed that the sortie rates on the UTTR, and thus the number of flights on the MRR, increased proportionally to the number of F-16 sorties through Skull Valley. Cole/Jefferson/Fly Post Tr. 3061, at 97. According to the Air Force, 5726 F-16 sorties were flown in the UTTR South Area, most of which flew from Hill AFB. Using the 5% MRR usage factor, the Applicant calculated that approximately 286 F-16s used the MRR for return flights in FY 1998. *Id.* The Applicant then increased the number of FY 1998 Moser flights proportionally to account for the higher Skull Valley sortie counts in FY 1999 and FY 2000 as well as the sorties that would be flown in the future by the additional F-16s assigned to Hill AFB. *Id.* So for the value of *N*, the Applicant used 336 in the NUREG-0800 equation. *See* Revised Addendum at 20; Cole/Jefferson/Fly Post Tr. 3061, at 97. Thus, the Applicant calculated the crash impact probability to be 2.0×10^{-8} per year. *Id.*

C.66 The Staff prepared an independent estimate of the number of flights on the MRR using actual FY 2000 UTTR sortie data, rather than Skull Valley flight information used by the Applicant. Campe/Ghosh Post Tr. 4078, at 39; SER at 15-81. The Staff found that the UTTR South flight count, rather than the Skull Valley flight count, is more appropriate for estimating the annual number of F-16s flying through the MRR. The Staff also adjusted the FY 2000 data to account for an additional twelve F-16s to be stationed at Hill AFB. Campe/Ghosh Post Tr. 4078, at 39. The Staff estimated the number of flights on the MRR to be 5% of 7059,¹⁵² or 353. SER at 15-80 to 15-82; Staff Findings ¶2.529. Using a modified number for pilot avoidance, the Staff calculated the crash impact probability to the Applicant's facility to be 2.5×10^{-8} per year. Campe/Ghosh Post Tr. 4078, at 40; SER at 15-82.

C.67 The State asserts, however, that the number of F-16s using the MRR is likely to be substantially higher than either the Applicant or the Staff estimates. State Findings ¶10. In calculating the number for *N*, the State asserts that the Applicant should have assumed that one-third of all flights on the UTTR returned to Hill AFB via the MRR because in the future, up to one-third of the flights on the UTTR may be conducted at night. Resnikoff Post Tr. 8698, at 16; Horstman Post Tr. 4214, at 30. The State's theory of increased use of the MRR was based

¹⁵²The Staff used FY 2000 data, 7059 flights, rather than an average of FY 1999 and FY 2000 because use of FY 1999 sortie information would lead to an insignificant change to the estimated probability compared to FY 2000 data. SER at 15-81 to 15-82.

on the assumption that all flights at night would use the Moser Route, purportedly due to the 388th FW's use of night vision goggles in training. Horstman Post Tr. 4214, at 30. The State relies on an Air Force document that states that night-vision-goggle training will increase and that of the total sorties flown in MOAs, approximately one-third will be night sorties. State Exh. 64 at 4.

C.68 The State does not dispute that the MRR is used only at night, during marginal weather conditions, and when runway 32 at Hill AFB is the active runway. *See* State Findings ¶107. The Aircraft Crash Report states that “[b]ecause pilots train on the UTTR mostly during daytime and in good weather and because aircraft landing at Hill usually use runway 14 . . . due to the wind patterns at Hill, it agrees that the Moser recovery is seldom used.” Aircraft Crash Report at 48a. It points out that subsequent to preparation of the Applicant’s Crash Report, however, the Air Force announced on July 18, 2001, that night-vision-goggle training would increase and stated that of the total training flights in MOAs, “approximately one third will be night sorties.” State Exh. 64 at 4; Horstman Post Tr. 4214, at 30; State Findings ¶107. From this, the State argues that a realistic number of flights using the MRR could be as high as 33% of the flights returning to Hill AFB from the UTTR South Area. Horstman Post Tr. 4214, at 30. The State also asserts that there will be some 10,410 aircraft per year using the UTTR in the future. State Findings ¶110.

C.69 In FY 1998 there were 5726 sorties flown in the UTTR South range. Cole/Jefferson/Fly Post Tr. 3061, at 97. The State argues that, to account for the increase in sorties of F-16s and the increase in aircraft assigned to Hill AFB since 1998, the 5726 flights in the UTTR in 1998 should be increased by the ratio of Skull Valley sorties occurring in 1998 to those occurring in 2001. Taking the number of sorties occurring in Skull Valley in 1998, which was determined to be 3871, and increasing this number proportionally to the number of sorties occurring in 2001, which was determined to be 7040, the State estimated that approximately 10,410 sorties would occur on the UTTR South Area in 2001. Resnikoff Post Tr. 8698, at 16. As the State sees it, as many as 33% of these flights, or 3436 flights, might therefore return to Hill AFB on the MRR. *Id.* Using a crash rate, C , for F-16s of 4.10×10^{-8} , the number of flights, N , of 3,436, the area, A , of 0.1337 square mile, and the width, w , as 11.5 miles, the State calculated the crash impact probability to be 1.64×10^{-6} per year. *See* State Findings ¶111.

C.70 The Applicant points out that the State’s estimate of annual flights on the MRR, which is 33% of the total returning flights, is not consistent with the actual number of flights recorded in the UTTR South. In this regard, General Jefferson noted that the State is assuming approximately 10,410 flights in the UTTR South. Tr. 8864-65 (Jefferson). But there have been less than 10,000 flights annually on the UTTR South since 1998. Tr. 8865-66 (Jefferson). General Jefferson testified that if he were to increase those F-16 sorties for the UTTR

South by 17% to account for additional F-16s coming to Hill AFB in 2001, they would still be significantly less than 10,000. *See* Tr. at 8866 (Jefferson).

C.71 On the basis of complications associated with the use of the MRR that make it undesirable as an air corridor, the discussions the Applicant and the Staff had with Air Force personnel, and the comparison of the State's assumed total number of flights to the number of flights that actually occurred in the UTTR, we find that even with an increase in night sorties, much closer to 5% of flights returning from the UTTR South to Hill AFB will use the MRR than to 33%.

C.72 We disagree with the State's methods and assumptions regarding the determination of the number of sorties for the MRR. In estimating the MRR use factor, the State assumed that a 33% increase in night training would lead to a 33% increase in the use of the MRR. The State's reliance on the Air Force document for its assumption was flawed because the Air Force statement is of a contingent nature: use of the MRR is contingent upon certain wind conditions being present. As stated by the Air Force, there is no expected increase overall in MRR usage from night training. *Campe/Ghosh Post Tr.* 4078, at 39; *Cole/Jefferson/Fly Post Tr.* 3061, at 98 & n.168. Hence, we find the State's estimate of a 33% increase in MRR flights to be not well supported.

C.73 In addition, we disagree with the analysis undertaken by the State regarding the number of flights, approximately 10,410 per year, which reflected an extrapolation of fluctuations of use of the UTTR indicating an upward trend of flights using the MRR. The data, however, do not show an unambiguous increasing trend before 2001, but rather seem to have fluctuated from year to year without showing any trend. Hence, we find the State's analysis of crash probability from flights on the MRR to be not well founded insofar as its estimates of future flights on the UTTR and its estimate of flights using the MRR in the future are concerned. We find that the Staff estimate of crash probability of 1.6×10^{-7} (without taking credit for pilot avoidance) per year is reasonable, as well as the Applicant's slightly lower estimate, for the reasons expressed in their analyses.

C.74 The Board reiterates that all numerical values derived by the parties are indirect estimates of aircraft counts using the MRR because of the unavailability of data from the Air Force. Even with this analytical uncertainty, however, we are able to find that there is only a minor risk to the facility from aircraft traversing the MRR because of the margin between the values we accept and the Commission's cumulative standard hazard of 1×10^{-6} annually.

b. Aircraft on IR-420

C.75 Michael Army Airfield is located on Dugway Proving Ground, 17 miles south-southwest of the facility. *Cole/Jefferson/Fly Post Tr.* 3061, at 98. IR-420 is a military airway that runs from northeast to southwest and ends about

7 miles north of the facility site, at the northern edge of the Sevier B MOA (i.e., IR-420 runs from the edge of Sevier B to the northeast). *Id.* Aircraft flying to and from Michael AAF from the northeast, including aircraft flying to and from Hill AFB, may fly in the direction of IR-420 and pass within a few miles of the facility site. The majority of the flights to and from Michael AAF are F-16s from Hill AFB conducting training. Those aircraft using IR-420 are accounted for in Applicant's Skull Valley-transiting F-16 calculation.¹⁵³ *Id.* Most of the remainder of the aircraft flying to and from Michael AAF are cargo aircraft such as the C-5, C-17, C-141, C-130, and the smaller C-21 and C-12. *Id.* at 98-99.

C.76 The Applicant used the same method to calculate the hazard to the facility from F-16s to estimate the probability of an aircraft impacting the facility from aircraft flying to and from Michael AAF (i.e., $P = C \times N \times A/w$). *Id.* at 99. The State did not submit testimony on the hazard posed by aircraft flying to and from Michael AAF in the direction of IR-420. *See* Horstman Post Tr. 4214; Resnikoff Post Tr. 8698. NUREG-0800 provides an in-flight crash rate of 4×10^{-10} per mile for large commercial aircraft, which is appropriate to apply to the types of large cargo aircraft flying to and from Michael AAF. The Applicant estimated a maximum of approximately 414 annual flights by aircraft other than F-16s at this airfield.¹⁵⁴ Using the effective area of the facility in a manner similar to that for F-16s, the Applicant calculated an upper bound on the probability of an aircraft impacting the facility to be 3.0×10^{-9} per year. Cole/Jefferson/Fly Post Tr. 3061, at 99.

C.77 The State did not challenge the Applicant's probability calculation related to aircraft traversing IR-420 to MAA. *See* State Findings. Similarly, the Staff does not dispute the estimate of risk. *See* Campe/Ghosh Post Tr. 4078, at 41. We find that the parties are in accord with respect to the estimation of the hazard posed to the Applicant's facility by aircraft flying on IR-420. *See* Cole/Jefferson/Fly Post Tr. 3061, at 99; State Exh. 81; Campe/Ghosh Post Tr. 4078, at 41. Inasmuch as no dispute exists with respect to the estimate of the risk posed to the facility from flights transiting IR-420, we find 3.0×10^{-9} per year to be a reasonable estimate of the annual probability of impact to the Applicant's facility.

¹⁵³ Any F-16 using IR-420 would necessarily fall into the Sevier MOA traffic count as IR-420 ends where the Sevier MOAs begin at the north end of Skull Valley. Any F-16s that went to Michael AAF without transiting Skull Valley would not be relevant to the hazard to the facility. Cole/Jefferson/Fly Post Tr. 3061, at 98 n.169.

¹⁵⁴ The 414 flight estimate was based on FY 1997 data from Michael AAF. Based on the total number of takeoffs and landings at Michael AAF in later years from FY 1998 to FY 2000, excluding those conducted by F-16s, a maximum of 212 flights per year during that period were conducted by aircraft other than F-16s. If it is taken into account that the aircraft fly to and from airfields in all directions from Michael AAF, the estimated number of flights in the direction of the facility would be even lower. *Id.* at 99-100.

c. *Training on the UTTR*

C.78 Aircraft on the UTTR South Area perform a variety of activities, including air-to-air combat training, air-to-ground attack training, air-refueling training, and transportation to and from Michael AAF (which is located beneath UTTR airspace). Cole/Jefferson/Fly Post Tr. 3061, at 90-91. We determined on summary disposition that aircraft conducting air-to-ground attack training and weapons testing using air-delivered ordnance and aircraft conducting air refueling training would pose no significant hazard to the facility. *See* LBP-01-19, 53 NRC at 446. The hazards posed by aircraft flying to and from Michael Army Airfield on Dugway have been discussed previously. Thus, the only activity we assess here is air-to-air combat training on the UTTR.

C.79 We find that aircraft conducting air-to-air combat training on the UTTR pose a negligible hazard to the facility. This is primarily because the activity on the UTTR occurs too far away from the facility to pose a hazard. The facility is located 2 miles east of the eastern boundary of the UTTR restricted airspace. The aggressive maneuvering that takes place in air-to-air combat training occurs toward the center of the restricted area range, typically more than 10 miles inside range boundaries. On the basis of where F-16s fly on the UTTR, the Applicant assumed a 3-mile buffer zone just inside the UTTR restricted area as a practical limit as to how far aircraft will fly from the edge of the UTTR restricted area. Thus, the facility is located 5 miles east of the closest point at which an event leading to a crash would be expected to occur and a crashing aircraft on the UTTR would not be able to reach the facility before impacting the ground if it were out of control. Cole/Jefferson/Fly Post Tr. 3061, at 91-92.

C.80 The assumed 3-mile buffer is reasonable because it reflects what actually takes place on the range and corresponds to the practical limit that pilots observe while flying training exercises on the UTTR. Aggressive maneuvering during simulated air-to-air engagements at visual or beyond visual ranges, tends to take place toward the center of the restricted areas. Furthermore, the Cedar Mountains provide a clear visual indication to pilots of the eastern edge of the restricted area and Clover Control provides warnings to pilots as they approach within 5 miles of the edge of the restricted area to prevent them from straying outside. *Id.*

C.81 Accidents on the UTTR that did not leave the pilot in control of the aircraft would not pose a hazard to the facility. Review of the F-16 crash reports for accidents occurring during special in-flight operations (i.e., operations involving aggressive maneuvers on a training range) in which the pilot does not maintain control of the aircraft (e.g., a midair collision or G-induced loss of consciousness) indicates that most such accidents would occur toward the center of the restricted ranges. It is most likely such crashing aircraft would travel less than 5 miles horizontally before impacting the ground. Even in the event of G-induced loss

of consciousness, which is the type of accident that would not leave the pilot in control but would cause the aircraft to travel the greatest distance before hitting the ground, the aircraft would travel no more than about 5 miles. *Id.* at 92-93.

C.82 For accidents in which a pilot does maintain control, the aircraft would be 5 or more miles from the facility site when the accident occurred by virtue of the 2 miles that the facility is from the eastern boundary of the UTTR airspace and the 3-mile buffer observed while operating in restricted airspace. The UTTR is a large, safe area to receive a crashing aircraft in an emergency. Moreover, Michael AAF, on the east side of the UTTR, would be available for the pilot to make an emergency landing if possible. Therefore, it would be unreasonable to postulate that a pilot in control of a crashing aircraft in such circumstances would glide over the Cedar Mountains, and off the restricted range toward Skull Valley, the facility, and other inhabited structures located there. *Id.* at 93-94.

C.83 Using the NUREG-0800 formula, the Applicant calculated the risk to the facility to be less than 1.0×10^{-8} year. We note that the Applicant has used an “*R*” factor to reduce the probability of crashes from combat training on the reasoning that “invariably the pilot would steer the aircraft away” from the Applicant’s facility. *Id.* at 94-95. But given the flight conditions and operations in the UTTR, the *R1* component would be less than in Skull Valley, and there is no more reason to credit the *R2* component than there was in Skull Valley. Accordingly, the Board finds that it is not realistic or conservative to allow a reduction in this crash probability based on a pilot’s ability to avoid the Applicant’s site.

C.84 The Staff agreed with the Applicant’s assessment that a 5-mile cutoff radius is reasonable for an F-16. On the primary basis of the 5-mile glide distance, the Applicant and the Staff concluded that the annual probability of an onsite crash is negligible, i.e., less than 1×10^{-8} per year. Campe/Ghosh Post Tr. 4078, at 37.

C.85 We do not agree with the State’s calculation for risk. State witness Dr. Resnikoff asserted that aircraft on the UTTR would pose a hazard to the facility by assuming that a crashing aircraft could fly 10 miles before impacting the ground. State Exh. 78; Tr. at 8792-94 (Resnikoff). Using this figure, the State calculated the hazard to the facility to be 2.74×10^{-7} per year. Resnikoff Post Tr. 8698, at 18.

C.86 The only support for Dr. Resnikoff’s assertion was a previous assessment the Applicant had performed, before it had obtained the information from the accident reports, in which the Applicant had conservatively assumed that a crashing aircraft could fly a maximum of 10 miles before impacting the ground. Tr. at 8798-99 (Resnikoff). Thus, the only basis for Dr. Resnikoff’s assumption has been superseded and there is no reason to credit his claim.

C.87 We agree that a 5-mile glide is a more appropriate distance for an F-16, and thus agree with the probability calculations arrived at by the Applicant and

Staff. In any event, the crash probability related to aircraft traversing the UTTR is insignificant to the overall cumulative hazard calculation.

d. Military Ordnance

(1) DIRECT IMPACT OF F-16 CARRYING ORDNANCE

C.88 We have explained in the Narrative portion of this opinion why this accident scenario can be readily disregarded.

(2) DIRECT IMPACT OF JETTISONED ORDNANCE

C.89 Based on data from Hill AFB regarding ordnance usage by F-16s in FY 1999 and FY 2000, approximately 2% of the F-16s transiting Skull Valley carry jettisonable ordnance.¹⁵⁵ Cole/Jefferson/Fly Post Tr. 3061, at 12; Campe/Ghosh Post Tr. 4078, at 32. 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. Cole/Jefferson/Fly Post Tr. 3061, at 102. The potential hazard posed to the facility by jettisoned military ordnance is very small because of the small number of aircraft carrying ordnance, the rarity of aircraft jettisoning ordnance, and the small probability that ordnance jettisoned somewhere along the route would hit the facility. *Id.* at 102-03. Using the NUREG-0800 formula, the Applicant estimated the probability that ordnance would impact the facility to be 3.2×10^{-8} per year. *Id.*

C.90 The Applicant generally followed the same approach that it used in calculating the hazard to the facility for F-16s transiting Skull Valley as follows:

C.91 The Applicant claims the number of aircraft carrying live or inert ordnance through Skull Valley per year, *N*, would be 150. *Id.* This is based on the average number of F-16s carrying ordnance through Skull Valley for FY 1999 and FY 2000 (2.556% of the total number of Skull Valley sorties), increased by 17.4% to account for the additional aircraft based at Hill AFB in FY 2001. *Id.* at 102. The Applicant based its estimate on the two most recent years, the same years it used to estimate the Skull Valley sortie count. *Id.*

- The crash rate for the F-16s, *C*, was taken to be 2.736×10^{-8} per mile. Cole/Jefferson/Fly Post Tr. 3061, at 103.

¹⁵⁵ Because of the other ways available to Air Force pilots to train to deliver the newer, laser-directed or self-guided ordnance, there is very little requirement for pilots to train by dropping live or heavy-weight ordnance on the UTTR. Tr. at 3501-03, 13,084-85 (Fly).

- The pilot was assumed to jettison ordnance in 90% 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). Cole/Jefferson/Fly Post Tr. 3061, at 103; Campe/Ghosh Post Tr. 4078, at 31. Even though some accident reports reflect that pilots will take steps to avoid jettisoning ordnance near built-up or populated areas, the Applicant conservatively assumed no “ R ” factor to account for such avoidance. Revised Addendum at 30-31.¹⁵⁶
- Skull Valley was treated as an airway with a width, w , of 10 miles. Cole/Jefferson/Fly Post Tr. 3061, at 103; Campe/Ghosh Post Tr. 4078, at 33.
- The area of the facility, 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. Cole/Jefferson/Fly Post Tr. 3061, at 103.¹⁵⁷ Thus, the area of the facility was calculated to be 0.08763 square miles. Cole/Jefferson/Fly Post Tr. 3061, at 103.

Based on these input values, the Applicant calculated the hazard to the facility from jettisoned ordnance to be 3.2×10^{-8} per year. *Id.* at 103.

C.92 The Board notes that the Applicant used a modified NUREG-0800 formula to calculate the probability as shown by:

$$P = N \times C \times e \times A/w$$

Id. The Applicant has included an additional factor, “ e ,” which reduces the probability of ordnance impacts by assuming that the pilot would jettison ordnance in only 90% of crashes. *Id.* at 102-03. The Applicant assumed the pilot would eject quickly in the other 10% of crashes without time to jettison ordnance. *Id.* at 103.

¹⁵⁶ Pilots are also trained to steer their aircraft away from populated areas before ejecting if possible, but they are trained to jettison ordnance quickly upon suffering an engine failure at low altitude. *See* Tr. at 3557-58 (Fly).

¹⁵⁷ Dr. Resnikoff asserted that the Applicant should have used a “skid area” in front of the facility to account for jettisoned ordnance potentially skidding into the facility. Resnikoff Post Tr. 8698, at 20. The only basis for his assertion was an undocumented conversation between Dr. Resnikoff and Lieutenant Colonel Horstman. Tr. at 8801-05 (Resnikoff). We agree with Applicant’s witness General Jefferson, who testified that the ordnance would not skid because it would impact the ground at a steep angle. Tr. at 8868-69 (Jefferson).

C.93 The Board finds the Applicant's overall approach to be logical. As explained below, however, the Board finds that the input values for *N* and *w* should be modified.

C.94 The State claimed that the Applicant should have assumed that the fraction of sorties in Skull Valley carrying jettisonable ordnance would be no less than it was in FY 1998 increased by the increase in sorties since FY 1998, rather than what it was in FY 1999 and FY 2000. Horstman Post Tr. 4214, at 29. The FY 1998 fraction was higher than the FY 1999 and FY 2000 fractions.¹⁵⁸ Lieutenant Colonel Horstman asserted that lower ordnance usage in FY 2000 was due to some of the F-16s at Hill AFB having been deployed to the Caribbean for drug interdiction missions. Horstman Post Tr. 4214, at 29. The deployment to the Caribbean was, however, much smaller than other past deployments and the training of the F-16s is not based on one particular deployment. Tr. at 13,090-91 (Fly). Moreover, the State did not account at all for the FY 1999 ordnance usage, which was almost identical to the usage in FY 2000. Revised Addendum, Tab HH at 14. Requirements for F-16 ordnance usage in training are established by Air Force regulations and each unit's designated operational capability. Tr. at 13,082-84 (Fly). Those requirements do not change frequently. Tr. at 13,086-87 (Fly). Furthermore, the Air Force Safety Agency has stated that ordnance expenditures are not expected to increase in the future. Tr. at 13,087-88 (Cole).

C.95 The State asserts that F-16s transiting Skull Valley may carry up to six ordnance per flight and an F-16 may carry two MK-84 2000-pound bombs per flight. Horstman Post Tr. 4214, at 27. After a pilot zooms the aircraft in an emergency, the pilot will release the bombs and fuel tanks from the aircraft, a procedure known as "jettison all stores." *Id.* at 28. The State asserts that typically a pilot will take no action to select where the ordnance will impact. This is because the immediate jettison of all stores may be necessary to control the aircraft, and also because the pilot's attention may be focused on tasks relating to the pilot's survival, such as restarting a failed engine or ejecting. *Id.*

C.96 In FY 1998, the 388th fighter wing carried ordnance on 678 sorties. Revised Addendum, Tab HH at 13. That number was reduced to 151 sorties with ordnance in FY 1999 and 128 sorties with ordnance in FY 2000. *Id.* at 13-14. The 419th FW at Hill AFB also carries ordnance but no records showing ordnance carried by the 419th are available. *Id.* at 12 n.27. The Applicant points out that according to the Vice Commander of the 388th FW, it is reasonable to assume the

¹⁵⁸The State did not claim that the Applicant should have used FY 1998 as the baseline for estimating the sortie count for Skull Valley. *See* Horstman Post Tr. 4214, at 12. Had the State done so, its estimated sortie count would have been approximately 4500 (increasing the FY 1998 Sevier B MOA count by 17.4% to account for the additional F-16s added to Hill AFB in FY 2001). Horstman Post Tr. 4214, at 11.

419th FW carries ordnance of the same type and at the same rate as the 388th FW. *Id.* The Applicant has used the ratio of aircraft assigned to the 388th and 419th FWs to determine that by multiplying the number of 388th sorties by 1.278, the total 388th and 419th fighter wing sorties is obtained.¹⁵⁹ *Id.* The total number of sorties carrying ordnance is therefore estimated to be 866, 193, and 164 for FY 1998, FY 1999, and FY 2000, respectively.

C.97 The State asserts that the number of sorties that carry ordnance varies dramatically and is dependent on Air Force training tactics and budget, national policy, and world conflict. Horstman Post Tr. 4214, at 28; Tr. at 3494 (Jefferson). On February 1, 2001, 388th FW Operations Group Commander Colonel Coots advised that current training needs require more sorties to carry ordnance than the training conducted in FY 2000. Horstman Post Tr. 4214, at 29. The Applicant does not know the reason for the decline in the number of sorties carrying ordnance from FY 1998 to FY 2000. Tr. at 3500 (Jefferson). Hill AFB is capable of flying 678 sorties with ordnance through Skull Valley in a single year. Tr. at 3499 (Jefferson). The State argues that it is unrealistic and not conservative to assume that future flights will carry less ordnance than flights in FY 1998 data in calculating the number of sorties carrying ordnance. State Findings ¶ 63. Using FY 1998 data, the State calculates that 21.2% (866/4086) of Skull Valley flights carried ordnance in 1998. *Id.* ¶ 117.

C.98 The Applicant reasons that most of the ordnance is delivered to the UTTR South Area, and not all flights to the UTTR South Area will transit Skull Valley. Aircraft Crash Report at 81. The Applicant therefore determines the percentage of all flights carrying ordnance by dividing the number of sorties carrying ordnance by the number of UTTR South Area sorties, rather than Skull Valley sorties. Aircraft Crash Report at 81-82. There were 5726 F-16 sorties in the UTTR South Area in FY 1998. Aircraft Crash Report at 82. Using the reasoning adopted by the Applicant, 15.1% (866/5726) of all flights, including those through Skull Valley, carried ordnance in 1998.

C.99 Using the State's crash rate, C , for F-16s of 4.10×10^{-8} , taking 21.2% of 7040 as the number of flights, N , or 1492, the area, A , of 0.12519 square mile, including an assumed skid area for ordnance,¹⁶⁰ and its asserted width, w , of 5 miles,¹⁶¹ the State's calculated annual probability of impact from jettisoned ordnance is 1.53×10^{-6} per year. State Findings ¶ 120.

C.100 Given the wide range of claims by the Applicant and the State about the number N , and given only 3 years of data were available (FY 1998, 1999, and 2000), it is reasonable to use the average of the 3-year data to estimate the

¹⁵⁹The Board notes that PSF did not account for 419th FW ordnance in its Aircraft Report shown in PFS Exh. N, but based all calculations and discussion on 388th FW data only.

¹⁶⁰Resnikoff Post Tr. 8698, at 20; *see also* State Exhs. 79 and 80.

¹⁶¹Resnikoff Post Tr. 8698, at 20; *see also* State Findings ¶¶ 40-45.

percentage of all flights carrying ordnance. This approach provides $(866 + 193 + 164)/(4086 + 4586 + 5997) = 0.08337$, the proportion of all flights carrying ordnance. Multiplying 7040 (the number of flights the Board has found) by that percentage, yields an estimate for N of 587, or about 40% of the value the State would assign. We have already indicated our findings on the other factors. Thus, based on the above inputs, we calculate the probability of jettisoned ordnance directly impacting the PFS facility as follows:

$$\begin{aligned}
 P &= C \times N \times e \times A \div w \\
 &= 2.736 \times 10^{-8}/\text{mile} \times 587 \times 0.90 \times 0.08763 \text{ sq. mile} \div 6 \text{ miles} \\
 &= 2.11 \times 10^{-7} \text{ per year}
 \end{aligned}$$

Although meeting the Commission’s governing criterion, this probability is high enough to warrant inclusion in the cumulative risk.

(3) NEARBY EXPLOSION

C.101 The Applicant also addressed the potential hazard to the facility posed by jettisoned live ordnance that might land near the facility (without hitting it) 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 facility (also without hitting it) and found both to be insignificant. *See* Cole/Jefferson/Fly Post Tr. 3061, at 104-06. The State submitted no testimony on these potential hazards.

C.102 The U.S. Air Force has specifically stated that “[n]o 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.” *Id.* at 101-02. The Air Force has also stated that “[t]he UTTR has not experienced an unanticipated munitions release outside of designated launch/drop/shoot boxes.” *Id.* at 102. Consequently, the likelihood or probability of an inadvertent weapons release from F-16s flying over Skull Valley impacting or affecting the facility is very small.

C.103 As stated above, Air Force pilots do not arm the live ordnance they are carrying while transiting Skull Valley near the facility. Furthermore, 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 104; *see also* Tr. at 8444 (Horstman). Thus, it is highly unlikely that jettisoned live ordnance or live ordnance carried aboard a crashing aircraft that did not directly impact the facility would damage the facility.

C.104 Nevertheless, the Applicant conservatively assumed that ordnance jettisoned from or carried aboard a crashing aircraft would have a 1% chance of

exploding and calculated the hazard that potentially exploding ordnance landing nearby the PFSF would pose to the facility. Cole/Jefferson/Fly Post Tr. 3061, at 105-06. The Applicant assumed that a storage cask or the Canister Transfer Building could be damaged if a bomb exploded close enough to exceed their explosive overpressure limits. Johns Post Tr. 3205, at 5-6; Aircraft Crash Report at 83b. The Applicant conservatively assumed that each F-16 carrying ordnance through Skull Valley was carrying a 2000-pound bomb, the largest single piece of ordnance they carry. Cole/Jefferson/Fly Post Tr. 3061, at 105. The Applicant then calculated the probability that the jettisoned ordnance would land close enough to explode and damage the facility, or an F-16 would crash near the facility without jettisoning the ordnance, using a method similar to what it used to calculate the probability that an F-16 would crash and hit the facility. *Id.* The Applicant concluded that there would be an annual probability of less than 1×10^{-10} per year that the facility would be damaged by a nearby explosion of ordnance. *Id.* at 105-06. Again, the State did not challenge the impact of nearby exploding ordnance, and in addition, the Staff found the Applicant's assessment to be reasonable. Staff Findings ¶ 2.517.

(4) CONCLUSION

C.105 We find that the Applicant used logical methodology to calculate the hazard to the facility posed by ordnance. As noted above, the Applicant's assessment of the crash impact hazard posed by F-16 transits of Skull Valley is based on reasonable data and analysis in three of the four respective ways ordnance can impact the facility. The Board has determined, based on its own analysis, that a higher hazard probability is more appropriate for the hazard posed by jettisoned ordnance. But the Board's estimate of 2.1×10^{-7} /year (relative to the Applicant's value of 3.2×10^{-8} /year) is still within the Commission's 1×10^{-6} acceptance criterion. The State did not challenge the Applicant's assessment of the hazard posed by potential nearby explosions of ordnance.

C.106 In summary, we find that the risk posed to the facility from jettisoned ordnance is within the acceptance criterion of 1×10^{-6} /year stated in CLI-01-22. This risk level, however, adds to the already excessive risk posed by F-16s transiting Skull Valley.

III. CONCLUSIONS OF LAW

The Licensing Board has considered all of the material presented by the parties on contention Utah K/Confederated Tribes B (Inadequate Consideration of Credible Accidents). Based upon a review of the entire evidentiary record in this proceeding and the proposed findings of fact and conclusions of law submitted by the parties, and in accordance with the views set forth in Parts I and

II above — which we believe are supported by a preponderance of the reliable, material, and probative evidence in the record — the Board has decided the matters in controversy concerning this contention and reaches the following legal conclusions:

1. Pursuant to 10 C.F.R. §§ 72.90, 72.94, and 72.98, proposed sites for an ISFSI must be examined with respect to the frequency and severity of external man-induced events that could affect the safe operation of the ISFSI. The facility must be designed to accommodate the effects of credible accidents and must include them in the design bases of the facility. *See* 10 C.F.R. § 72.122(b)(1). The Commission previously approved an annual probability of occurrence criterion of 1×10^{-6} for determining whether aircraft crash accidents must be included in the design bases of an ISFSI. *See* CLI-01-22, 54 NRC 255, 263 (2001).

2. The Applicant has not demonstrated, as required by that Commission decision, that the cumulative probability of a civilian or military aircraft (including jettisoned ordnance) crashing at or affecting the PFS facility is within the acceptance criterion of 1×10^{-6} per year. Specifically, PFS has not provided reasonable assurance that F-16 aircraft crash accidents do not pose a significant threat to the facility. Consequently, the PFS application for a Part 72 license to construct and operate an independent spent fuel storage facility in the Skull Valley cannot be granted at this juncture.

For the reasons set forth in this opinion, it is this 10th day of March 2003, ORDERED that:

1. Contention Utah K/Confederated Tribes B (Inadequate Consideration of Credible Accidents) is RESOLVED in favor of Intervenor State of Utah relative to the issue of the hazard of F-16s transiting Skull Valley, as it impacts on the cumulative hazard to the PFS facility from aircraft accidents and ordnance.

2. In accordance with 10 C.F.R. § 2.730(f), the Licensing Board's rulings in Part I above, as supported by the Detailed Analysis of the Record and Findings of Fact in Part II above, and the brief Conclusions of Law in Part III above, are REFERRED to the Commission for its consideration and further action, as appropriate.

3. In accordance with Subpart I.E above, Applicant PFS, Intervenor State of Utah, and the NRC Staff shall FILE within 20 days a joint report outlining their positions regarding further proceedings on the issue of the consequences of an F-16 accident at the Skull Valley facility.

4. In the absence of Commission acceptance of our referral of this ruling under ordering paragraph two above, and upon a determination by Applicant PFS (as may be expressed in the report submitted under ordering paragraph three above) not to proceed further relative to the issue of the consequences of an F-16 accident at the Skull Valley facility, pursuant to 10 C.F.R. § 2.760(a), this Partial

Initial Decision will constitute the FINAL ACTION of the Commission within forty (40) days of its date unless a petition for review is filed in accordance with 10 C.F.R. § 2.786, or the Commission directs otherwise.

5. *Any party wishing to file a petition for review on the grounds specified in 10 C.F.R. § 2.786(b)(4) must do so within fifteen (15) days after service of this decision, which shall be considered to have been served by regular mail for the purpose of calculating that petition filing date.*

THE ATOMIC SAFETY AND
LICENSING BOARD

Michael C. Farrar, Chairman
ADMINISTRATIVE JUDGE

Jerry R. Kline
ADMINISTRATIVE JUDGE

Peter S. Lam
ADMINISTRATIVE JUDGE

Rockville, Maryland
March 10, 2003

Copies of this Memorandum and Order were sent this date by Internet e-mail transmission to counsel for (1) Applicant PFS; (2) Intervenors Skull Valley Band of Goshute Indians, OGD, Confederated Tribes of the Goshute Reservation, Southern Utah Wilderness Alliance, and the State of Utah; and (3) the NRC Staff.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:

Michael C. Farrar, Chairman
Dr. Jerry R. Kline
Dr. Peter S. Lam

In the Matter of

Docket No. 72-22-ISFSI
(ASLBP No. 97-732-02-ISFSI)

PRIVATE FUEL STORAGE, L.L.C.
(Independent Spent Fuel Storage
Installation)

March 21, 2003

RULES OF PRACTICE: MOTIONS (RIPENESS)

When a Commission order is limited in scope to “licensees who currently store spent fuel or have identified near term plans to store spent fuel in an ISFSI” (67 Fed. Reg. 65,152 (Oct. 23, 2002)), entity that is in the process of applying for a license is not directly affected by the order. Hence, any motion related to that entity and the terms of the order is premature. *Cf. Yankee Atomic Electric Co.* (Yankee Nuclear Power Station), CLI-96-7, 43 NRC 235, 274 (1996) (rejecting contention as not ripe where applicant had not pursued, nor had been granted, a license amendment that would trigger the concern to which the contention was addressed). Furthermore, if such an order is eventually applied to the facility, an adversely affected person would have the opportunity to request a hearing and related relief at that time.

MEMORANDUM AND ORDER
(Re: Safeguards and Security Matters)

By motion filed November 7, 2002, Intervenor State of Utah requested access to a nonpublic list of post-9/11 supplemental safeguard and security requirements that an October 16, 2002 NRC order had imposed on certain licensees of 10 C.F.R. Part 72 independent spent fuel storage installations (ISFSIs). Additionally, the State requested time to use the list of supplemental requirements as a basis for framing such additional contentions as might be appropriate. In responses submitted on November 15, 2002, and November 18, 2002, Applicant Private Fuel Storage (PFS) and the NRC Staff, respectively, opposed the State's motion. For the reasons set forth below, we deny the State's request.¹

I. BACKGROUND

In October 2001, a year before filing the pending motion, the State proffered late-filed Contention Utah RR, entitled "Suicide Mission Terrorism and Sabotage." That contention challenged, in the aftermath of the September 11, 2001 terrorist attacks, planned security at the Applicant's proposed Skull Valley, Utah facility. Ultimately, the Board decided not to admit that contention (finding it represented an impermissible challenge to the NRC's existing regulatory requirements and policies pertaining to ISFSI physical security) but referred its ruling to the Commission. *See* LBP-01-37, 54 NRC 476, 488-89 (2001), *referral accepted*, CLI-02-3, 55 NRC 155 (2002).²

¹ We note that there was some concern expressed by the parties regarding whether the State's motion should be handled by this PFS Licensing Board or the original one chaired by Judge Bollwerk. Having consulted with him in his capacity as Chief Administrative Judge, we advise the parties that under the deliberately drawn terms of his December 19, 2001, notice reconstituting this proceeding to establish this Board, the only matters intended to be before the Bollwerk Board, now and in the future, are those specifically referenced in the reconstitution order. *See* 66 Fed. Reg. 67,335 (Dec. 28, 2001). Accordingly, under the plain language of the reconstitution order, and absent some other directive, all other aspects of the PFS proceeding — including newly arising or regenerated items relating to matters that previously were before the Bollwerk Board — now fall within the jurisdiction of this Board.

² After the parties filed their pleadings on the matter now before us, the Commission resolved the matter referred to it about the role of terrorism-related contentions in adjudicatory proceedings. Specifically, the Commission held, in CLI-02-25, 56 NRC 340 (2002) and related cases, that the National Environmental Policy Act provides no justification for including a terrorism review in nuclear licensing cases (the Commission indicated that such matters were being handled by the agency in a comprehensive but different fashion). *See also Long Island Lighting Co.* (Shoreham Nuclear Power Station), ALAB-156, 6 AEC 831, 851 (1973). For purposes of ruling on the pending motion, we
(Continued)

The issue of post-9/11 security requirements was thus pending during 2002 in connection with this and other ongoing licensing adjudications. In a related development, the agency published in the *Federal Register* the October 16, 2002 order that, effective immediately, imposed additional 9/11-related requirements on all existing ISFSI licensees operating under 10 C.F.R. Part 72. *See* 67 Fed. Reg. 65,152 (Oct. 23, 2002).

Existing Commission regulations require Part 72 licensees to follow the safeguards contingency plan procedures in 10 C.F.R. Part 73, App. C, along with the specific safeguards requirements detailed in 10 C.F.R. §§ 73.55, 73.71. Going further, the October 16 order contained interim requirements to “supplement existing regulatory requirements,” and indicated that specific licenses would be adjusted accordingly. *Id.* at 65,152-53. The specific safeguards information for affected licensees, which was provided in Attachment 2 to the October 16 order, was not, however, made publicly available. *See id.* at 65,153 n.1. The October 16 order also provided an opportunity for licensees and those “adversely affected” by its dictates to request a hearing. *Id.* at 65,153-54.

Filed in the wake of the October 16, 2002 order, the State’s pending motion requests that the Board (1) require the Executive Director for Operations (EDO) to make available a copy of Attachment 2, albeit under any necessary protective measures; and (2) provide a 45-day time period following the actual availability of Attachment 2 within which to submit related contentions. Additionally, the State asserts that a review of Attachment 2 is necessary to enable it to determine whether it needs to “take action” regarding Contention Utah RR. *See* State Motion for Production at 1-3.

II. RULING

By its terms, the October 16 order is limited in scope to “licensees who *currently* store spent fuel or have identified *near term plans* to store spent fuel in an ISFSI under the specific license provisions of 10 CFR part 72.” 67 Fed. Reg. at 65,152 (emphasis supplied). Obviously, PFS is not a licensee at this juncture; and even assuming it were to be granted a license in relatively short order,³ there is every indication that the storage of spent nuclear fuel at the PFS facility cannot

will assume, without deciding, that the Commission’s decision leaves room for intervenors to file legitimate contentions regarding licensees’ *compliance* with terrorism-related orders imposed by the Commission.

³ *Cf.* our recent decision herein on “Credible Accidents,” LBP-03-4, 57 NRC 69 (2003).

logistically be a matter of “near term plans.”⁴ PFS is thus not an entity that would come under any aspect of the October 16 order.

It also is unclear whether the October 16 order would ever apply to PFS even if it were to be granted a license. As the State recognized in its motion (at 2), nothing in the order indicates that Attachment 2 would then be applied as a condition to any PFS license. In that regard, the October 16 order indicates that the requirements listed in Attachment 2 are “interim requirements” that could be altered if “a significant change in the threat environment has occurred, or the Commission determines that other changes are needed.” 67 Fed. Reg. at 65,153. Thus, again assuming PFS is eventually granted a license, there is a considerable degree of uncertainty as to whether, and to what degree, the supplemental safeguards under Attachment 2, rather than some other mandate, would be applicable to the Skull Valley facility.

It thus is apparent that the State’s requests are premature. *Cf. Yankee Atomic Electric Co. (Yankee Nuclear Power Station), CLI-96-7, 43 NRC 235, 274 (1996)* (rejecting contention as not ripe where applicant had not pursued, nor had been granted, a license amendment that would trigger the concern to which the contention was addressed). Further, if Attachment 2 (or something like it) is eventually applied to the PFS facility, any adversely affected person would, as the October 16 order noted, have the opportunity to request a hearing. *See 67 Fed. Reg. at 65,153-54.* Under that procedure, the State would seemingly have the opportunity then to request a hearing.⁵

In sum, PFS is not currently a licensee and so is not directly affected by the October 16 order and its Attachment 2. Nor is there any concrete indication that the safeguards requirements in Attachment 2 would apply to PFS even if it is granted a license in the future, although the State will have an opportunity to request a hearing if Attachment 2 (or something like it) is applied to any PFS Part 72 license. As a consequence, the State’s motion requesting access to review

⁴In this regard, in its response to the State’s motion, the NRC Staff listed a number of additional procedural contingencies the Applicant must meet before it would be ready to receive spent nuclear fuel at the proposed Skull Valley facility, including receiving authorizations from the Bureau of Indian Affairs and the Bureau of Land Management and fulfilling specific financial-assurance license conditions prior to construction. Of course, it also would need to perform the actual construction of the facility and an associated rail line, which could require at least 18 months for completion. *See NRC Staff Response (Nov. 18, 2002) at 5 n.8.*

⁵*See id.*; *see also Pacific Gas & Electric Co. (Diablo Canyon Power Plant Independent Spent Fuel Storage Installation), CLI-02-23, 56 NRC 230, 240 (2002)* (in denying request to suspend ISFSI construction/operation authorization proceeding pending agency post-9/11 comprehensive review of adequacy of security measures, Commission noted that if additional license requirements were be imposed in the future, petitioner could submit late-filed contentions).

Attachment 2 to the agency's October 16, 2002 order and for additional time to file contentions relating to that attachment is *denied* as premature.⁶

It is so ORDERED.

THE ATOMIC SAFETY AND
LICENSING BOARD

Michael C. Farrar, Chairman
ADMINISTRATIVE JUDGE

Jerry R. Kline
ADMINISTRATIVE JUDGE

Peter S. Lam
ADMINISTRATIVE JUDGE

Rockville, Maryland
March 21, 2003

Copies of this Memorandum and Order were sent this date by Internet e-mail transmission to counsel for (1) Applicant PFS; (2) Intervenors Skull Valley Band of Goshute Indians, Ohngo Gaudadeh Devia, Confederated Tribes of the Goshute Reservation, Southern Utah Wilderness Alliance, and the State of Utah; and (3) the NRC Staff.

⁶It should be added that to the degree that the State sought to support its motion based on the asserted need to "take action" relative to Contention Utah RR, jurisdiction relative to that contention then resided, by reason of the accepted referral, with the Commission rather than this Board. Of course, by reason of the Commission's decision in CLI-02-25, above, upholding our dismissal of the contention, that matter has since been resolved before the agency.

We also note that although the State cites 10 C.F.R. § 2.744 in support of its request that the Board order production by the agency's EDO of Attachment 2 to the October 16 order, it apparently has not complied with the procedural prerequisites for obtaining such an order, i.e., the submission of such a request to the EDO and that official's denial of the request. *See* 10 C.F.R. § 2.744(a), (b). Nevertheless, as the Staff suggests, *see* Staff Response at 10 n.12, it is not necessary at this time to decide the issue of the State's compliance with section 2.744, given that the State's request has been denied on the alternate ground of prematurity.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

COMMISSIONERS:

Nils J. Diaz, Chairman
Greta Joy Dicus
Edward McGaffigan, Jr.
Jeffrey S. Merrifield

In the Matter of

Docket No. 70-143-MLA

NUCLEAR FUEL SERVICES, INC.
(Erwin, Tennessee)

April 29, 2003

The Commission reviews and denies Petitioners' request to enjoin construction of buildings by the Licensee.

RULES OF PRACTICE: REQUEST FOR STAY

Section 2.1263 provides for stay requests in Subpart L cases, but authorizes stays of only "any decision or action of the Commission, a presiding officer, or any action by the NRC staff in issuing a license." It does not provide for enforcement-type "injunctions" against licensees. Where, as in this proceeding, there has been no final decision by the Presiding Officer, and the NRC Staff has not issued the license amendment, the Petitioners' request does not amount to a challenge of any decision within the scope of the adjudicatory proceeding. Instead, the Petitioners' request for an injunction more appropriately should be viewed as akin to a petition for enforcement under 10 C.F.R. § 2.206.

REGULATIONS: INTERPRETATION (10 C.F.R. §§ 51.101(a) AND 70.23(a)(7))

Our rules *contemplate* that construction should not begin until the NRC has completed its environmental review. To that effect, both 10 C.F.R. § 51.101(a)

and 10 C.F.R. § 70.23(a)(7) discourage construction activities until the Staff has completed an environmental review. These rules provide a disincentive to early construction by raising the possibility of ultimate denial of the license application should an applicant move forward precipitously, despite open environmental issues.

MEMORANDUM AND ORDER

Before the Commission is an “Emergency Request To Enjoin Construction,” filed by the Friends of the Nolichucky River Valley, the State of Franklin Group of the Sierra Club, the Oak Ridge Environmental Peace Alliance, and the Tennessee Environmental Council, all Petitioners in this license amendment proceeding.¹ The Petitioners seek to halt construction by Nuclear Fuel Services, Inc. (“NFS”) of any buildings intended for use as part the Blended Low-Enriched Uranium (“BLEU”) project at NFS’s Erwin, Tennessee site. While the Petitioners’ request falls beyond the scope of this adjudicatory proceeding, a point we clarify further below, the Commission nonetheless has reviewed the Petitioners’ claims. For the reasons we provide below, we deny the request to enjoin construction.

1. BACKGROUND

The license amendment at issue in this proceeding is the first of three license amendments NFS seeks to implement to participate in the BLEU Project, part of a Department of Energy program to reduce the stockpiles of surplus high-enriched uranium (HEU) through reuse as low-enriched uranium (LEU) or disposal as radioactive waste.² In furtherance of the BLEU Project, Framatome ANP, Inc., has contracted with NFS to downblend surplus high-enriched uranium material to a low-enriched uranium nitrate and to convert the low-enriched uranium nitrate to an oxide form.³ NFS seeks to obtain three related license amendments, which together would authorize it to produce LEU oxide, receive and store LEU nitrate, downblend HEU to LEU, and convert LEU nitrate to LEU oxide.⁴

¹ Petitioners’ Emergency Request To Enjoin Construction by NFS of BLEU Project Facilities (Jan. 21, 2003).

² 67 Fed. Reg. 66,172, 66,173 (Oct. 30, 2002); 68 Fed. Reg. 796 (Jan. 7, 2003).

³ 67 Fed. Reg. at 66,174.

⁴ *Id.*

The first license amendment application, filed on February 28, 2002, requests authority to “store LEU-bearing material at the Uranyl Nitrate Building.”⁵ Low-enriched uranyl nitrate solutions would be shipped from the Department of Energy’s Savannah River site to NFS’s Erwin site for storage in the Uranyl Nitrate Building.⁶ The building will contain approximately twenty-four low-enriched uranyl nitrate tanks, each having a capacity of 10,500 gallons.⁷ The Uranyl Nitrate Building is also intended to store low-enriched nitrate solutions that will be produced onsite at an NFS downblending facility.⁸ As part of this license amendment, NFS requests authority to increase its possession limit of U-235.⁹

A second license amendment application, submitted to the NRC by letter dated October 11, 2002, requests the license changes necessary to downblend highly enriched uranium/aluminum alloy and HEU material metal to low-enriched uranyl nitrate solutions.¹⁰ NFS intends to relocate processing equipment previously used elsewhere at its Erwin site to an existing but inactive production area that will be modified and designated the Blended Low-Enriched Uranium Preparation Facility (BPF).¹¹ A third license amendment application, which NFS expects to submit in May or June 2003, would request the authority to convert uranyl nitrate solutions to UO₂ powder and conduct associated effluent processing. The UO₂ powder would be shipped to Framatome ANP, Inc., for conversion to commercial reactor fuel to be used in the Tennessee Valley Authority (TVA) nuclear power reactors. Activities associated with the third license amendment would include the construction and operation of an Oxide Conversion Building (OCB) and an Effluent Processing Building (EPB).¹² In total, the three related license amendments involve the construction of three new buildings — the Uranyl Nitrate Building, the Oxide Conversion Building, and the Effluent Processing Building — on a site referred to as the “BLEU Complex.”¹³

In this adjudicatory proceeding, the Petitioners seek a hearing to challenge the first of the three related license amendments. The Nuclear Regulatory

⁵ Letter from B. Marie Moore, Vice President, Safety and Regulation, NFS, to Director, Office of Nuclear Materials Safety and Safeguards, NRC (Feb. 28, 2002); *see also* 67 Fed. Reg. 66,172 (Oct. 30, 2002); 68 Fed. Reg. 796 (Jan. 7, 2003).

⁶ Environmental Assessment for Proposed License Amendments to Special Nuclear Material License No. SNM-124 Regarding Downblending and Oxide Conversion of Surplus High-Enriched Uranium (June 2002) (“Environmental Assessment”) at 1-2.

⁷ *Id.*

⁸ *Id.*

⁹ 67 Fed. Reg. at 66,173.

¹⁰ 68 Fed. Reg. 796 (Jan. 7, 2003); Environmental Assessment at 2-1.

¹¹ *Id.*

¹² *See* Environmental Assessment at 1-1, 1-3, 2-5, 2-7; 67 Fed. Reg. at 66,174.

¹³ Environmental Assessment at 2-1.

Commission Staff has issued a Finding of No Significant Impact (FONSI) for the first proposed amendment,¹⁴ but has not issued the amendment itself. Whether the Petitioners satisfy all requirements for intervention and can be admitted as parties to a hearing has yet to be determined by the Presiding Officer.

At the Petitioners' request, the Presiding Officer has placed this proceeding in abeyance until the filing of the third license amendment application.¹⁵ Given that many of the issues the Petitioners seek to raise are "global" — pertaining to all three license amendments — and that "neither the Licensee nor the Staff provided any good practical reason to conduct a piecemeal adjudication of the challenges to the overall BLEU project,"¹⁶ the Presiding Officer found that holding the proceeding in abeyance made "good sense from a case management standpoint."¹⁷ Although NFS opposed the abeyance order, it acknowledged that "attempting to litigate only those environmental issues related to the first amendment would require that the parties and the Presiding Officer make an effort to isolate them from issues related to the other two amendments," a "problem[atic] . . . approach [in] that it may be difficult to assign each environmental issue to one of the three amendments."¹⁸

In their "injunction" motion before us, the Petitioners seek to enjoin NFS from: continuing construction of the Uranyl Nitrate Storage Building (UNB) (associated with the first license amendment), making modifications to the Blended Low-Enrichment Processing Building (associated with the second amendment), and commencing construction of the Oxide Conversion Building (OCB) or Effluent Processing Building (EPF) (associated with the third license amendment).¹⁹ The Petitioners state that they "observed" construction activities at the NFS site in December 2002 and January 2003,²⁰ and that NRC Staff counsel has informed them that "construction of the UNB [uranyl nitrate building] [is] well underway, and that NFS plan[s] to commence construction of the OCB [oxide conversion building] within a week or two."²¹

The Petitioners request the Commission to enjoin all construction activities associated with the BLEU Project license amendments "because NFS's construction is proceeding *before* the NRC Staff has complied with NEPA by completing its environmental review and determining whether an Environmental

¹⁴ 67 Fed. Reg. 45,555 (July 9, 2002).

¹⁵ Order (Directing the Holding of the Proceeding in Abeyance) (Jan. 21, 2003), attached to LBP-03-1, 57 NRC 9, 16 (2003).

¹⁶ LBP-03-1, 57 NRC at 14.

¹⁷ Order Holding Proceeding in Abeyance, *id.* at 17.

¹⁸ Applicant's Motion for Clarification of Scope of Hearing (Nov. 12, 2002) at 4.

¹⁹ Emergency Request at 1-2.

²⁰ *Id.* at 5.

²¹ *Id.*

Impact Statement (EIS) is required for the proposed BLEU project.”²² To allow construction to go forward, the Petitioners claim, “will influence the NRC’s decisionmaking process regarding the proposed BLEU project, by committing resources to a preordained course of action before the agency has decided whether to prepare an EIS that evaluates the impacts of that course of action or reasonable alternatives.”²³ The Petitioners “contend that the NRC should prepare an EIS for the [entire] BLEU Project because it will have significant adverse impacts on the environment.”²⁴ They further claim that the NRC Staff has “not complete[d] an environmental review for any of the three license amendments, because such review could only follow completion of a safety review,” which the Staff has not concluded.²⁵

In response, NFS claims that the Staff’s Environmental Assessment already examined the impacts of the “entire BLEU project.”²⁶ NFS states that “unless NFS changes the project, the EA will be the NRC’s final environmental review for the BLEU project.”²⁷ Thus, argues NFS, any NFS construction “activities cannot possibly foreclose an [environmental] analysis that is already complete.”²⁸ NFS also insists that it “has neither violated nor is about to violate any Commission regulation” because “[t]here is no prohibition on pre-licensing construction in the Commission’s regulations applicable to NFS.”²⁹

While the NRC Staff is not currently a party to this proceeding, it has submitted to the Commission an “Amicus Clarification of Record,” seeking to “correct an error contained in Applicant’s Opposition.”³⁰ The error, the Staff claims, was NFS’s assertion that the Staff “does not intend to submit additional Environmental Assessments absent new information.”³¹ Instead, the Staff claims, it “has repeatedly made clear to the applicant” that “[t]he staff has always intended to prepare a separate EA and Finding of No Significant Impact (FONSI) or Environmental Impact Statement, if such review is deemed necessary for the second amendment, noticed on January 7, 2003, and the proposed third amendment.”³²

²² *Id.* at 2 (emphasis in original).

²³ *Id.* at 7.

²⁴ *Id.* at 2.

²⁵ *Id.* at 4.

²⁶ Applicant’s Opposition to Petitioners’ Emergency Request To Enjoin Construction by NFS of BLEU Project Facilities (Feb. 5, 2003) (Applicant’s Opposition) at 5 (emphasis in original).

²⁷ *Id.*

²⁸ *Id.* at 8.

²⁹ *Id.* at 4-5 (citing 10 C.F.R. § 51.101).

³⁰ NRC Staff’s Amicus Clarification of Record (Feb. 10, 2003) at 1.

³¹ *Id.*

³² *Id.* at 1-2.

Earlier, at a telephone conference with the Presiding Officer on January 17, 2003, the Staff repeatedly emphasized that while “the EA involves some issues on the second and third amendments for environmental NEPA purposes,” to consider “cumulative impact[s]” and “avoid segmentation problems,” the EA “was not meant to address a final approval of the BLEU project.”³³ Instead, “the Staff will be doing a separate, independent environmental assessment, or an EIS, if a FONSI is not issued, for . . . the second and the third [amendments]’”:³⁴

[A]nd that leads into the clarification of something that [NFS counsel] stated, which was that it was their belief that the EA covered and was final for all three amendments that would only be revisited if the Staff determined that there had been some changes when the second and third amendments came in.

And we want to clarify again on the record, and we have stated this numerous times, that when the EA looked at information on all three amendments, the EA only covered the first amendment. And that when the second amendment, which has now come in, has been reviewed, an EA or an EIS *will be prepared* on the second amendment; and if they choose to come in with a third amendment, we will do the same for that. . . .

A new environmental review, a complete environmental review for the second amendment, will be undertaken and will be expressed in either an EA or an EIS. And we just want to make sure that is clear to the licensee.³⁵

The Staff “apologize[d]” if the Environmental Assessment “is misleading and maybe confused” NFS.³⁶

NFS, however, apparently continues to take issue with the Staff’s characterization of the scope and completeness of the issued EA, and likewise of the extent of the environmental reviews that will be conducted for the second and third amendments.³⁷ This is a matter we do not resolve today. Our decision to deny the Petitioners’ “injunction” request does not rest on NFS’s assertion that the EA represents a full and complete review of the impacts of all three license amendments.

³³ Transcript, Telephone Conference Call (Jan. 17, 2003) at 38-41.

³⁴ *Id.* at 31.

³⁵ *Id.* at 38-40 (emphasis added).

³⁶ *Id.* at 43.

³⁷ NFS requested that the Commission allow it the opportunity to respond to the Staff’s Amicus Clarification, a request we now grant. *See* Applicant’s Motion for Leave To File Response to NRC Staff Amicus Clarification of Record (Feb. 13, 2003). NFS filed its response at the same time as its request.

II. THE NATURE OF THE PETITIONERS' REQUEST

The Petitioners' emergency request for an injunction, while cast as an adjudicatory matter, in actuality falls outside our adjudicatory rules (10 C.F.R. Part 2). The nearest pertinent rule, 10 C.F.R. § 2.1263, provides for stay requests in Subpart L cases. (This is a Subpart L case.) But section 2.1263 authorizes stays of only "any decision or action of the Commission, a presiding officer, or any action by the NRC Staff in issuing a license."³⁸ It does not provide for enforcement-type "injunctions" against licensees. In this proceeding, there has been no final decision by the Presiding Officer. Nor has the NRC Staff issued any license amendment related to the BLEU Project. The Petitioners' request therefore does not challenge any decision within the scope of this adjudicatory proceeding.

Instead, the emergency request for an injunction more appropriately should be viewed as akin to a petition for enforcement under 10 C.F.R. § 2.206. At bottom, the Petitioners' allegation is that under NRC rules NFS cannot be allowed to proceed with construction activities before the Staff has completed its environmental review of the BLEU Project:

NRC regulations at 10 C.F.R. § 70.23(a)(7) also contemplate that construction of a special nuclear materials facility should not begin until the NRC has completed its environmental review. Here, the NRC staff has yet to make a conclusive determination regarding the question of whether the proposed BLEU Project will have a significant impact on the environment. Therefore, construction should not be allowed to continue or commence.³⁹

The Petitioners thus seek Commission enforcement action against the Licensee — that we "order NFS to suspend" its construction activities.⁴⁰ While we ordinarily might refer this controversy to the Staff to evaluate whether the Licensee's current or planned activities violate any NRC regulations, in exercise of our supervisory authority (and in view of the Petitioners' claim of a true emergency) the Commission itself has chosen to review and decide the Petitioners' emergency request.⁴¹

³⁸ 10 C.F.R. § 2.1263. Section 2.1263 incorporates the traditional four-part inquiry for stays set out in 10 C.F.R. § 2.788 — likelihood of success, irreparable injury, harm to others, and the public interest.

³⁹ Emergency Request at 9.

⁴⁰ *Id.* at 6.

⁴¹ See *Texas Utilities Electric Co.* (Comanche Peak Station Electric Station, Unit 2), CLI-93-2, 37 NRC 55, 58 (1993).

III. ANALYSIS

Given the record before us, we do not find it necessary to order NFS to cease all construction activities associated with the BLEU Project. To begin with, it is questionable whether the Commission has authority to halt NFS's prelicensing construction activities in the circumstances of this case. The record before us does not reveal any statute or regulation that requires NFS to obtain a construction permit or similar authorization prior to beginning construction. The Atomic Energy Act provisions authorizing NRC construction permits in some settings do not apply here.⁴² The Petitioners themselves state that "NFS's building construction does not require federal action in the form of issuance of an NRC safety permit."⁴³ And the NRC Staff presumably agrees, for it currently is standing by even as NFS goes forward on construction with its amendment application still pending.

We, too, do not understand applicable NRC regulations or statutes to prohibit outright NFS's construction activities. But the Petitioners undoubtedly are correct that our rules "*contemplate* that construction . . . should not begin until the NRC has completed its environmental review."⁴⁴ To that effect, both 10 C.F.R. § 51.101(a) and 10 C.F.R. § 70.23(a)(7) discourage construction activities until the Staff has completed an environmental review.⁴⁵ For example, section 51.101(a)

⁴² See, e.g., Atomic Energy Act, 42 U.S.C. § 2235 (2001) (construction permits for production and utilization facilities).

⁴³ Emergency Request at 6.

⁴⁴ *Id.* at 9 (emphasis added).

⁴⁵ Section 51.101(a)(2) reads as follows:

Until a record of decision is issued in connection with a proposed licensing or regulatory action for which an environmental impact statement is required under § 51.20, or until a final finding of no significant impact is issued in connection with a proposed licensing or regulatory action for which an environmental assessment is required under § 51.20:

. . . .

(2) Any action concerning the proposal taken by an applicant which would (i) have an adverse environmental impact, or (ii) limit the choice of reasonable alternatives may be grounds for denial of the license. In the case of an application covered by . . . 70.21(f) . . . , the provisions of this paragraph will be applied in accordance with . . . 70.23(a)(7).

Key portions of section 70.23(a)(7) read as follows:

An application for a license will be approved if the Commission determines that:

. . . .

. . . the Director of Nuclear Material Safety and Safeguards or his designee, before commencement of construction of the plant or facility in which the activity will be conducted, on the basis of information filed and evaluations made pursuant to subpart A of part 51 of this chapter, has concluded, after weighing the environmental, economic, technical, and other benefits against environmental costs and considering available alternatives, that the action called for is the

(Continued)

provides that certain actions taken prior to completion of the NRC's environmental review "may be grounds for denial of the license." Thus, while not absolutely barring preclicensing construction, NRC rules provide a disincentive to early construction by raising the possibility of ultimate denial of the license application should an applicant move forward precipitously, despite open environmental issues.

In short, NFS proceeds at its own risk with construction activities. If NFS begins or continues to construct buildings associated with license amendments for which the Staff's environmental review is incomplete, NFS's construction may prove grounds for denial of one or more of the license amendments. As to the first license amendment — involving the Uranyl Storage Building — the NRC Staff *has* completed an environmental review and issued a final Finding of No Significant Impacts (FONSI).⁴⁶ The Petitioners will have full opportunity to challenge the adequacy of the Environmental Assessment upon which the FONSI is based, assuming they are found to satisfy the threshold intervention standards for an adjudicatory hearing.

As to any construction activities associated with the second or third BLEU Project license amendments, however, the Commission expects NFS to consult the NRC Staff on the status of the environmental reviews. Recent statements by the Staff, described earlier in this decision, suggest that while there has been some environmental review of the impacts of the second and third license amendments, the Staff expects to conduct additional, more extensive reviews, and to issue a "separate, independent environmental assessment" or EIS on those amendments.⁴⁷ As of now, the Staff has issued no FONSI for the second or third amendments. It is therefore incumbent upon NFS to confirm the status of the environmental reviews for the second and third amendments prior to proceeding with construction.

issuance of the proposed license, with any appropriate conditions to protect environmental values. Commencement of construction prior to this conclusion is grounds for denial to possess and use special nuclear material in the plant or facility. As used in this paragraph, the term "commencement of construction" means any clearing of land, excavation, or other substantial action that would adversely affect the environment of a site.

⁴⁶ The Petitioners incorrectly assume that the Staff cannot have completed an environmental review for *any* of the license amendments, not even of the first amendment, because "such review could only follow completion of a safety review." Emergency Request at 4, 8-9. But as the Commission stated last year, the NRC's NEPA review need not be delayed "until completion of the agency's operational safety review." *Duke Cogema Stone & Webster* (Savannah River Mixed Oxide Fuel Fabrication Facility), CLI-02-7, 55 NRC 205, 220 (2002). While the safety and environmental reviews may address many similar issues, "the two inquiries are not coextensive" and, in any event, there is no requirement that both reviews must be completed and published at the same time. *Id.* Here, the NRC Staff has declared that the FONSI issued for the first proposed license amendment is the "final agency determination on the first amendment." See Transcript at 31.

⁴⁷ *Supra* at 7-8.

Having pointed to no NRC rule as a basis for a Commission injunction against NFS, the Petitioners rely on NEPA, suggesting that the “Commission can treat NFS’s construction activities as a ‘federal action’ and order NFS to suspend them.”⁴⁸ In support of this claim, the Petitioners cite *Maryland Conservation Council v. Gilchrist*,⁴⁹ which found that “[a] non-federal project is considered a ‘federal action’ if it cannot ‘begin or continue without prior approval of a federal agency.’”⁵⁰ Because the purpose of constructing the Uranyl Nitrate Building, the Oxide Conversion Building, and the Effluent Processing Building is “to operate them under a permit granted by the NRC,” the Petitioners argue, the construction activities themselves should be deemed a “federal action” and enjoined.⁵¹ They further claim that “[c]onstruction of the BLEU Project facilities will influence NRC’s decisionmaking process regarding the BLEU Project, by committing resources to a preordained course of action before the agency has decided whether to prepare an EIS that evaluates the impacts of that course of action or reasonable alternatives.”⁵²

But as we explained above, while NFS will require license amendments before it can begin the process operations associated with the BLEU Project (and before it can exceed its current U-235 possession limit), NFS does not appear to require any NRC permit to begin construction activities, thus rendering uncertain our current authority to halt those actions. In contrast to the holding in *Gilchrist*, NFS seemingly can “begin or continue [construction] without prior approval” of the NRC.

Nor does NFS’s construction activities “preordain” or restrict the NRC’s decisionmaking. The Staff retains full discretion to deny any or all of the three license amendments, or to impose licensing conditions, as needed. And assuming the Petitioners have standing to intervene and are admitted as parties to an adjudicatory hearing, they will have the opportunity to challenge the environmental review of all aspects of NFS’s BLEU Project. If the Presiding Officer finds the environmental review of any of the three license amendments inadequate, we would expect that he will deny or condition the license[s] as appropriate. NFS therefore commits construction resources at its own financial risk, and as we noted above may in fact jeopardize issuance of the license amendments by embarking on construction prior to completion of the Staff’s environmental review. In *Gilchrist*, where stretches of highway were being constructed immediately adjacent to both sides of a federally funded park, there was strong potential to influence the ultimate decision of which route to take

⁴⁸ Emergency Request at 6.

⁴⁹ 808 F.2d 1039 (4th Cir. 1987)

⁵⁰ *Id.* at 1042.

⁵¹ Emergency Request at 6.

⁵² *Id.* at 7.

through the park. No comparable potential exists here. Yet not even in *Gilchrist* did the court grant the “extraordinary” relief of the requested injunction.⁵³

The circumstances of our case bear similarity to those in *Natural Resources Defense Council, Inc. v. EPA*,⁵⁴ where EPA had sought by rule to bar the construction of new sources of pollution discharge pending issuance of a National Pollution Discharge Elimination System (NPDES) permit, which incorporated a NEPA review. EPA’s construction ban was “designed to preserve the status quo for as long as necessary to complete [the] NEPA review.”⁵⁵ In striking down the construction ban, the court reasoned that the Clean Water Act did not “prohibit construction of a new source without a permit.”⁵⁶ While the Act prohibited new sources from discharging pollutants without a permit, and from discharging pollutants in violation of existing applicable standards, it did not actually “prevent such sources from being built.”⁵⁷ The construction ban thus lay outside the agency’s jurisdiction. Analogous circumstances are present here, where the AEA and NRC rules require a license to conduct the BLEU Project, but neither statute nor rule prevents NFS from beginning construction of BLEU Project buildings.

The court in *NRDC v. EPA* rejected EPA’s argument that it had authority under NEPA to impose a construction ban. Because NEPA is at its core “a procedural device,” it did not “work a broadening of the agency’s substantive powers.”⁵⁸ In arguments virtually identical to the Petitioners’ in our case, EPA had emphasized that construction of the discharge source proceeded in reliance on the future issuance of a NPDES permit, and that, therefore, “[w]ithout the permit the source would be unable to operate as intended.”⁵⁹ But while acknowledging that ordinarily facility planning and the permit process proceed “hand in hand, due to EPA’s close examination of the planned facility in establishing permit conditions,” and also the “practical reality” that “it would be most desirable” for the environmental review to precede construction, the court nonetheless found it a “considerable leap . . . to conclude that the agency is vested with power to

⁵³ *Gilchrist*, 808 F.2d at 1043 (remanding to district court to determine whether highway program in fact violates NEPA by limiting the choice of alternatives available to decisionmakers); *Quince Orchard Valley Citizens Association v. Hodel*, 872 F.2d 75, 78 (4th Cir. 1989) (noting that on remand district court “declined to preliminarily enjoin construction”).

⁵⁴ 822 F.2d 104 (D.C. Cir. 1987).

⁵⁵ *Id.* at 127.

⁵⁶ *Id.* at 128.

⁵⁷ *Id.*

⁵⁸ *Id.* at 129.

⁵⁹ *Id.* at 130.

call a halt to construction activity.’’⁶⁰ In the end, ‘‘NEPA does not mandate action which goes beyond the agency’s organic jurisdiction.’’⁶¹

It obviously makes sense for NRC licensees not to proceed with construction that, after a NEPA and licensing review, might prove fruitless. That is the purpose underlying sections 51.101 and 70.23(a)(7), which seek to discourage premature construction. But as in *NRDC v. EPA*, we draw a distinction between those actions we can discourage by our authority over licensing, and those actions we prevent outright.

Finally, even if our power to halt NFS’s construction activities were clearer, Petitioners have given us no reason to take emergency action. They nowhere indicate how they might suffer immediate environmental harm simply as a result of new building construction within the boundaries of NFS’s existing site. The Petitioners’ request does not allege any direct environmental impacts to them from the construction process, e.g., dust, noise, etc., or from the mere buildings themselves. The potential environmental or radiological harm that the Petitioners fear essentially relates to the processing operations associated with the BLEU Project. But NFS may not begin those operations without the appropriate license amendments, none of which has been issued. In the event that the first license amendment — or either of the later amendments — is issued, the Petitioners will have an opportunity under our rules to request a stay of the licensing action.⁶² In the absence of a compelling threat of immediate and irreparable injury to the Petitioners from NFS’s construction activities, an extraordinary Commission ‘‘injunction’’ order is unwarranted.

IV. CONCLUSION

For the foregoing reasons, the Commission denies the Petitioners’ Emergency Request To Enjoin Construction.

IT IS SO ORDERED.

For the Commission

ANNETTE L. VIETTI-COOK
Secretary of the Commission

Dated at Rockville, Maryland,
this 29th day of April 2003.

⁶⁰ *Id.*

⁶¹ *Gage v. Atomic Energy Commission*, 479 F.2d 1214, 1120 n.19 (D.C. Cir. 1973).

⁶² *See* 10 C.F.R. § 2.1263.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:

Charles Bechhoefer, Chairman
G. Paul Bollwerk, III
Dr. Richard F. Cole

In the Matter of

Docket No. 40-02384-CivP
(ASLBP No. 02-797-01-CivP)
(EA 99-290)
(License No. SMB-00602)
(Order Imposing Civil
Monetary Penalty)

EARTHLINE TECHNOLOGIES
(previously RMI ENVIRONMENTAL
SERVICES)
(Ashtabula, Ohio)

April 1, 2003

In a proceeding concerning imposition by the NRC Staff of a civil monetary penalty for an alleged violation of NRC's employee-protection regulations, based on asserted discrimination by a management official against an employee for contacting the NRC concerning safety matters, the Licensing Board noted protective actions that the Licensee had already implemented (including training of all employees with respect to protected activities) and, at the request of both the NRC Staff and the Licensee, approved withdrawal of the citation for the violation and termination of the proceeding.

ORDER
(Terminating Proceeding)

As outlined in the Order Imposing Civil Monetary Penalty of \$17,600, dated January 15, 2002, and published at 67 Fed. Reg. 3917 (Jan. 28, 2002), this proceeding concerns the alleged violation by Earthline Technologies (Earthline) of NRC's employee-protection regulations, based on asserted discrimination by a management official against an employee for contacting the NRC concerning safety matters. At the request of both parties to the proceeding — Earthline Technologies (Earthline) and the NRC Staff (Staff) — a settlement judge was appointed on April 19, 2002, to assist in resolving the outstanding issues.

By order dated June 25, 2002, the Licensing Board granted the parties' request to place this proceeding in abeyance, pending the completion of negotiations concerning corrective actions to be taken by Earthline.¹ The Board required quarterly status reports from the parties on the progress of their negotiations. Such reports were filed on August 29, 2002, and November 29, 2002.

On March 20, 2003, both parties jointly filed what they denominated as a "Final Report" on the status of negotiations.² As set forth in that report, Earthline had agreed to undertake employee perception surveys performed by an independent consultant, the National Safety Council (NSC), to gauge the culture within Earthline regarding radiological safety and employees' freedom to raise radiological safety concerns with management. With the survey results, Earthline provided the Staff with recommendations made by NSC and the corrective actions Earthline proposed to implement based on the survey results and the NSC recommendations.

The parties further report that on November 21, 2002, the Staff met with representatives of Earthline and NSC to discuss the survey results and proposed responsive actions to be undertaken. The parties advise that they agreed on additional corrective actions to be completed no later than February 28, 2003. They entered a Memorandum of Understanding to this effect, a copy of which has also been submitted to the Licensing Board as part of the Final Report.

The Final Report indicates that Earthline has completed all corrective actions, including training sessions conducted at the Earthline site that all employees at the site attended. The topics included legal and company policies dealing with

¹In this regard, the Licensing Board wishes to express its appreciation to Administrative Judge Ann Marshall Young for her efforts as settlement judge in assisting the parties to reach a mutually acceptable resolution of their differences in this proceeding.

²This Final Report was a corrected version of an earlier Final Report filed on March 13, 2003. All references in this Order to "Final Report" shall be deemed to refer to the corrected version of the report, filed on March 20, 2003.

protected activities, as well as harassment and discrimination in the workplace. There was specific training relating to the protection of whistleblowers. Several topics were specified. Employees were also assured that there would be no retaliation for reporting of safety concerns or for participating in the investigation of safety concerns reported by others.

The parties assert that Earthline has now met all of the requirements in the Memorandum of Understanding between the parties. As a result, they both request that the citation for Violation A³ — the genesis of the proposed civil penalty — be withdrawn and the proceeding be terminated.

The Board has reviewed the Final Report, including the survey results and recommendations of NSC that the parties forwarded with that report. Based on this information, the Board believes that withdrawal of the citation and termination of this proceeding, as requested by both parties, is in the public interest and, in particular, reflects the interest of the NRC Staff (which is urging that we accept this agreement). *See* 10 C.F.R. §§ 2.205(g), 2.203.

Based on the foregoing, it is, this 1st day of April 2003, ORDERED:

1. The civil penalty imposed by the Order Imposing Civil Monetary Penalty of \$17,600, dated January 15, 2002, is hereby *rescinded*.
2. This proceeding is hereby *terminated*.

³In the Notice of Violation and Proposed Imposition of Civil Penalty, served upon Earthline by letter from the Staff dated September 24, 2001, there were two violations set forth. Violation A was the one involved in this proceeding, for which a civil penalty of \$17,600 was sought. Violation B was another transgression for which Earthline was not assessed a civil penalty. The latter violation is not involved in this proceeding.

3. Absent review by the Commission on its own motion, this Order will become the final action of the Commission within forty (40) days after its issuance.

THE ATOMIC SAFETY AND
LICENSING BOARD

Charles Bechhoefer, Chairman
ADMINISTRATIVE JUDGE

G. Paul Bollwerk, III
ADMINISTRATIVE JUDGE

Dr. Richard F. Cole
ADMINISTRATIVE JUDGE

Dated at Rockville, Maryland,
this 1st day of April 2003.

[Copies of this Order have been transmitted this date by e-mail to counsel for each of the parties.]

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS

Martin J. Virgilio, Director

In the Matter of

**Docket Nos. 50-219
72-15
(License No. DPR-16)**

**AMERGEN ENERGY COMPANY, LLC
(Oyster Creek Nuclear Generating
Station)**

April 17, 2003

The Petitioners requested NRC to take the following actions: (1) suspend Certificate of Compliance No. 1004 for the NUHOMS dry spent fuel storage system; (2) halt transfer of spent fuel from wet pool storage to dry storage modules at the Oyster Creek Generating Station (Oyster Creek); (3) conduct a site-specific public hearing before independent judges on the dry cask licensing proceeding for Oyster Creek and other nuclear issues identified in the petition; (4) make a determination of the NUHOMS capability to withstand terrorist attacks similar to those on September 11, 2001; (5) develop criteria and regulations to empirically verify dry storage system capability and to apply those requirements to Oyster Creek; (6) halt loading until a thorough inspection of the total system has been completed to verify that the NUHOMS modules were fabricated properly and will last the design life.

The final Director's Decision on this petition was issued on April 17, 2003. In that Decision, the Director of the Office of Nuclear Material Safety and Safeguards stated that the concerns raised by the Petitioners regarding the use of NUHOMS dry spent fuel storage systems at the Oyster Creek site were reviewed and determined not to pose an immediate safety issue. Therefore, the request to immediately suspend CoC No. 1004 for the NUHOMS dry spent fuel storage system and to halt transfer of spent fuel from wet pool storage to dry storage modules at Oyster Creek was denied because the safety concerns with the

NUHOMS system had been initially reviewed by the NRC Staff and determined not to pose an undue risk to public health and safety.

The Petitioners' request for NRC to conduct a site-specific public hearing before independent judges on the dry cask licensing proceeding for Oyster Creek and other nuclear issues identified in the petition was also denied. The petition did not present a legal basis under which to conduct an adjudicatory hearing on the Oyster Creek dry spent fuel storage activities or for the other concerns identified in the petition.

The Petitioners' request for NRC to make a determination of the NUHOMS capability to withstand terrorist attacks similar to those on September 11, 2001, was also denied. The NRC, other federal, state, and local agencies, and the nuclear industry have implemented a significant number of measures to prevent and mitigate terrorist attacks similar to those on September 11, 2001. In addition, although dry spent fuel storage systems are not specifically assessed as to their ability to withstand the impact of a commercial aircraft, the design of the storage systems must have the capability to provide for the protection of public health and safety against naturally occurring events. This includes flying debris from tornadoes or hurricanes, and seismic events. To provide this level of protection, the design must be robust. This robustness prevents the dispersion of radioactive materials under analyzed accident conditions. The inherent robustness of the design will limit the release of radioactive materials under a terrorist attack and continue to protect public health and safety.

The Petitioners' request for NRC to develop criteria and regulations to empirically verify dry storage system capability and to apply those requirements to the Oyster Creek storage design prior to approval was also denied. The NRC technical review includes evaluating storage design characteristics such as structural, thermal, radiation shielding, radioactive material confinement, nuclear criticality, material interactions, and overall performance. The NUHOMS design has been analyzed using industry standards for material characteristics based on empirical data for design-life performance. Dry storage systems are evaluated using conservative analysis and assumptions to store the spent fuel safely for a design life of 20 years, at a minimum.

DIRECTOR'S DECISION UNDER 10 C.F.R. § 2.206

I. INTRODUCTION

By letter dated June 21, 2002, as supplemented by a telephone call with the U.S. Nuclear Regulatory Commission's (NRC's) Petition Review Board (PRB) on July 18, 2002, Ms. Edith Gbur of the Jersey Shore Nuclear Watch and other

members of the public filed a petition pursuant to Title 10 of the *Code of Federal Regulations*, section 2.206. The Petitioners requested that the NRC take the following actions:

1. Suspend Certificate of Compliance (CoC) No. 1004 for the NUHOMS dry spent fuel storage system.
2. Halt transfer of spent fuel from wet pool storage to dry storage modules at the Oyster Creek Generating Station (Oyster Creek).
3. Conduct a site-specific public hearing before independent judges on the dry cask licensing proceeding for Oyster Creek and other nuclear issues identified in the petition.
4. Make a determination of the NUHOMS' capability to withstand terrorist attacks similar to those on September 11, 2001.
5. Develop criteria and regulations to empirically verify dry storage system capability and to apply those requirements to Oyster Creek.
6. Halt loading until a thorough inspection of the total system has been completed to verify that the NUHOMS modules were fabricated properly and will last the design life.

As the basis for the request, safety concerns were presented in the following areas:

1. Location of the Oyster Creek independent spent fuel storage installation (ISFSI) relative to local roads and communities;
2. Ability of the NUHOMS dry spent fuel storage system to survive a sabotage attack;
3. Adequacy of Oyster Creek security measures for fuel-handling activities;
4. Adequacy of the Oyster Creek emergency evacuation plan; and
5. Quality of the NUHOMS systems planned for use at Oyster Creek.

The Petitioners and other members of the public participated in a teleconference with NRC's Office of Nuclear Material Safety and Safeguards PRB on July 18, 2002, to clarify the bases for the petition. In addition, Ms. Gbur forwarded to NRC a series of form letters signed by various members of the public in August 2002, to demonstrate additional support for the petition. On November 8, 2002, NRC received additional form letters forwarded by Ms. Gbur. The transcript and the form letters were treated as supplements to the petition and are available in the Agencywide Documents Access and Management System (ADAMS), which provides text and image files of NRC's public documents.

These documents may be accessed through NRC's Public Electronic Reading Room on the Internet at <http://www.nrc.gov/reading-rm/adams.html>. The docket number, 07200015, for the Oyster Creek ISFSI can be used for searching ADAMS for these documents. If you do not have access to ADAMS or if there are problems in accessing the documents located in ADAMS, contact the NRC Public Document Room Reference staff at 1-800-397-4209, 301-415-4737, or by e-mail to pdr@nrc.gov.

In a letter dated August 12, 2002, the NRC Staff informed the Petitioners that their request to immediately suspend CoC No. 1004 for the NUHOMS dry spent fuel storage system and halt transfer of spent fuel from wet pool storage to dry storage modules at Oyster Creek was denied because the safety concerns with the NUHOMS system had been initially reviewed by NRC Staff and determined not to pose an undue risk to public health and safety.

On October 30, 2002, NRC Staff held a teleconference with Ms. Gbur and Mr. Peter James Atherton to discuss the status of the Staff's review of their petition. Ms. Gbur and Mr. Atherton requested that NRC address a combination of two of the concerns in the petition as a separate safety concern. That concern is also addressed below.

The NRC sent a copy of the proposed Director's Decision to the Petitioners and to AmerGen Energy Company, Inc. (AmerGen), for comment on December 10, 2002. However, Ms. Gbur did not receive her copy of the proposed Director's Decision, so NRC sent another copy to her on January 7, 2003. Ms. Gbur responded with the Petitioners' comments by e-mails dated February 6 and March 5, 10, and 19, 2003. The comments and the Staff responses to them are available electronically through NRC's Public Electronic Reading Room at <http://www.nrc.gov/reading-rm/adams.html> under docket number 07200015.

II. DISCUSSION

As the basis for their requested actions, the Petitioners raise a number of specific concerns related to NRC's process for licensing spent fuel storage, and also concerns specifically related to the Oyster Creek ISFSI. These concerns, and the evaluations of these concerns by NRC Staff, are as follows:

1. *Concern:* The location of the Oyster Creek ISFSI relative to local roads and communities is unacceptable. The petition stated:
 - (A) The Oyster Creek ISFSI is only 400 feet to a major highway, and in close proximity to the Garden State Parkway and nearby residences and schools.
 - (B) There was no environmental impact statement prepared for the ISFSI providing the public with an opportunity for comment.

- (C) The CoC for the NUHOMS system was issued without the residents near the Oyster Creek site being informed that the NUHOMS system was being planned for use at Oyster Creek.

Evaluation:

- (A) AmerGen is required to monitor radiation at the site boundary to ensure that dose rates are below the regulatory limit. The annual maximum dose limit to an individual located at the site boundary is 25 millirem for normal ISFSI operations. This means that if an individual were to stand at the Oyster Creek site boundary 24 hours a day for a year, that individual could potentially receive up to approximately the same radiation dose as would be received from a chest x-ray. This is the equivalent of approximately a tenth of the total radiation dose that an average person continuously receives from the natural environment over the period of a year.

In the event of an accident, the ISFSI is designed such that the radiation dose at the site boundary would remain below 5 rem. This limit is based on Environmental Protection Agency guidelines and has been determined by NRC to be a safe limit for protecting public health and safety. However, ISFSIs are designed to not release any radioactive materials, or significant amounts of direct radiation, as a result of analyzed accident conditions. Therefore, it is highly unlikely that a person outside the Licensee's controlled area (including the highway) would be exposed to a radiation dose even close to 5 rem, or an amount significantly more than the 25-millirem limit associated with normal operations.

The NRC Staff has reviewed the location of the ISFSI during inspection of the site parameter evaluations required in 10 C.F.R. § 72.212 (including use of the NUHOMS design at Oyster Creek, Security Plan changes to accommodate the 10 C.F.R. Part 72 activities, and radiation protection to members of the public) and has determined that it meets regulatory requirements and provides adequate protection of public health and safety. In addition, see the response to Concern 2(A) for information regarding the NRC's response to the terrorist attacks of September 11, 2001.

- (B) NRC prepared a generic environmental impact statement (EIS) during the development of the regulations for the interim storage of spent fuel (10 C.F.R. Part 72). This generic EIS for spent fuel storage found that, "[b]ecause of the physical characteristics and conditions of storage that include specific security provisions, the potential risk

to the public health and safety due to accidents or acts of sabotage at a 'storage only' facility also appears to be extremely small.' When the general license provisions for dry spent fuel storage were proposed to be added to the NRC regulations, they were published in the *Federal Register* for public comment. In the *Federal Register* notice for the proposed rule (54 Fed. Reg. 19,379 (May 5, 1989)), NRC presented the results of its environmental assessment (EA). The EA summarized a number of related environmental reviews that NRC had performed, which included evaluations of the risks and potential consequences of accidents and sabotage events involving dry spent fuel storage systems. In that EA, NRC concluded that dry spent fuel storage under a general license by reactor licensees would not have a significant environmental impact.

Furthermore, as NRC approves new dry spent fuel storage systems for use under the general license provisions, they are added to the list of approved casks through rulemaking. In each rulemaking, NRC performs an additional EA, based on the requested action. As a result, NRC performed an EA for the NUHOMS system when the system was first approved in 1994, and for each amendment to the NUHOMS since then. The last NUHOMS amendment was proposed for addition to the list of approved casks in the *Federal Register*, in November 2001. In each case, NRC determined that use of the NUHOMS system would not have a significant effect on the environment.

In addition to these environmental reviews, the original EIS for the Oyster Creek site is also applicable to the operation of an ISFSI under the general license provisions of 10 C.F.R. Part 72. Together, the generic EIS for spent fuel storage, the EA for the general license provisions, the EA for the NUHOMS system design, and the original EIS for the site form the basis for compliance with the environmental review requirements of the National Environmental Policy Act.

- (C) The Licensee for the Oyster Creek site notified NRC in a letter on November 29, 1995, of its plans to operate an ISFSI under the Part 72 general licensing provisions. That letter was made available to the public through NRC's public document room, under the Oyster Creek docket. Since that time, the NUHOMS design has undergone four amendment rulemakings with opportunities for public comments. The latest amendment provided an opportunity for public comment in November 2001.

2. *Concern:* The NUHOMS dry spent fuel storage system is unable to survive a sabotage attack. The petition stated:
- (A) The NUHOMS design-basis threat does not consider current acts of terrorism.
 - (B) The Oyster Creek ISFSI was licensed without any independent security evaluation of the Licensee's ability to defend the storage modules from terrorist activities that could result in a dispersal of radioactive materials.
 - (C) NRC should complete its study on the consequences of an aircraft impact with a storage module before any additional NUHOMS systems are loaded.

Evaluation:

- (A) When the events of September 11, 2001, unfolded, U.S. nuclear power plant facilities, including ISFSIs, already possessed a strong capability to prevent and respond to many types of terrorist acts that could be directed at them. In addition, the NRC took immediate actions and advised all nuclear power plant facilities to go to the highest level of security. The NRC also issued more than thirty threat advisories to address enhanced security measures in the aftermath of September 11, 2001. In addition, NRC security specialists performed numerous onsite physical security vulnerability assessments at licensed facilities to evaluate the effectiveness of the enhanced security measures that were put into place. These assessments demonstrated that the industry responded promptly and appropriately to the NRC threat advisories. To this day, all nuclear power plant facilities remain at a heightened security level.

The events of September 11, 2001, were unprecedented, and since that time, the NRC has taken appropriate steps to protect public health and safety. For example, the NRC quickly recognized the need to reexamine basic assumptions underlying the current civilian nuclear facility security and safeguards programs. Shortly after September 11, 2001, Chairman Meserve, with the full support of the rest of the Commission, directed the Staff to undertake a comprehensive review of the NRC's security and safeguards programs. This is an ongoing review and as results become available, they will be evaluated and, if appropriate, incorporated into NRC's regulatory processes. The comprehensive review takes advantage of insights gained by the NRC in consultation with the Office of Homeland Security, Federal Bureau of Investigation (FBI), Department of

Transportation (DOT), Department of Energy (DOE), and others. This cooperation further allows the NRC to keep abreast of the current threat environment, and communicate its actions to other federal agencies to ensure an appropriate response to security concerns throughout the nation's entire critical energy infrastructure.

In light of the current threat environment, the Commission concluded that specific security measures, including those outlined in threat advisories and voluntarily implemented at nuclear power plant facilities, should be embodied in an order consistent with the NRC's established regulatory framework. On February 25, 2002, the NRC issued orders to all operating power reactor licensees to require that certain interim compensatory measures (ICMs) for security be taken beyond that called for by current regulations. In addition, the NRC issued similar orders to all ISFSI licensees on October 16, 2002, to require implementation of ICMs designed to enhance security at these facilities. These new requirements will remain in effect pending notification from the Commission that a significant change in the threat environment has occurred, or until the Commission determines that other changes are needed following the comprehensive review of current safeguards and security programs. The orders were effective immediately upon issuance. For the most part, the orders formalized a series of steps that nuclear power plant facilities had been advised to take by the NRC in the aftermath of the terrorist attacks on September 11, 2001; however, the Commission included certain additional security enhancements in the orders. Details of certain new security requirements cannot be made public, but some of the specific measures implemented by the licensees in response to the advisories and ICMs included increased patrols, augmented security forces and capabilities, additional security posts, installation of additional physical barriers, vehicle checks at greater standoff distances, enhanced coordination with law enforcement and military authorities, and more restrictive site access controls for all personnel. The NRC Staff is verifying that all licensees are in compliance with the ICMs by conducting independent inspections at licensee sites.

The NRC continues to reexamine its activities to determine whether any significant safeguards vulnerabilities exist. If a vulnerability is identified, the NRC Staff will revise physical protection, material control, and other requirements, as appropriate. Also, the NRC will continue to assist the Office of Homeland Security and other federal agencies to evaluate threats beyond the feasible response

capabilities of NRC licensees in order to consider the need to augment the site security organization with public assets, such as local law enforcement personnel.

In addition, the federal government has taken a number of steps to improve aviation security and minimize the threat of terrorists using airplanes to damage facilities critical to our nation's infrastructure. The Commission's view is that the efforts associated with protecting our nation from terrorist attacks by air should be directed toward enhancing security at airports and on airplanes. Thus, the Commission endorses the prompt response by the Congress to strengthen aviation security under the Aviation and Transportation Security Act of 2001, because this legislation provides for improved protection against air attacks on all industrial facilities, both nuclear and nonnuclear. The NRC further supports the steps taken by the Federal Aviation Administration (FAA) to improve aircraft security, including enhanced passenger and baggage screening, strengthening of cockpit doors, and the Air Marshal program. The U.S. intelligence community and various federal law enforcement agencies have also increased efforts to identify potential terrorists and prevent potential attacks before they occur. For example, the FAA and Department of Defense (DOD) have acted more than once to protect airspace above nuclear power plant facilities from what were thought to be credible threats against certain specific sites. These potential threats were later judged to be noncredible.

The FAA and DOD also concluded that a Notice to Airmen (NOTAM) was an appropriate means to help protect the airspace above sensitive sites. Accordingly, the FAA issued a NOTAM strongly urging pilots to:

not circle or loiter over the following sites: Nuclear/Electrical power plants, power distribution stations, dams, reservoirs, refineries, or military installations, unless otherwise authorized by air traffic control or as required to land or depart at towered/non-towered airports.

This notice is still in effect. Should additional restrictions be deemed appropriate as a result of changing or more specific threats, our communication with the other federal agencies will allow a prompt and coordinated response.

The NRC Staff acknowledges that ISFSIs were not specifically designed to withstand a deliberate aircraft crash. Prior to September 11, 2001, the U.S. intelligence community and the NRC did not consider a deliberate aircraft attack against an ISFSI to be a credible

threat. Nevertheless, the Staff recognizes that design and construction considerations could contribute to an ISFSI's survivability in the event of an aircraft impact or other type of terrorist attack. The NRC requires that these facilities be designed with a defense-in-depth philosophy to withstand severe natural phenomena; including earthquakes, tornadoes, and airborne missiles, such as automobiles or telephone poles. This robust design would therefore provide substantial protection for the spent fuel in the event of an aircraft crash or other terrorist attack. Ultimately, the capability of a site to successfully cope with an aircraft crash will depend upon a number of factors, including the ISFSI's specific design and construction features, the design and flight characteristics of the aircraft, the point of impact, and the response of onsite and offsite resources. The NRC Staff believes that the likelihood of an intentional aircraft crash into a dry spent fuel storage facility is very small, and even if it were to occur, such an event is unlikely to result in a significant release, if any, of radioactive material beyond the immediate vicinity. Therefore, NRC has reasonable assurance that ISFSIs, including the one at Oyster Creek, can be operated safely and that the public health and safety will be adequately protected.

The Staff further notes that the NRC, in conjunction with DOE laboratories, is continuing a major research and engineering effort to evaluate the vulnerabilities and potential effects of a large commercial aircraft impacting a nuclear power plant facility. This effort also includes consideration of possible additional preventive or mitigative measures to further protect public health and safety in the event of a deliberate aircraft crash into a nuclear power plant or ISFSI. The final results from that analysis are not yet available. If the ongoing research and security review recommends any other security enhancements, the NRC will take appropriate action.

- (B) See the response to Concern 2(A).
 - (C) See the response to Concern 2(A).
3. *Concern:* The Oyster Creek security measures are not adequate for fuel-handling activities. The petition states:
- (A) The fuel is vulnerable to accident and terrorist attack during transport from the spent fuel pool to the ISFSI.
 - (B) The spent fuel is most vulnerable to terrorist attack after the assemblies are taken out of the spent fuel pool and air-dried before being sealed and loaded into the transfer cask.

- (C) The reactor building walls and roof, where spent fuel transfer takes place, do not offer adequate protection from terrorist attacks.

Evaluation:

- (A) The spent fuel is moved from the spent fuel pool to the ISFSI within the welded steel fuel canister. This fuel canister is handled during these movement activities using the transfer cask. The transfer cask is a very robust device designed to provide radiation shielding and protect the fuel canister during handling operations. In addition to the protection provided by the transfer cask, the security measures discussed in the response to Concern 2(A) provide protection against terrorists attacks. Therefore, the public health and safety are protected through use of the robust transfer cask in conjunction with the Licensee's security measures, and the fuel is adequately protected from accidents and terrorist attacks during fuel-handling activities.
- (B) The fuel canister is placed in the transfer cask before being moved to the spent fuel pool for fuel loading. The spent fuel assemblies are loaded into the fuel canister under water in the spent fuel pool by moving fuel from the spent fuel pool racks to the fuel canister. The transfer cask with the fuel canister is removed from the pool and set down adjacent to the pool for lid welding and vacuum drying operations. The fuel canister is then backfilled with helium, the vent and drain ports are sealed, and the canister is moved to the ISFSI pad. As a result, the scenario postulated by the Petitioners does not exist as the spent fuel is in the fuel canister, which is in the transfer cask, prior to being removed from the spent fuel pool. In addition, see the response to Concern 2(A) for information regarding the NRC's response to the terrorist attacks of September 11, 2001.
- (C) The reactor building contains the spent fuel pool and is the location where spent fuel is transferred from the spent fuel pool to dry storage casks. The reactor building is located within the protected area and afforded protection under the same physical security protection program as the nuclear power plant. In addition, certain spent fuel pool design features could contribute to ensuring public health and safety in the event of a deliberate attempt to crash an aircraft into the reactor building. Specifically, spent fuel pools are small in size relative to the rest of the plant. This characteristic would make the spent fuel pools difficult to target. In addition, the NRC's requirements that spent fuel pools be designed to withstand a variety of design-basis events such as tornadoes (and missiles generated by

tornadoes), hurricanes, fires, floods, and earthquakes have resulted in nuclear plant designs that afford a measure of protection against deliberate aircraft impacts or other terrorist attacks. Spent fuel pools are massive structures with thick walls constructed of reinforced concrete. Furthermore, the defense-in-depth design philosophy used in nuclear facilities means that systems critical to the safety of stored fuel have redundant and separated systems in order to ensure safety. The February 25, 2002, NRC orders to reactor licensees also directed them to evaluate and address potential vulnerabilities of spent fuel pools and the reactor plant itself, and to develop specific guidance and strategies to respond to a hypothetical event that damages large areas of the plant, because of explosions or fire. Collectively, these measures ensure that adequate protection is provided for the reactor building and spent fuel pool.

The Staff recognizes that additional requirements beyond those provided by existing regulations and the ICMs may be warranted. The comprehensive review of the NRC's safeguards and physical security programs initiated by the Commission following the September 11, 2001, terrorist attacks include specific studies on the impacts of aircraft on nuclear power plant facilities, including the spent fuel pool housed in the reactor building. The review also includes an evaluation of the potential consequences of terrorist attacks using various explosives or heat-producing devices on spent fuel pools and spent nuclear fuel dry casks at spent nuclear fuel storage sites. The Staff will use the insights gained from these studies as it considers the need for further security enhancements.

4. *Concern:* During the October 30, 2002, teleconference call, the Petitioners requested that NRC address whether the accident scenario had been evaluated for a plane crashing into the spent fuel pool building while the fuel canister is positioned adjacent to the pool during lid welding and canister drying operations.

Evaluation: The NUHOMS fuel canister is contained within a transfer cask during handling operations, before insertion into the concrete module. The transfer cask is a robust steel cylinder, designed to protect the canister and its contents from damage during handling activities, including drop accidents and other design-basis accident conditions. The transfer cask is used to lift the fuel canister out of the pool after being loaded with spent fuel and is set down on an area adjacent to the pool for dry storage preparation activities, lid welding, and canister drying.

Although the NUHOMS transfer cask has not specifically been evaluated for the ability to withstand the impact of a plane while located adjacent to the spent fuel pool, the system has been evaluated for design-basis accidents such as a drop of the transfer cask with the fuel canister inside, or the impact of a tornado missile. To provide this level of protection, the design must be robust. Therefore, the inherent robustness of the transfer cask and fuel canister configuration, in addition to the actions discussed in the response to Concern 2(A), will limit the release of radioactive materials under an aircraft collision or other terrorist attack, and continue to protect public health and safety.

5. *Concern:* The Oyster Creek emergency evacuation plan is inadequate. The petition stated:
 - (A) Draft Report SC 46-14, “Radiation Protection Issues Related to Terrorist Activities That Result in the Dispersal of Radioactive Material,” shows that a nonradiological dispersal device of 1000 pounds of TNT near 100 kilograms of pressurized water reactor fuel yields a deadly total effective dose to a distance of 60 to 70 miles.
 - (B) The emergency evacuation plan does not consider a disruption caused by a terrorist attack.

Evaluation:

- (A) The document referenced in the petition is a draft report presented to the National Council on Radiation Protection and Measurements (NCRP). However, the draft report results were apparently not fully endorsed by NCRP. The final version of the document was issued in NCRP Report No. 138, “Management of Terrorist Events Involving Radioactive Material,” and contained less specific results for this type of threat than those presented in the draft report. In particular, the NCRP Report discusses the threat of a radiological dispersal device by placing a conventional explosive adjacent to radioactive material. However, placing an explosive device next to radioactive material is significantly different from placing the device next to a robust storage cask, as it is much more resistant to the blast. Furthermore, NRC has performed preliminary evaluations of dry spent fuel storage systems subject to a truck bomb sabotage event and determined that public health and safety will continue to be protected and the need for an immediate evacuation would not likely be necessary.
- (B) Emergency preparedness programs are designed to cope with a spectrum of accidents including those involving rapid, large releases

of radioactivity. Emergency preparedness exercises have invariably included large releases of radioactivity that occur shortly after the initiation of events. Necessary protective actions and offsite response are not influenced by the cause of accidents. Emergency planning is not predicated on a determination of the probability of a given accident sequence. Rather, emergency planning assumes the improbable has already occurred and develops a response to address the consequences of potential releases. Whether releases from the plant occur as a result of terrorist acts or equipment malfunctions, emergency plans guide decisionmakers and responders in the same way. Although the Oyster Creek Emergency Plan is not specifically designed to consider disruption caused by a terrorist attack, the response to a radiological emergency at a nuclear facility involves a number of interrelated functions performed by onsite and offsite components of each site's emergency response organization. The effectiveness of this organization is critical to ensuring the health and safety of the public. In recognition of this important function, NRC requires licensees to conduct periodic drills and exercises. In addition, NRC requires that licensees conduct Emergency Plan drills and exercises as close to actual accident conditions as practical, and involve the principal functional areas of the licensees' emergency response capabilities.

- (C) NRC has reasonable assurance, based on the robustness of dry spent fuel storage systems, that a potential breach in the fuel canister caused by a sabotage event would result in only a small release of radioactive material and would be localized to the damaged dry storage system. Thus, public health and safety would continue to be protected and the need for an immediate evacuation would not likely be necessary.
6. *Concern:* The quality of the NUHOMS systems planned for use at Oyster Creek is inadequate. The petition stated:
- (A) The NUHOMS systems delivered to Oyster Creek were not properly fabricated and qualified to last the design life.
 - (B) The spent fuel module was not empirically tested to determine whether it is environmentally qualified to endure the licensed life of the module.

Evaluation:

- (A) The Licensee is required to ensure that the dry storage system is constructed in accordance with design and regulatory requirements.

The storage system vendor is also responsible for ensuring compliance with these same requirements. NRC inspects the Licensee's vendor oversight program and has performed inspections of the NUHOMS vendor and fabricator. NRC inspections have not identified any safety-significant deficiencies that would affect the ability of the NUHOMS systems to safely store spent fuel at Oyster Creek.

- (B) NRC Staff evaluates environmental conditions as a part of its technical review of the storage design prior to approval. The technical review includes evaluating the storage design characteristics such as structural, thermal, radiation shielding, radioactive material confinement, nuclear criticality, material interactions, and overall performance. The technical review considers adverse environmental conditions such as earthquakes, tornados, tornado missiles (such as automobiles), floods, and temperature extremes. Dry storage systems are evaluated using conservative analysis and assumptions to store the spent fuel safely for a design life of 20 years, at a minimum.

The NUHOMS system has been designed, analyzed, and evaluated against recognized national codes and standards for material performance. These codes and standards are developed utilizing empirical data, where it is available, and provide criteria for evaluating the design-life performance. This is an accepted engineering practice for demonstrating design capability.

Based on the specific items noted above and cited by the Petitioners as the bases for their petition, the following Petitioner requests are dispositioned as follows:

1. The Petitioners requested that NRC suspend CoC No. 1004 for the NUHOMS dry spent fuel storage system, halt transfer of spent fuel from wet pool storage to dry storage modules at Oyster Creek, and halt loading of all NUHOMS systems until a thorough inspection has been completed to verify compliance with fabrication requirements.

Response: In our letter dated August 12, 2002, we notified the Petitioners that we found no safety basis for NRC immediately suspending CoC No. 1004 and prohibiting transfer of spent fuel from wet pool storage to dry storage modules at Oyster Creek, but would continue to consider the request as our safety review proceeded. Based on the Staff's safety review, as detailed in the specific items above, we find no basis for suspending CoC No. 1004 or disallowing transfer of spent fuel from wet storage to dry storage at Oyster Creek.

2. The Petitioners requested that NRC conduct a site-specific public hearing before independent judges on the dry cask licensing proceeding for Oyster Creek and other nuclear issues identified in the petition.

Response: AmerGen is licensed by the NRC to operate the Oyster Creek Nuclear Generating Station under the provisions of 10 C.F.R. Part 50. A 10 C.F.R. Part 72 general license is granted to persons authorized to possess or operate nuclear power reactors under 10 C.F.R. Part 50, in accordance with 10 C.F.R. § 72.210. Consequently, AmerGen has already been granted a general license under the provisions of 10 C.F.R. Part 72 to operate an ISFSI, provided that an NRC-approved spent fuel storage design is used and that certain other conditions are met. The Nuclear Waste Policy Act of 1982 (NWPA) mandated that NRC establish a process for approving interim storage system designs through rulemaking for use at any power reactor site. The 10 C.F.R. Part 72 general licensing requirements were noticed as a proposed rule in the *Federal Register* in May 1989. NRC received 237 comment letters in response to the proposed rule. Of the 237 letters, 52 were in opposition to the proposed rule. NRC addressed these comments in the “Statements of Consideration” for the proposed rule (55 Fed. Reg. 29,182 (July 18, 1990)).

One commenter stated that the proposed rule did not guarantee hearing rights as mandated by the Atomic Energy Act. NRC responded, in part, that the operating reactor licensee is required to address the ISFSI activities within the plant’s safety analysis report. If no amendment to the operating license is needed, then spent fuel may be stored at an ISFSI under the general licensing provisions. The 10 C.F.R. Part 72 general licensing provisions became effective in August 1990 and implemented the mandate of the NWPA.

Dry spent fuel storage systems are reviewed and approved by NRC for use under the 10 C.F.R. Part 72 general licensing provisions. As each cask design is approved, it is added to the list of approved storage designs in 10 C.F.R. § 72.214 through a public rulemaking process. The public is provided an opportunity to comment on each spent fuel storage system design and any amendments to that design, prior to final approval for use. During the NRC approval process for the NUHOMS spent fuel storage system planned for use at Oyster Creek, the public was provided with an opportunity to comment on the proposed rule to add the design to the list of approved storage systems in 10 C.F.R. § 72.214.

The Licensee for the Oyster Creek site notified NRC in a letter on November 29, 1995, of its plans to operate an ISFSI under the Part 72 general licensing provisions. That letter was made available to the public

through NRC's public document room. Since that time, the NUHOMS design has undergone four amendment rulemakings with opportunities for public comments on each amendment. The latest amendment that provided an opportunity for public comment became effective in February 2002. Based on the Staff's review, as detailed in the specific items above, we find no basis to conduct a hearing on the Oyster Creek ISFSI activities or for the other concerns identified in the petition.

3. The Petitioners requested that NRC make a determination of the NUHOMS capability to withstand terrorist attacks similar to those on September 11, 2001.

Response: The NRC, other federal, state, and local agencies, and the nuclear industry have implemented a significant number of measures to prevent and mitigate terrorist attacks similar to those on September 11, 2001. These measures are summarized in the response to Concern 2(A). In addition, although dry spent fuel storage systems are not specifically assessed as to their ability to withstand the impact of a commercial aircraft, the design of the storage systems must have the capability to provide for the protection of public health and safety against naturally occurring events. This includes flying debris from tornadoes or hurricanes, and seismic events. To provide this level of protection, the design must be robust. This robustness prevents the dispersion of radioactive materials under analyzed accident conditions. The inherent robustness of the design will limit the release of radioactive materials under a terrorist attack, and continue to protect public health and safety.

4. The Petitioners requested that NRC develop criteria and regulations to empirically verify dry storage system capability and to apply those requirements to the Oyster Creek storage design prior to approval.

Response: The NRC technical review includes evaluating storage design characteristics such as structural, thermal, radiation shielding, radioactive material confinement, nuclear criticality, material interactions, and overall performance. The technical review considers adverse environmental conditions such as earthquakes, tornados, tornado missiles, floods, and temperature extremes. The NUHOMS system has been designed, analyzed, and evaluated against recognized national codes and standards for material performance. These codes and standards are developed utilizing empirical data, where it is available, and provide criteria for evaluating the design-life performance. This is an accepted engineering practice for demonstrating design capability.

III. CONCLUSION

The NRC Staff has evaluated the NRC actions requested by the Petitioners, using the information provided in the aforementioned documents, the PRB tele-conference, and the Petitioners' comments to the proposed Director's Decision. NRC has determined that the requests in the petition do not have a sufficient safety basis and, therefore, denies this petition based on its evaluation of the information provided by the Petitioners.

As provided in 10 C.F.R. § 2.206(c), a copy of this Director's Decision will be filed with the Secretary of the Commission for the Commission to review. As provided for by this regulation, the Decision will constitute the final action of the Commission 25 days after the date of the Decision unless the Commission, on its own motion, institutes a review of the Decision within that time.

Martin J. Virgilio, Director
Office of Nuclear Material Safety
and Safeguards

Dated at Rockville, Maryland,
this 17th day of April 2003.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

COMMISSIONERS:

Nils J. Diaz, Chairman
Greta Joy Dicus
Edward McGaffigan, Jr.
Jeffrey S. Merrifield

In the Matter of

Docket No. 72-26-ISFSI

**PACIFIC GAS AND ELECTRIC
COMPANY
(Diablo Canyon Power Plant
Independent Spent Fuel Storage
Installation)**

May 16, 2003

The San Luis Obispo Mothers for Peace, the Lead Intervenor in this proceeding to authorize construction of a dry cask independent spent fuel storage installation at the site of the Diablo Canyon Nuclear Power Plants, filed a rulemaking petition jointly with the Union of Concerned Scientists and requested a suspension of this proceeding while the Commission considers the rulemaking petition. The Commission denies the request.

**RULES OF PRACTICE: SUSPENSION OF PROCEEDING
STAY OF PROCEEDING**

We evaluate the San Luis Obispo Mothers for Peace's current request under the same standard we used for its earlier request to suspend the proceeding pending the Commission's comprehensive review of measures to protect against terrorist attack: "[W]e consider whether moving forward with the adjudication will jeopardize the public health and safety, prove an obstacle to fair and efficient decisionmaking, or prevent appropriate implementation of any pertinent rule or policy changes that might emerge from our important ongoing evaluation of terrorism-related policies." *Pacific Gas and Electric Co.* (Diablo Canyon

Power Plant Independent Spent Fuel Storage Installation), CLI-02-23, 56 NRC 230, 238, quoting *Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), CLI-01-26, 54 NRC 376, 380 (2001); accord *Duke Energy Corp.* (McGuire Nuclear Station, Units 1 and 2; Catawba Nuclear Station, Units 1 and 2), CLI-01-27, 54 NRC 385, 389-90 (2001); *Duke Cogema Stone & Webster* (Savannah River Mixed Oxide Fuel Fabrication Facility), CLI-01-28, 54 NRC 393, 399 (2001). MFP has advanced no new arguments that warrant suspension of this proceeding.

RULES OF PRACTICE: SUSPENSION OF PROCEEDING

EFFICIENT LICENSING AND REGULATION

Given the current posture of the ISFSI proceeding, suspending the proceeding would prove “an obstacle to fair and efficient decisionmaking.” The sole contention under consideration by the Licensing Board is the Licensee’s financial qualifications in view of its bankruptcy. Subpart K oral arguments, the culmination of months of discovery, preparation, and written presentations to the Licensing Board, are imminent — scheduled for May 19, 2003. It is not sensible to postpone resolution of this single issue at this late stage in the proceeding.

RULES OF PRACTICE: SUSPENSION OF PROCEEDING

COMMISSION AUTHORITY

As “every license the Commission issues is subject to the possibility of additional requirements,” moving forward with the current Diablo Canyon licensing proceeding does not foreclose implementation of any new rules originating from the pending rulemaking petition. See CLI-02-23, 56 NRC at 240.

MEMORANDUM AND ORDER

This proceeding arises from the application of Pacific Gas and Electric Company (“PG&E”) to construct an independent spent fuel storage installation (“ISFSI”) at the site of its two Diablo Canyon nuclear power plants. The San Luis Obispo Mothers for Peace (“MFP”), the Lead Intervenor in this proceeding, recently filed a rulemaking petition jointly with the Union of Concerned Scientists (“UCS”). This Order denies a request to suspend this proceeding while the Commission considers the rulemaking petition.

I. BACKGROUND

We have described the history of this 10 C.F.R. Part 2, Subpart K proceeding elsewhere and see no need to repeat it in detail.¹ On December 21, 2001, PG&E filed an application for a materials license authorizing storage of spent nuclear fuel in a dry cask storage system at its Diablo Canyon site. Several intervenors and interested governmental entities have been participating in the adjudication of one admitted contention, which deals with the financial qualifications of PG&E in light of its Chapter 11 bankruptcy. The Licensing Board will hear oral arguments on May 19, 2003, and thereafter will rule on whether a further evidentiary hearing is warranted.

MFP is the Lead Intervenor in this proceeding, and UCS describes itself as “a nonprofit partnership of scientists and citizens” who seek “practical environmental solutions.”² Together, the organizations filed a petition for rulemaking (“Petition”) on April 28, 2003. MFP requested that the Commission suspend this licensing proceeding while it considers the petition. Pursuant to 10 C.F.R. § 2.802(d), a petitioner for rulemaking “may request the Commission to suspend all or any part of any licensing proceeding to which the petitioner is a party pending disposition of the petition for rulemaking.”³

II. DISCUSSION

The stated purpose of the petition is to provide better protection against radiological sabotage at nuclear power plants.⁴ MFP and UCS propose that 10 C.F.R. §§ 50.59⁵ and 50.54(p)⁶ be revised “to require plant owners to formally evaluate whether proposed changes, tests, and experiments cause protection against radiological sabotage to be decreased and, if so, that such actions only be conducted with prior NRC approval.”⁷

¹ See *Pacific Gas and Electric Co.* (Diablo Canyon Power Plant Independent Spent Fuel Storage Installation), CLI-02-23, 56 NRC 230, 234-35 (2002); CLI-03-1, 57 NRC 1, 3-4 (2003).

² See Petition at 1.

³ 10 C.F.R. § 2.802(d).

⁴ See Petition at 1.

⁵ This section describes the circumstances under which a licensee may make changes in the facility or procedures as described in the final safety analysis report and conduct tests or experiments not described in the final safety analysis report without obtaining a license amendment.

⁶ This section describes conditions under which a licensee may make changes in its safeguards contingency plan without prior approval of the Commission and requires a licensee to provide for the development, revision, implementation, and maintenance of its safeguards contingency plan.

⁷ Petition at 5.

Further, MFP and UCS propose that 10 C.F.R. Part 50 be revised to require nuclear power plant owners “to formally evaluate their facilities against specified aerial hazards and make changes as necessary to provide reasonable assurance that the ability of the facility to reach and maintain safe shutdown would not be compromised by an aerial assault.”⁸ Petitioners assert that the requested changes for aerial hazards are analogous to regulations promulgated by the NRC to rectify the fire protection regulation shortcomings after a fire at the Browns Ferry power station in 1975.⁹ The petition focuses on the effect of an aerial attack on the control building, which is located outside the heavily reinforced containment surrounding the nuclear reactor itself.

In a letter accompanying the petition, MFP requests that the Commission suspend the Diablo Canyon ISFSI proceeding while it considers the petition and advances two reasons for doing so. First, according to MFP, the petition has the “potential to bring about a significant redefinition of the fundamental design requirements that are considered adequate to protect independent spent fuel facilities [] against radiological sabotage.”¹⁰ Second, the petition seeks to upgrade the 10 C.F.R. § 50.59 safety evaluation process, which the Licensee would likely use in developing and revising procedures for dry cask loading and movement. To ensure that the ISFSI is adequately designed to accommodate the changes, MFP asserts that conclusion of the licensing proceeding should await the outcome of the rulemaking proceeding.¹¹

Although the Commission will evaluate the MFP-UCS rulemaking proposal carefully, we do not find it necessary to stay further licensing proceedings in this case. We denied a similar stay request earlier in this proceeding when MFP, ten other intervention petitioners, and one outside organization petitioned the Commission directly to suspend the proceeding pending the NRC’s ongoing comprehensive review of the adequacy of design and operation measures to protect against terrorist attack and other acts of malice or insanity.¹² Then as now, MFP contended, among other things, that NRC’s “design basis threat” is inadequate.¹³

⁸ *Id.*

⁹ *See id.*

¹⁰ Petition Cover Letter, David Lochbaum to Annette L. Vietti-Cook (Apr. 28, 2003).

¹¹ *See id.*

¹² *See* CLI-02-23, 56 NRC 230 (2002).

¹³ The “design basis threat” is the postulated threat that the physical protection system must be able to withstand. Design basis threats are used “to design safeguards systems to protect against acts of radiological sabotage and to prevent the theft of special nuclear material.” 10 C.F.R. § 73.1(a). The Commission recently revised the design basis threat for the 103 operating U.S. nuclear power plants by issuing a security order on April 29, 2003. The order, classified as safeguards information, is not available to the public.

We evaluate MFP's current request under the same standard we used for its earlier request:

[W]e consider whether moving forward with the adjudication will jeopardize the public health and safety, prove an obstacle to fair and efficient decisionmaking, or prevent appropriate implementation of any pertinent rule or policy changes that might emerge from our important ongoing evaluation of terrorism-related policies.¹⁴

MFP has advanced no new arguments that warrant suspension of this proceeding. Again, we find that there “is no reason to believe that any danger to public health and safety would result from *mere continuation of this adjudicatory proceeding.*”¹⁵ And, given the current posture of the ISFSI proceeding, suspending the proceeding would prove “an obstacle to fair and efficient decisionmaking.” *Id.* The sole contention under consideration by the Licensing Board is the Licensee's financial qualifications in view of its bankruptcy. Subpart K oral arguments, the culmination of months of discovery, preparation, and written presentations to the Licensing Board, are imminent — scheduled for May 19, 2003. It is not sensible to postpone resolution of this single issue at this late stage in the proceeding. Finally, conclusion of the licensing proceeding need not await the outcome of the filing of the rulemaking petition to ensure that the proposed ISFSI is adequately designed to accommodate any changes resulting from consideration of the rulemaking proposal. As “*every license* the Commission issues is subject to the possibility of additional requirements,”¹⁶ moving forward with the current Diablo Canyon licensing proceeding does not foreclose implementation of any new rules originating from the pending rulemaking petition.

III. CONCLUSION

The Commission *denies* MFP's request to suspend this proceeding while it is considering MFP's and UCS's rulemaking petition.

¹⁴ *Diablo Canyon*, CLI-02-23, 56 NRC at 238, quoting *Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), CLI-01-26, 54 NRC 376, 380 (2001); accord *Duke Energy Corp.* (McGuire Nuclear Station, Units 1 and 2; Catawba Nuclear Station, Units 1 and 2), CLI-01-27, 54 NRC 385, 389-90 (2001); *Duke Cogema Stone & Webster* (Savannah River Mixed Oxide Fuel Fabrication Facility), CLI-01-28, 54 NRC 393, 399 (2001).

¹⁵ CLI-02-23, 56 NRC at 239.

¹⁶ *Id.* at 240.

IT IS SO ORDERED.

For the Commission

ANNETTE L. VIETTI-COOK
Secretary of the Commission

Dated at Rockville, Maryland,
this 16th day of May 2003.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

COMMISSIONERS:

Nils J. Diaz, Chairman
Greta Joy Dicus
Edward McGaffigan, Jr.
Jeffrey S. Merrifield

In the Matter of

Docket No. 72-22-ISFSI

PRIVATE FUEL STORAGE, L.L.C.
(Independent Spent Fuel Storage
Installation)

May 28, 2003

DESIGN BASIS: CREDIBLE EVENTS

RISK ASSESSMENT: ACCEPTABLE RISK

The probability and consequences sides of the risk equation are intimately linked: negligible consequences would make probability irrelevant in the same way a vanishingly small probability makes consequences irrelevant.

RULES OF PRACTICE: COMMISSION GUIDANCE; COMMISSION DISCRETION TO DIRECT PUBLIC PROCEEDINGS

NRC SUPERVISORY AUTHORITY

The Commission has inherent power to “customize its process for individual cases.” See *Baltimore Gas & Electric Co.* (Calvert Cliffs Nuclear Power Plant, Units 1 and 2), CLI-98-15, 48 NRC 45, 53 (1998). See *National Whistleblower Center v. NRC*, 208 F.3d 256, 262 (D.C. Cir. 2000), *cert. denied*, 531 U.S. 1070 (2001).

RULES OF PRACTICE: COMMISSION GUIDANCE; COMMISSION DISCRETION TO DIRECT PUBLIC PROCEEDINGS

NRC SUPERVISORY AUTHORITY

Because this case has remained on the Commission's adjudicatory docket for 6 years, the Board is authorized to use whatever procedural devices it deems necessary to reach a timely decision, including, for example, ordering party disclosure in lieu of discovery, requiring simultaneous submissions, limiting the number of witnesses, forbidding summary disposition or other motions, conducting hearings at NRC headquarters in Maryland rather than in Utah, limiting extensions of time, forgoing a formal NRC Staff evaluation, or any other fair and workable procedural steps.

MEMORANDUM AND ORDER

In a March 10, 2003 order, the Atomic Safety and Licensing Board referred to the Commission a Partial Initial Decision on air crash probability at the proposed Private Fuel Storage (PFS) spent fuel storage facility in Utah.¹ The Board held that it could not approve a license for the PFS facility until PFS provides further proof of the proposed facility's safe design. Both PFS and the NRC Staff have filed petitions for review asking the Commission to overturn the Board's probability finding.

Because the Board now is addressing the question whether air crashes at the site would have significant consequences, an inquiry that may obviate the need for Commission review of the Board's probability finding, we decline to undertake review of the probability issue now. Rather, we have decided to hold that issue in abeyance until the Board has completed its "consequences" review. As necessary, we will review all issues relating to air crash risk at that time. Below, we direct the Board to expedite its consequences inquiry.

I. BACKGROUND

Two years ago in this same proceeding, the Commission decided that the "threshold probability" for a credible accident at an independent spent fuel storage installation should be one in a million (1×10^{-6}) per year of operation.²

¹ See LBP-03-4, 57 NRC 69 (2003).

² *Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), CLI-01-22, 54 NRC 255 (2001).

That is, any accident calculated to have less than a one in a million chance of happening is not credible, and a license applicant would not have to show that its facility could withstand such an accident. That decision also approved the Board's use of a formula for calculating the probability of an aircraft crash that was originally developed for use in reviewing reactor design safety.³

In hearings held over 12 days in April through July 2002, the Board took extensive evidence on the question of the likelihood that military aircraft, in particular the F-16, could crash into the PFS site. The Board heard from 11 witnesses and received 226 exhibits. The transcript of hearings on this issue alone exceeds 3200 pages. The Board detailed its findings in a 220-page Partial Initial Decision.

In that decision, the Board calculated that there was a 4.29-in-a-million (4.29×10^{-6}) chance that military aircraft or jettisoned ordnance could crash into the PFS site. The Board ruled that a military aircraft crash into the proposed PFS facility was therefore a credible event and that no license could issue until PFS proves that its proposed facility could withstand such an accident. The Board indicated that, if PFS should choose to pursue the matter, it would hold further proceedings on whether the design of the facility could suffer such an accident without releasing dangerous levels of radiation.⁴

PFS and the NRC Staff both have said that they will prepare for proceedings on consequences.⁵ The State of Utah claims that PFS must file a formal license application amendment, followed by Staff review, a revised Safety Evaluation Report, and contentions, before any such hearing can take place.⁶ The Board plans to consider the further process for resolving the consequences issue at a conference on May 29, 2003. At that time the Board also will consider PFS's pending motion for reconsideration that asks the Board to approve a conditioned or limited license as a means to deal with the air crash risk in the short term.

II. DISCUSSION

A. Parties' Claims of Error

PFS asserts three principal grounds for review. First, it claims that the Board's calculated probability of 4.29 in a million (4.29×10^{-6}) should be considered close enough to the threshold probability of one in a million that an aircraft crash should be deemed not a credible event. Related to that argument is PFS's

³ 54 NRC at 264. *See* Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, NUREG-0800 (Rev. 2, July 1981) § 3.5.1.6 "Aircraft Hazards."

⁴ *See* LBP-03-4, 57 NRC at 144.

⁵ Joint Report on "Consequences" Proceedings, March 31, 2003.

⁶ *Id.*

assertion that a conservative estimate of anything less than 1 in 100,000 (1×10^{-5}) should be considered acceptable where qualitative factors show that the “realistic” probability is actually less than that. Second, PFS argues that the Board erred in not factoring in an “*R* factor” representing “pilot avoidance” — the likelihood that the pilot of a crashing F-16 will steer it away from the PFS facility before he ejects. PFS claims that a pilot could do so in 90% of F-16 accidents, and would do so in 95% of those. This would result in an 86% reduction in probability. Third, PFS argues that the Board erred in not admitting its proffered evidence that even if the site were hit by a crashing jet, the casks would not release harmful levels of radiation.⁷

Like PFS, the NRC Staff insists that the Board was wrong to deem an F-16 crash into the facility a “credible event.” First, the Staff argues that a calculated probability of 4.29×10^{-6} should be “rounded down” to a 1×10^{-6} probability. The Staff also claims that the Board should have reduced the calculated probability to reflect the likelihood that the pilot of a crashing F-16 would steer it away from the PFS site prior to ejecting.

B. Failure To Consider “Consequences” Evidence at the “Probability” Hearing

We reject outright PFS’s third ground for review, that the Board erred in not admitting PFS’s proffered evidence on consequences, for two reasons. First, the Board excluded “consequences” evidence from the hearing in response to motions by both PFS and the NRC Staff, who viewed such evidence as irrelevant to a hearing scheduled exclusively to address the probability that an air accident would take place.⁸ In addition, at this point, even were we to conclude that the Board erred, the error was harmless in light of the Board’s decision to allow further litigation on the consequences issue.

C. The Board’s Probability Ruling

Two principal arguments made by PFS and the NRC Staff — that the record justifies “rounding down” the Board’s probability finding, and that the Board undervalued the “pilot avoidance” factor — would demand an exhaustive Commission reevaluation of the factual record. In deciding whether to grant a petition

⁷The petitions for review also advert to other claimed Board factual errors but do not develop them in detail, presumably because of our ten-page limit on petitions for review.

⁸See Applicant’s Motion To Strike Portions of State of Utah’s Prefiled Testimony of Dr. Marvin Resnikoff Regarding Utah Contention K/Confederated Tribes Contention B (March 25, 2002), NRC Staff’s Motion in Limine To Exclude Portions of the State of Utah’s Prefiled Testimony and Exhibits Concerning Contention Utah K/Confederated Tribes B (March 25, 2002).

for review, the Commission gives due weight to the existence of a substantial question regarding the considerations listed in 10 C.F.R. § 2.786(b)(4), including whether a finding of material fact is “clearly erroneous.”⁹ However, we are reluctant to decide at this juncture whether to undertake a largely fact-based review here, not just because the factual findings here are extensive, but also because the Board has not completed its “risk” inquiry. Specifically, the Board is still considering the “consequences” aspect of risk.

We do not rule out the possibility of reviewing the Board’s probability findings later, in connection with any review of the Board’s ultimate determination of risk (i.e., after the Board’s “consequences” ruling). To do so now, however, with the Board in the midst of its consequences proceeding, could be an *unnecessary* burden on the parties. The parties would be forced simultaneously to pursue the probability issue on appeal before the Commission — this would require extensive briefs — and the consequences issue at hearings before the Board. Because the outcome of our probability review is far from certain, and because the consequences hearing will have a direct bearing on the overall review in any event, we are not inclined to burden the parties at this point in time with the extensive briefing it would take for us to review the probability question on appeal. In addition, the Boards have just issued four additional merits rulings, and a fifth is expected imminently.¹⁰ Our scrutiny is best concentrated on those rulings rather than on a probability ruling that may be rendered moot or unimportant by subsequent Board findings.

The probability and consequences sides of the risk equation, of course, are intimately linked: negligible consequences would make probability irrelevant in the same way a vanishingly small probability makes consequences irrelevant. For example, the Board did not look at the probability of certain types of aircraft accidents — those involving small private aircraft — in part because such a crash would certainly not penetrate a storage cask.¹¹ PFS itself recognized the link between the two multipliers in the risk equation when it offered to present consequences evidence at the probability hearing for the purpose of demonstrating the conservatism of its risk calculations. Thus, if PFS successfully demonstrates at the anticipated hearing that the posited crashes would not penetrate a storage cask or, even if they did, would be unlikely to cause release of dangerous levels

⁹ See 10 C.F.R. § 2.786(b)(4)(i). See also *Carolina Power & Light Co.* (Shearon Harris Nuclear Power Plant), CLI-01-11, 53 NRC 370, 382 (2001) (collecting cases), *aff’d sub nom. Orange County v. NRC*, 2002 WL 31098379 (D.C. Cir., Sept. 19, 2002). *Hydro Resources, Inc.* (P.O. Box 15910, Rio Rancho, NM 87174), CLI-00-12, 52 NRC 1, 3 (2000).

¹⁰ See LBP-03-8, 57 NRC 293 (2003).

¹¹ See *Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), LBP-01-19, 53 NRC 416, 452 (2001); see Applicant’s Motion for Summary Disposition of Utah Contention K and Confederated Tribes Contention B (Dec. 30, 2000), at 21-22.

of radiation, then the overall risk is satisfactorily low and there would be no need for the Commission to undertake review of the probability ruling.

PFS's and the NRC Staff's petitions for review on the probability issue are accordingly not denied, but held in abeyance, until the complete record is available to us.

III. CONSEQUENCES PRESENTATION

In the exercise of our inherent supervisory power over licensing proceedings, we will turn our attention to a matter not specifically raised by the parties. The NRC Staff, PFS, and Utah have all given the Board various estimates of the time it will take to complete the discovery, hearing, and submissions of proposed findings in the consequences proceeding. PFS, which submitted the tightest proposed schedule, believes that the consequences hearings can be completed by October of this year and a Board decision available in January of 2004. Others say it could take longer. We direct the Board to make every effort to wind up the consequences hearing no later than December of this year.

Both PFS and Utah have already done some investigation of consequences. The prefiled testimony of the State's expert, Dr. Marvin Resnikoff, discussed whether an F-16 crash or jettisoned ordnance could penetrate a cask and the possible consequences of that penetration.¹² PFS sought to introduce at the probability hearing evidence that the casks would not be penetrated in the unlikely event of a crash in order to demonstrate its calculation's conservatism. Considering that the parties have had some opportunity to investigate the consequences of an aircraft striking the facility, we find it realistic to urge the Board to expedite the hearing on this issue.

Hence, we specifically authorize the Board to use whatever procedural devices it deems necessary to reach a timely decision.¹³ Appropriate measures might include, for example, ordering party disclosure in lieu of discovery, requiring simultaneous submissions, limiting the number of witnesses, forbidding summary disposition or other motions, conducting hearings at NRC headquarters in Maryland rather than in Utah, limiting extensions of time, forgoing a formal NRC Staff evaluation, and any other fair and workable procedural steps.

¹² State of Utah's Prefiled Testimony of Dr. Marvin Resnikoff for Contention Utah K/Confederated Tribes B (Feb. 19, 2002), at 21-27.

¹³ The Commission has inherent power to "customize its process for individual cases." *See Baltimore Gas & Electric Co.* (Calvert Cliffs Nuclear Power Plant, Units 1 and 2), CLI-98-15, 48 NRC 45, 53 (1998). *See National Whistleblower Center v. NRC*, 208 F.3d 256, 262 (D.C. Cir. 2000), *cert. denied*, 531 U.S. 1070 (2001).

The Board's goal should be to hold an evidentiary hearing in early autumn and to decide the consequences issue before the end of the year. We authorize unusual procedural measures here because this case has remained on our adjudicatory docket for 6 years. Although we have no doubt that the parties have worked assiduously, the time has now come to make every effort to bring the proceeding to closure soon and to decide whether to issue a license or not. We would expect the Board to report to the Commission if it cannot issue a consequences decision prior to the end of this year. Such a report shall set out the reasons for the delay and establish an alternate deadline for a decision.

IV. CONCLUSION

Insofar as PFS's petition for review seeks Commission review of the Board's refusal to entertain consequences evidence at the probability hearing, the petition is denied. In all other respects, the PFS and the NRC Staff petitions for review are held in abeyance pending further Commission order, which we expect to issue after the upcoming Board order on consequences becomes ripe for review. The Board is directed to proceed expeditiously on the consequences aspect of the air crash issue, with a view toward resolving it no later than the end of 2003.

IT IS SO ORDERED.

For the Commission

ANDREW L. BATES
Acting Secretary of the Commission

Dated at Rockville, Maryland,
this 28th day of May 2003.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:

Alan S. Rosenthal, Presiding Officer
Thomas D. Murphy, Special Assistant

In the Matter of

Docket No. 40-8027-MLA-5
(ASLBP No. 03-807-01-MLA)

SEQUOYAH FUELS CORPORATION
(Gore, Oklahoma Site)

May 1, 2003

MEMORANDUM
(Certification of Questions to the Commission
Pursuant to 10 C.F.R. § 2.1209(d))

This materials license amendment proceeding was initiated by the filing of a notice in the *Federal Register* advising that the Commission was considering the issuance of an amendment to source materials license SUB-1010 issued to the Sequoyah Fuels Corporation (Licensee). The amendment would permit the Licensee to possess at its site near Gore, Oklahoma, byproduct material as defined in section 11e(2) of the Atomic Energy Act of 1954 (AEA), as amended, 42 U.S.C. 2014e(2) (2000). 67 Fed. Reg. 69,048 (Nov. 14, 2002).¹

Pursuant to the opportunity for hearing provided in the notice, timely hearing requests with respect to the proposed amendment were filed by the State of Oklahoma, Citizen's Action for Safe Energy (CASE), the Cherokee Nation, and fifteen individuals. The Licensee and the NRC Staff filed oppositions to the CASE

¹Under the aegis of the source materials license, the Licensee operated a uranium conversion facility on that site until 1993 when it advised the NRC of its intent to shut the facility down and to decommission it.

and fifteen individuals' requests on December 26, 2002, and January 10, 2003, respectively. They sought and were granted, however, an extension to April 16, 2003, of the time within which to respond to the requests of Oklahoma and the Cherokee Nation for the reason that settlement negotiations were underway with those entities. On April 15, 2003, the Cherokee Nation withdrew its request based upon a letter agreement that it had reached with the Licensee. The following day, the Licensee and the Staff filed their oppositions to the Oklahoma request.

The oppositions to the remaining hearing requests are founded upon the assertion that none of the requestors has satisfied the requirements of the Commission's Rules of Practice governing the grant of such requests. Specifically, the claim is that the requestors have failed either to establish their standing to challenge the proposed action or to identify an area of concern germane to the proceeding. *See* 10 C.F.R. §§ 2.1205(e) and (h).

At least in the instance of Oklahoma, the validity of that claim appears to rest upon whether Oklahoma is precluded from insisting, as it does in the December 16 hearing request (at 15-17), that the waste on the Licensee's site in question does not qualify as section 11e(2) byproduct material (in other words does not meet the definition of byproduct material set forth in that section of the AEA). As the Licensee and NRC Staff correctly maintain for reasons explained below, as matters now stand I cannot entertain Oklahoma's assertions in that regard. Nonetheless, there are good reasons for now calling the assertions to the attention of the Commission so that it might determine whether the State should be accorded an opportunity to have them heard in this adjudicatory proceeding.²

A.1. As reflected in the November 14 *Federal Register* notice, this license amendment proposal had its genesis in a January 5, 2001 Licensee request that the Commission determine if waste material from its Gore site could be classified as section 11e(2) byproduct material. In actuality, the relevant history of NRC consideration of that issue has a much earlier origin. The starting point is 1993, the year in which the Licensee advised the Commission of its decision to shut down and to decommission the Gore facility.

On July 6, 1993, the then Executive Director for Operations sent a memorandum to the Commissioners entitled "Clarification of Staff Remarks." The memorandum noted that, at the close of a June 25, 1993 briefing on operating

²I think there to be little room for doubt that Oklahoma has the standing to raise, on behalf of its citizens, issues going to whether a particular course of action sought to be pursued by a corporation within its borders is consistent with the dictates of an act of Congress. *See Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), LBP-98-7, 47 NRC 142, 169 (1998), *aff'd on other grounds*, CLI-98-13, 48 NRC 26 (1998). As I see it, the only issue is whether, because of circumstances now to be set forth, the State is foreclosed from challenging the proposed action on the ground that the material in question does not come within the ambit of section 11e(2) of the AEA and therefore cannot be so classified.

reactors and fuel cycle facilities, a Commissioner had inquired as to the criteria that might be used in the decommissioning of the Gore facility. A Staff member had responded that the Licensee “had proposed to remediate [the] site by being declared an 11e(2) byproduct material disposal site, therefore using 10 C.F.R. Part 40, Appendix A, as the criteria.” The memorandum went on to observe that this description of the proposal had been based upon section 2.2.2 of the February 16, 1993 Preliminary Plan for Completion of Decommissioning, which section suggested that the Gore decommissioning waste might be able to be characterized as section 11e(2) byproduct material.

According to the memorandum, however, the NRC Office of the General Counsel had provided informal advice to the effect that:

hexafluoride conversion plants had never been considered as uranium mills, and were not contemplated as such in the Uranium Mill Tailings Radiation Control Act of 1978.^{3]} The uranium contaminated decommissioning wastes at Sequoyah Fuels do not fit the definition of 11e.(2) byproduct material and thus fall outside the coverage of the Act.⁴

The memorandum concluded by stressing that no decision had as yet been made as to the “criteria against which the Sequoyah decommissioning effort would be evaluated.” Rather, that decision would abide the event of the submission of a “full site characterization and detailed decommissioning plan.”

2. Last June, almost 9 years after this recording of the informal opinion of the Office of the General Counsel that the Gore decommissioning wastes did not qualify as section 11e(2) material, the Executive Director for Operations sent another memorandum to the Commissioners. SECY-02-0095 (June 4, 2002). Its stated purpose was to “request Commission approval that certain Sequoyah Fuels Corporation (SFC) waste can be classified as Atomic Energy Act, Section 11e.(2) byproduct material.”

As the memorandum explained, in March 1999 the Licensee had submitted a decommissioning plan to remediate the site and to terminate its license in accordance with the restricted release provisions in the 1997 License Termination Rule (LTR) contained in 10 C.F.R. § 20.1403. Then, in January 2001, it had formally requested that the NRC Staff “evaluate whether a portion of its waste could be considered as 11e(2) byproduct material and, thereby, be remediated

³This reference to that Act (UMTRCA) stemmed from the fact that it added the definition of byproduct material found in section 11e(2) of the AEA: “the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content.”

⁴The memorandum pointed out, however, that the fact that the waste could not be characterized as 11e(2) byproduct material did not absolutely preclude the application of 10 C.F.R. Part 40, Appendix A.

under the uranium mill tailings impoundment regulations in Appendix A of 10 C.F.R. Part 40.” The memorandum acknowledged that the Licensee’s like proposal in 1993 had met with Staff disapproval. Nonetheless, it was now putting two options before the Commission.

The first presented option (SECY-02-0095 at 5-6) would have had the Licensee continue to decommission the site under the restricted release provisions of the LTR found in 10 C.F.R. § 20.1403. Under this option, the Staff’s previous position on the section 11e(2) byproduct material issue would be maintained. More specifically, there would be no need to engage in “interpretations based on detailed analyses and arguments over what constitutes ‘milling,’ ‘ores,’ and ‘extraction or concentration’ — the key terms in the definition of 11e.(2) byproduct material.”

The second option addressed in SECY-02-0095 (at 6-9) called for the acceptance of the Licensee’s “proposal that the residual radioactivity produced as a result of the front-end process at the uranium conversion facility can be classified as byproduct material as defined in Section 11e.(2) of the AEA.” Under this option, the memorandum noted, the material would be disposed of in a 10 C.F.R. Part 40, Appendix A tailings impoundment at the site. At the completion of remediation, ownership and control of the material cell would be transferred to the Department of Energy under Title II of the UMTRCA.

The memorandum discussed (at 3-9) the advantages and disadvantages associated with each of the options, as well as the reasons why the Staff now concluded (at 3), contrary to the determination reached in 1993, that the “activity at the front end of the Sequoyah processing was uranium milling, and thus produced 11e.(2) byproduct material as its wastes.” Its conclusion (at 10) was that, although both options were “legally viable and protective of public health and safety and the environment,” a weighing of the advantages and disadvantages of each favored the adoption of the second option. Accordingly, the Commission was urged to approve it.

On July 25, 2002, the Executive Director for Operations was informed by memorandum from the NRC Secretary that the Commission had approved the second option. As this memorandum and its accompanying papers reflected, three of the four voting Commissioners supported that option while the fourth would have adopted the first option. Then Chairman Meserve set forth in some detail the reasons why he supported the second option, which reasons were specifically endorsed by Commissioner McGaffigan.⁵ For her part, Commissioner Dicus provided in equal detail the basis for her preference for the first option.

⁵ The Chairman took note in his comments (n.3) of the fact that the Staff recommendation contained in SECY-02-0095 had been accompanied by a Differing Professional View in which its Staff member authors had pointed out that the wastes arising from the processing at the Gore facility
(Continued)

In the wake of the Commission decision, the NRC Staff sent an August 27, 2002 letter to the Licensee advising it of that decision and inviting it to submit a license amendment application to possess section 11e(2) byproduct material. Thereafter, by September 30, 2002 letter, the invitation was accepted. This proceeding, triggered by the November 14, 2002 *Federal Register* notice, ensued.

B. As seen from the foregoing, the Commission determination last July with regard to the classification of the Gore decommissioning waste as section 11e(2) byproduct material was made in circumstances in which entities such as the State of Oklahoma did not have an opportunity to express their views on the classification issue. In this regard, there is absolutely nothing in SECY-02-0095 to suggest that the NRC Staff sought the views of the State.⁶

As such, this adjudicatory proceeding appears to be the only opportunity that Oklahoma may have to assert its position on the section 11e(2) classification issue. Yet, given the Commission's determination last July, it is not apparent that I am now empowered to entertain that position. My authority as the presiding officer for this proceeding seemingly does not extend to what, in the final analysis, represents a challenge to a decision reached by the Commission itself.

The short of the matter thus is that only the Commission itself can now decide whether, in the totality of circumstances, Oklahoma should now be given the opportunity to challenge the Licensee's proposal now before me on the ground that it is not legally permissible because it is inconsistent with the terms of section 11e(2) of the AEA.⁷ For that reason, I am hereby certifying to the Commission, pursuant to 10 C.F.R. § 2.1209(d), the following questions:

1. Should the State of Oklahoma be permitted to raise in this pending materials license amendment proceeding the question whether the decommissioning waste present on the site of the Licensee Sequoyah Fuels Corporation qualifies as

had different radiological concentrations than the wastes typically produced at uranium mills. He concluded, however, that this was not of current significance because "the definition of 11e(2) byproduct material focuses on the nature and purpose of the processing, not the characteristics of the wastes."

⁶The only reference to the State in SECY-02-0095 is found in footnote 1, in which it was recorded that Oklahoma had indicated that it did not wish to assume responsibility for the Gore site. Yet, in its April 16, 2003 opposition to Oklahoma's hearing request (at 19), the Licensee maintains that "Oklahoma could have made its argument directly to the Commission but chose not to do so." It is not explained what mechanism was available for that purpose given the context in which the matter was being considered.

⁷It might be noted in passing that, in SECY-02-0095 (at 10), the Office of the General Counsel observed that the then pending adjudicatory proceeding regarding the Licensee's decommissioning plans did not involve any issue related to classification of material at the Gore site as section 11e(2) byproduct material. Thus, that office concluded that no separation of functions issues were raised by the paper. This proceeding, of course, was not in existence at the time.

byproduct material within the ambit of section 11e(2) of the Atomic Energy Act of 1954, as amended, 42 U.S.C. § 2014e(2) (2000)?

2. If the answer to that question is in the affirmative, does the Commission wish to entertain Oklahoma's assertions on the issue itself or, alternatively, does it want the State's section 11e(2) claims to be considered in the first instance by this presiding officer?⁸

BY THE PRESIDING OFFICER⁹

Alan S. Rosenthal
ADMINISTRATIVE JUDGE

Rockville, Maryland
May 1, 2003

⁸It is my current intention to withhold action on all of the pending hearing requests to await the Commission response to these questions. As previously noted, however, I am satisfied that at least the Oklahoma request satisfies the standing and area of concern requirements of the Rules of Practice should it be determined that it is entitled to be heard on the section 11e(2) classification issue it has raised. *See* note 2, *supra*.

⁹Copies of this Memorandum were sent this date by e-mail transmission to the counsel for the parties directly concerned.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:

Michael C. Farrar, Chairman
Dr. Jerry R. Kline
Dr. Peter S. Lam

In the Matter of

Docket No. 72-22-ISFSI
(ASLBP No. 97-732-02-ISFSI)

PRIVATE FUEL STORAGE, L.L.C.
(Independent Spent Fuel Storage
Installation)

May 22, 2003

SEISMIC AND GEOLOGIC CRITERIA: FACILITY DESIGN
(STANDARD FOR DETERMINING ADEQUACY)

Commission regulations establishing the comprehensive requirements for subsurface soils used to support proposed independent spent fuel storage facilities (ISFSIs) require an extensive site-specific evaluation of the subsurface soils if the site's soil characteristics directly affect the safety or environmental impacts of the proposed facility. *See* 10 C.F.R. § 72.102. Sites located on areas other than bedrock also require an evaluation to determine their potential instability due to vibratory ground motions and to demonstrate that the soil conditions are adequate to sustain the proposed foundation loads.

REGULATORY GUIDANCE: INTERPRETATION AND
APPLICATION (REGULATORY GUIDE 1.132)

Regulatory Guide 1.132 is a guidance document for nuclear power plants that is not necessarily applicable to spent fuel facilities, whose structures are quite different and do not involve interconnected safety systems sensitive to ground

motion. Because Regulatory Guide 1.132 is merely a guidance document, it is not binding upon licensing proceedings.

RULES OF PRACTICE: POST-HEARING RESOLUTION OF ISSUES BY STAFF

Once proposed design requirements have been established and accepted, actual testing of the soil to demonstrate that it can meet these requirements may be performed after the licensing hearing by the NRC Staff. Support for this practice of post-hearing verification can be found in the regulatory history surrounding the promulgation of the rules governing ISFSIs in 10 C.F.R. Part 72.

REGULATORY GUIDANCE

There is no Commission regulation that requires the suitability of a proposed design, if otherwise found to be acceptable, to have been demonstrated through prior use.

RULES OF PRACTICE: WITNESS (CREDIBILITY)

It is legitimate for a party to be concerned that the potential for large financial gain may cloud the judgment of a testifying witness, and in that circumstance a licensing board must scrutinize the demeanor and testimony of the witness with particular care.

EVIDENCE: EXPERT TESTIMONY

Although the range of an expert's experience on previous projects may not exactly track that involved in the proposed facility, experience and expertise gained in performing similar types of technical analyses over the course of an expert's career can provide sufficient confidence to support the expert's analysis of the facility in question.

RULES OF PRACTICE: WITNESS (CREDIBILITY)

Conflict of interest posed by affiliations of members of an expert advisory panel should be probed extensively to determine whether study results were tainted thereby.

REGULATIONS: INTERPRETATION (10 C.F.R. §§ 72.104(a), 72.106(b))

In the event of a design basis accident at an ISFSI, the dose consequences must not exceed a total effective dose of 5 rem as established in 10 C.F.R. § 72.106(b). The suggestion that a design basis accident must not result in dose consequences that exceed 25 mrem, established in 10 C.F.R. § 72.104(a) as the standard for normal operations, is without merit.

REGULATIONS: INTERPRETATION (10 C.F.R. § 72.104(a))

When calculating radiation dose limits for normal operating dose levels, applicants may rely upon 10 C.F.R. § 72.104(a), which establishes dose limits for any real individual. In performing such calculations, applicants can take site specifications into account to limit the amount of anticipated time an individual is exposed to radiation.

REGULATIONS: INTERPRETATION (10 C.F.R. § 72.106(b))

An applicant may take credit for a contingency plan to rectify an accident scenario.

TECHNICAL ISSUES DISCUSSED

The following technical issues are discussed: Independent Spent Fuel Storage Installation, Factors of Safety, Characterization of Subsurface Soils, Soil-Cement and Cement-Treated Soil, Young's Modulus, Soil-Structure Interaction, Seismic Analysis Programs, Time Histories, Cold Bonding, Risk Reduction Factors, Probabilistic Seismic Analysis, Radiological Dose Consequences of a Hypothetical Cask Tip-Over.

**PARTIAL INITIAL DECISION
(Regarding Geotechnical Issues)**

As we have noted in many previous decisions, Private Fuel Storage (PFS) is a consortium of electric utility companies that applied for an NRC license to build and to operate, on the Reservation of the Skull Valley Band of Goshute Indians some 50 miles southwest of Salt Lake City, an aboveground facility for the temporary storage of spent fuel rods from the nation's nuclear reactors. The Band would derive substantial income from making its Reservation available to

the Applicant for the facility, which is intended to serve as the spent fuel's way station before the coming to fruition of the permanent underground repository long planned for Nevada's Yucca Mountain.

The State of Utah and the Southern Utah Wilderness Alliance (SUWA), among others, challenged a number of aspects of the proposed facility. During a 9-week evidentiary trial, which was held in Salt Lake and at NRC Headquarters and ended in mid-2002, the Applicant PFS — responding to the State's and SUWA's contentions — attempted to demonstrate that its proposal was acceptable in terms of meeting certain safety and environmental regulatory criteria established under federal law, including the Atomic Energy Act and the National Environmental Policy Act (NEPA).

One of those issues, which we resolve today, stemmed from the State's so-called "geotechnical" contentions (denominated Utah L and QQ), involving whether the design of the proposed facility is sufficient to withstand any seismic forces it is likely to face as a consequence of earthquakes that might affect it.¹ Those contentions derive from the Commission's regulations governing site evaluations, under which proposed sites must be examined in terms of "the frequency and the severity of external natural and man-induced events that could affect [the facility's] safe operation." 10 C.F.R. § 72.90(b). In terms of seismic forces, this in turn requires the facility be designed to withstand the so-called "design basis earthquake," or "safe shutdown earthquake"² (a term used in this field to similar purpose as the "credible accident" concept that underlay our recent decision on aircraft crash likelihood).

For purposes of understanding and deciding the seismic issues, the proposed facility's design can be simply described. Being a facility for storage only, it consists essentially — insofar as seismic risks are involved — of a canister transfer building (CTB) and an array of 500 concrete pads on which the spent fuel storage casks would sit. Other onsite structures that support the facility's storage mission raise no seismic risk concerns.

In the CTB, canisters — sealed at the nuclear power plant at which they originated — containing spent fuel rods would be transferred from (1) the *transportation* casks within which they traveled by rail to the facility to (2) the *storage* casks which will sit upon the concrete pads. Those transfers of canisters

¹ Apart from certain issues about potential aircraft accidents that have arisen since our March 10 decision on that subject and that will be considered at two May 29 Board sessions, this Board has remaining before it only one issue, SUWA's environmental contention concerning the placement down Skull Valley of the proposed rail line that would service the facility. For its part, our sister Board has before it several issues about the Applicant's financial qualifications, which it anticipates will be decided shortly.

² 10 C.F.R. Part 100, Appendix A, referenced in 10 C.F.R. § 72.102(b).

into the storage casks will be facilitated by the CTB's overhead bridge crane and semi-gantry crane. The application envisions the eventual emplacement of up to 4000 of the storage casks on the concrete pads.

The seismic issues before us concern the stability, during possible earthquakes, of those storage casks, which will be some 20 feet tall and 11 feet in diameter, made of concrete sandwiched between layers of stainless steel. Openings in the top and bottom of the casks are designed to create natural air circulation that would provide the level of cooling then needed by the canisters of spent fuel (which before being transported to Skull Valley would have been cooled for any number of years in pools of water — and perhaps in dry storage as well — at the various nuclear power plants at which the fuel originated). Concern was expressed at the hearing about the casks tipping over, either in the CTB (which can hold only five casks at a time) or on the concrete pads, with consequent potential rupturing of the fuel rods or diminution of the natural cooling they need.

A very large, dual-tracked transporter vehicle would straddle and lift a storage cask in order to move it (at 2 miles per hour and 4 inches off the ground) from the CTB to the concrete pad upon which it will sit. The pads — each 67 feet long and 30 feet wide — will be made of 3-foot-thick reinforced concrete. The pads will be separated from each other by 5 feet in the long direction; in the other direction, they will be separated by 35 feet in order to provide a travel lane for the transporter vehicle to place the casks in a 4×2 array on each pad.

To provide support to the pads and the CTB, the Applicant proposes to underlay and to surround them with a mixture of soil and cement. Depending on the proportions of each constituent contained therein, the various mixtures are known as “soil-cement” or “cement-treated soil,” the former being of more substantial quality and of greater strength.

We have previously described Skull Valley as being framed by the Stansbury Mountains to the east and the Cedar Mountains to the west: our recent decision on the risk of aircraft crashes (LBP-03-4, 57 NRC 69 (2003)) provides that and other information about the local geography. For purposes of geotechnical analysis, important nearby features, in addition to the faults associated with those mountains, include the Wasatch Fault, just east of Salt Lake City, as well as two previously unknown faults (informally named the East and West faults) discovered through the Applicant's investigations.

As will be seen, the State filed a number of contentions that were eventually reshaped into the specific issues that came to hearing before us. In essence, the major issues the State raised involved the following six topics:

- the characterization of the site's subsurface soils, which the State charges was inadequate;
- the proposed uses of soil-cement to overcome foundation sliding, which the State asserts involve novel and untested techniques;

- the assumptions about facility behavior that underlie the seismic design, which assumptions the State says are flawed;
- the stability of the casks during a design basis earthquake, which the State urges has not been adequately demonstrated;
- the exemption from the long-standing “deterministic” standard for predicting ground motion in favor of a “probabilistic” one, which the State challenges as unsupported; and
- the ability of the facility to comply, after a design basis earthquake, with established radiological dose consequences standards, which the State believes will not be met.

On the facts presented, we find that the Applicant has met its burden of proof on all these seismic-related issues. Although the State presented thoughtful, valuable evidence that tested many aspects of the Applicant’s presentation, the Applicant’s position essentially withstood that scrutiny.

In this decision, we explore at some length all the subissues that underlie the main topics outlined above, and explain why we reject the conclusions the State would have us reach. At the same time, we recognize the seriousness of the questions the State raised; the extensive exploration of those questions in the hearing should provide reassurance to the State’s citizens that the merits of the Applicant’s proposal have been thoroughly scrutinized. In addition, the State brought to the fore two conflict-of-interest concerns that, although eventually found not to undercut the evidence to which those concerns related, plainly warranted analysis.

We set forth herein all the subsidiary findings needed to address the six major issues that the State raised about the scope and result of the Applicant’s seismic investigations and analyses. Our determinations on those six major issues lead inexorably to the ultimate safety findings: based on the preponderance of the evidence in the record and taking into account the nature of the seismic forces the facility is predicted to encounter and the investigations and analyses that have been conducted, the Applicant’s proof on the issues in controversy — which was essentially supported by the NRC Staff based on its lengthy prehearing review of the application and related materials — enables us to say, with the required degree of certainty, that (1) the spent fuel casks would not tip over during a design basis seismic event; and (2) even if one or more casks were to tip over, the spent fuel canister inside would not break or melt. It bears mention as well that, as both the Commission and this Board have previously indicated, even if a canister were to break or melt, the absence of significant dispersive forces would mitigate the consequences of such an event.

Not surprisingly given the complex nature of the contentions and the evidence, our decision today, so briefly summarized above, is a very long one. In Parts I and II, we set forth certain preliminary information about the genesis, development, and reshaping of the State’s contentions (including the efforts the parties made to put forward a consensus restatement of those contentions, which arose over a lengthy period of time), and about the facility design and the State’s concerns. We then turn in Parts III through VIII to address each of the six major concerns the State raised.

Those first eight parts of the decision — ending on page 371 — provide in narrative form an overview of the underlying reasoning that led us to the results we reach. Those eight parts, in turn, are keyed to Part IX, in which we provide a lengthy “Detailed Analysis of Record and Findings of Fact” [hereinafter referred to as “Findings”] that reviews the evidence and includes determinations either providing support for, or resulting from, the opinions and holdings expressed in the earlier, narrative portion of the decision. Finally, in Part X, we recite briefly our formal Conclusions of Law and our Order.

An outline of the entire decision’s contents is provided below. A separate table of contents for Part IX begins on page 371.

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I. BACKGROUND

A. Contention Utah L

The State’s first geotechnical challenge to the application, Contention Utah L, was submitted in November 1997 and admitted into the proceeding in April 1998. *See* LBP-98-7, 47 NRC 142, 253, *reconsideration granted in part and denied in part on other grounds*, LBP-98-10, 47 NRC 288, *aff’d on other grounds*, CLI-98-13, 48 NRC 26 (1998). As admitted, Utah L framed the State’s geotechnical concern as follows:

The Applicant has not demonstrated the suitability of the proposed ISFSI site because the License Application and [Safety Analysis Report] do not adequately address site and subsurface investigations necessary to determine geologic conditions, potential seismicity, ground motion, soil stability and foundation loading.

LBP-98-7, 47 NRC at 253. In support of its contention, the State submitted bases that addressed the following issues: (1) surface faulting, (2) ground motion, (3) characterization of subsurface soils, and (4) soil stability and foundation loading. LBP-01-39, 54 NRC 497, 501 (2002).

According to the current Commission regulation governing the ISFSI seismic design, potential licensees, such as PFS, proposing facilities located west of the Rocky Mountain Front, must comply with the standards regarding seismic stability requirements for nuclear power plants contained in 10 C.F.R. Part 100, App. A. *See* 10 C.F.R. § 72.102(b). Appendix A requires nuclear power plants to be

designed to withstand the ground motions of a “safe shutdown earthquake.”³ 10 C.F.R. Part 100, App. A. The regulation requires potential licensees to determine the safe shutdown earthquake — or what has also been referred to as a design basis earthquake (DBE) — using a *deterministic* methodology established in Appendix A. *Id.*

In 1997, the Commission amended sections of Part 100 to allow nuclear power plants to use a *probabilistic* analysis that accounts for the probability that an earthquake of a particular intensity will occur within a given timespan rather than limiting the analysis to the intensity of the earthquake. *See* CLI-01-12, 53 NRC 459, 461 (2001). *See also* 10 C.F.R. § 100.23 (establishing the Commission’s probabilistic seismic analysis for nuclear power plants). This amendment, however, was not made applicable to the methodology established for ISFSI licenses in Appendix A.

Later, in 1998, the Staff proposed a new rulemaking plan that would conform the regulations governing ISFSIs to the amended rule for nuclear power plants, allowing ISFSIs as well to use a probabilistic methodology in their seismic analysis. *See* SECY-98-126, Rulemaking Plan: Geological and Seismological Characteristics for Siting and Design of Cask [ISFSIs], 10 C.F.R. Part 72 (June 4, 1998). According to the Commission, this new approach would allow ISFSI applicants to design facilities based either on a 1000-year return period or on a 10,000-year return period (depending upon the amount of potential radiation a person outside the facility’s proposed boundary would receive if the structure in question were to fail). CLI-01-12, 53 NRC at 462. Under the new rule, structures that would cause radiation doses to exceed the maximum limits prescribed by Commission regulations would be designed to withstand a 10,000-year DBE, while all other facilities would be designed to withstand a 1000-year DBE. *Id.*

On April 2, 1999, the Applicant submitted an exemption request to the NRC Staff that would allow the Applicant to use a probabilistic seismic hazard analysis (PSHA) based upon a 1000-year DBE. LBP-99-21, 49 NRC 431, 433-34 (1999). According to the Applicant, its preliminary probabilistic analysis indicated that the “relative risk” at the proposed site warranted a DBE with much lower ground accelerations than required under Part 100’s deterministic approach. *Id.* at 434. This exemption request was of particular concern to the State because, as noted

³The safe shutdown earthquake is defined by 10 C.F.R. Part 100, App. A, as:

that earthquake which is based upon an evaluation of the maximum earthquake potential considering the regional and local geology and seismology and specific characteristics of local subsurface material. It is that earthquake which produces the maximum vibratory ground motion for which certain structures, systems, and components are designed to remain functional.

by the Staff, *the Applicant's facility could not meet the deterministic seismic qualifications applicable under the existing regulations.*⁴

In response to the Applicant's exemption request, the State filed a motion requesting that the Board either (1) require the Applicant to make its exemption request under the provisions of 10 C.F.R. § 2.758(b), which governs the consideration of Commission rules in adjudicatory proceedings, or (2) allow the State to amend its contention to contest the Applicant's exemption request. LBP-99-21, 49 NRC at 434-35. Both the Applicant and the Staff opposed these requests. *Id.*

We denied both of the State's requests. The first request was denied because section 2.758(b) was found to be inapplicable to the proceeding at that time. *Id.* at 439. And the request to allow the State to modify its contention was also denied, because we found it to be premature. *Id.* In that regard, we informed the State that this matter would not be ripe for consideration unless and until the Staff took favorable action on the Applicant's request. *Id.*

In August 1999, the Applicant modified its request to reflect a 2000-year return period earthquake. And, on December 15, 1999, the Staff issued its Safety Evaluation Report (SER) in which it noted that it planned to grant the exemption request based upon this 2000-year return period interval. LBP-00-15, 51 NRC 313, 315 (2000).

In response to the Staff's SER, the State filed another request to modify Utah L to address the Applicant's exemption request. *Id.* at 316. The modified contention requested that the Board require the Applicant either (1) to use a probabilistic methodology based upon a 10,000-year return period earthquake or (2) to comply with the current deterministic analysis requirement of 10 C.F.R. § 72.102(f). *Id.* at 316.

Both the Applicant and Staff opposed the State's request but for different reasons. *Id.* at 316-17. The Applicant argued that the State's request was outside the scope of the proceeding, an impermissible challenge to the Commission's regulations, and immaterial. *Id.* Taking a slightly different approach, the Staff contended that the request was not yet ripe because the SER did not grant the exemption but merely indicated the Staff's intended approval. *Id.* at 317. The Staff also asserted that the State's proposed modification was an impermissible challenge to Staff activity and outside the scope of the exemption request. *Id.* We denied the State's request, this time advising the State that such a request would not be ripe for adjudication until the Staff officially granted the Applicant's request. *Id.* at 318.

On September 29, 2000, the Staff issued its final SER, which noted that the Staff had completed its review of the Applicant's exemption request and

⁴See *id.* at 434-35; NRC Staff's Response to [State] Request for Admission of Late-Filed Modification to Basis 2 of Contention Utah L (Nov. 29, 2000) at 2.

concluded that the use of PSHA methodology with a 2000-year return period is acceptable for the proposed PFS facility. *See* [SER] Concerning the [PFS] Facility at 2-42 (Sept. 29, 2000). In response, the State again filed a request to modify Utah L to address the Applicant's exemption, and the State requested that if the Board found that it did not have the authority to address the State's concerns, the Board certify or refer the matter to the Commission. *See* LBP-01-3, 53 NRC 84, 89-90 (2001). According to the State, the Staff's support for its decision to grant the Applicant's exemption is deficient because:

(1) it fails to comply with the 1998 rulemaking plan, which provides only for 1000-year and 10,000-year design basis ground motion return periods, and fails to take into account (a) the radiological consequences of a failed design, or (b) the PFS failure to demonstrate that the PFS facility and its equipment will protect against exceeding the dose limitations of 10 C.F.R. § 72.104(a) or can withstand a 2000-year return period earthquake; (2) the reasons relied upon by the Staff for permitting the 2000-year return period — lower hazard compared to commercial power reactors, Department of Energy (DOE) category-3 facility performance characteristics, an exemption granted to DOE relative to ISFSI storage of Three Mile Island, Unit 2 fuel at DOE's Idaho National Engineering and Environmental Laboratory (INEEL) — are flawed or not compelling; and (3) a 2000-year return interval does not provide an adequate level of conservatism given the higher Utah new building construction/highway bridge design levels and the 30 to 40-year facility operating period. *See id.* at 6-14.

Id. at 90 (*citing* [State] Request for Admission of Late-Filed Modification to Basis 2 of Contention Utah L (Nov. 9, 2000) at 6-14).

In opposing the State's request, the Applicant argued that (1) the Board lacked jurisdiction to hear the issue, (2) it was an improper challenge to a Commission regulation, and (3) the State failed to support the modification with an adequate basis. LBP-01-3, 53 NRC at 90. For its part, the Staff requested that the Board certify or refer the issue to the Commission to definitively answer the question of whether the State's attack on the Applicant's exemption request was permissible in this adjudicatory proceeding or in the alternative that we deny the State's request outright for failing to provide a litigable contention. *Id.* at 91.

On January 31, 2001, we issued a Memorandum and Order admitting in part and denying in part the State's proffered modifications to Utah L. *Id.* at 101. In addition, having decided that the exemption matter was one that we believed could only be resolved by the Commission, we certified to the Commission the question of "whether the State's contention Utah L challenge to the April 1999 PFS seismic exemption request should be litigated in this proceeding." *Id.*

In accordance with its policy to accept Board certifications of issues that warrant early resolution, the Commission granted review of the Board's certified question and found that the State's exemption-related claims could be litigated

in this proceeding. CLI-01-12, 53 NRC at 461. In doing so, the Commission classified the State's challenge in the following manner:

what [the State] proposes to litigate is whether PFS's ISFSI design, which is dependent on an exemption from otherwise controlling seismic regulations, is adequate to withstand plausible earthquake risks. Viewed this way, [the State's] proposed revised Contention [Utah L] plainly puts into play safety issues that are material to licensing and suitable for consideration at an NRC hearing.

Id. at 465-66. Having decided the jurisdictional issue, the Commission remanded the matter to us, because it concluded that the Board, not the Commission, was the proper forum to hear a State challenge in the first instance. *Id.* at 476. Following the Commission decision, the Board, in an attempt to clarify the terms of Utah L in light of the recent decisions, split the issues into two parts. The State's exemption request was denominated Part B of Utah L, with the original four bases of the contention being Part A.⁵

After discovery was held on Part B, the Applicant filed for summary disposition thereon on November 9, 2001, insisting that there no longer remained a genuine dispute of material fact concerning Part B. LBP-02-1, 55 NRC at 14. The Staff supported the Applicant's request, while the State opposed it. *Id.* at 14-15.

After reviewing the arguments, we found that the State's experts had presented sufficient evidence to create doubt about the Applicant's claims that there no longer remained a dispute of material fact. *Id.* at 18. In that regard, we determined that Part B of Utah L could be resolved only after a full hearing on the matter, so we rejected the Applicant's motion. *Id.* We also ordered the parties to combine Part B of Utah L with Part A of Utah L and the newly admitted Utah QQ (*see* discussion below) to create a unified geotechnical contention that we believed would aid the presentation and understanding of the issues in the upcoming hearing. *Id.*

B. Contention Utah QQ

While we were dealing with the Applicant's exemption request as raised in Part B of Utah L, discovery was completed on the remaining seismic issues that

⁵ See Memorandum and Order (Requesting Joint Scheduling Report and Delineating Contention Utah L) (June 15, 2001). The Board further explained this division in a subsequent decision:

Part A challenges the Applicant's efforts to show that its facility design generally *meets the requirements* of the NRC's rules and regulations regarding seismic risk. Part B challenges the Applicant's efforts to rely upon an *exemption from meeting* one part of those rules and regulations and to substitute another method for demonstrating that the potential seismic risk is being properly addressed.

LBP-02-1, 55 NRC 11, 14 (2002).

comprised Part A of Utah L, and the Applicant, on December 30, 2000, filed for summary disposition of Part A. *See* LBP-01-39, 54 NRC 497, 502 (2001). In support of its claim that there no longer remained a dispute of material fact concerning Part A, the Applicant pointed to several geotechnical tests and analyses that it argued addressed the issues raised in the State's contention. *Id.* at 512-16. The State, in opposing the Applicant's motion, submitted a list of material facts that it claimed were still in dispute and a collection of expert affidavits to support this claim. *Id.* at 503. In its response, the Staff submitted its own collection of expert affidavits in support of the Applicant's motion. *Id.*

As we were deliberating over the parties' submissions, on March 30, 2001, the Applicant filed its twenty-second of twenty-three license amendments, to incorporate revised design basis ground motions anticipated at the proposed site. In response to this amendment, the State submitted a motion to add a new contention — Contention Utah QQ (Seismic Stability) — dealing with the Applicant's revised calculations. *See* [State]'s Request for Admission of Late-Filed [Utah QQ] (May 16, 2001) [hereinafter State Request].

As submitted, the Utah QQ, titled "Seismic Stability," states:

PFS's site specific investigations, laboratory analyses, characterization of seismic loading, and design calculations, including redesign of soil cement,[fn.] fail to demonstrate that a) the newly revised probabilistic seismic hazard design basis ground motions have been correctly and consistently applied to the Canister Transfer Building ("CTB"), storage pads, and their foundations; b) PFS's general design approach, including the redesign of soil cement, for the CTB, storage pads, or storage casks can safely withstand the effects of earthquakes; and c) the foundation design of the CTB, storage pads, and the underlying soils, or the stability of the storage casks, are adequate to safely withstand the newly revised probabilistic seismic hazard design basis ground motions. 10 C.F.R. §§ 72.102(c), (d); 72.122(b).

[fn.]PFS uses the term "soil cement" but the more correct term is "cement-treated soil." *See* Mitchell Dec. ¶ 12. The use of the term "soil cement" in this filing does not imply the State accepts that PFS will, in fact, use soil cement.

State Request at 2-3. In support of its contention, the State proffered a "basis presentation" that alleged that the Applicant's revised design "is unsupported and creates significant safety concerns." *Id.* The basis presentation was divided into four areas of concern:

- (1) application of the new design basis ground motion to the [Canister Transfer Building] and its foundation system;
- (2) application of the new design basis ground motion to the storage casks and the storage pads;
- (3) survivability and durability of cement-treated soil for the redesigned [Canister Transfer Building] and storage pad foundation systems;
- and (4) overestimation of the sliding resistance provided by the

clayey-silt and silty-clay underlying the [Canister Transfer Building] and storage pads.

See LBP-01-39, 54 NRC at 518.

On June 19, 2001, the State submitted a motion to revise Utah QQ to reflect another set of recently submitted Application revisions. The Applicant opposed this motion, but the Staff believed that the request was, at least in part, valid. On August 23, the State submitted a second request to modify its contention, to address yet another set of Applicant recalculations. Again, the Applicant opposed the State's motion and the Staff indicated that the request was valid in part. *Id.* at 504.

On December 26, 2001, we issued a Memorandum and Order admitting Utah QQ, as well as denying the Applicant's motion for summary disposition of Part A of Utah L. *Id.* at 524. The Board also granted the State leave to amend the bases of Utah QQ to reflect the revisions submitted by the Applicant. *Id.* at 521. In addition, the Board ordered the parties to create a statement that combined the thrust of both Part A of Utah L and Utah QQ (and later Part B of Utah L, *see* discussion above) to help the parties better to prepare for the then-upcoming hearing. *Id.* at 521.

C. Unified Contention L/QQ

In response to our order, on January 16, 2002, the parties submitted Unified Geotechnical Contention, Utah L and Utah QQ (Utah L/QQ) setting forth the remaining geotechnical issues and their supporting bases. Joint Submittal of Unified Geotechnical Contention, Utah L and Utah QQ (Jan. 16, 2002) (PFS Exh. 237) [hereinafter Unified Utah L/QQ]. The new unified contention Utah L/QQ contained five sections.

Section A, which deals with surface faulting, and Section B, which deals with ground motion, were drawn from bases 1 and 2 of the original Part A of Utah L. They read as follows:

A. Surface Faulting.

1. The Applicant's approach to surface faulting is neither integrated nor comprehensive and is inadequate to assess surface rupture at the site in that:
 - a. The Applicant has not used soil velocity data obtained from its seismic cone penetration tests in order to convert the seismic reflection data to show depth of marker beds.

- b. The Applicant's conclusion that the structural grain of the valley runs northwest does not account for the east-west Pass Canyon and the topographic embayment at the east-west trending Rydalch Pass.
- c. The Applicant has failed to collect any seismic tie lines perpendicular to the east-west lines shot in 1998 in order to correlate the 1998 lines among themselves or with the Geosphere and GSI lines, nor are the placement and number of seismic lines adequate to determine the length and projected locations of the East or West faults and other unnamed faults.

B. *Ground Motions.*

1. The Applicant's failure to adequately assess ground motion places undue risk on the public and the environment and fails to comply with 10 CFR § 72.102(c) in that:
 - a. The Applicant has not conducted a fully deterministic seismic hazard analysis that meets the requirements of 10 C.F.R. Part 100 Appendix A.

Id. at 1-2.

Prior to the hearing, the parties stipulated to the facts and issues in Sections A and B. *See* Joint Stipulation of Facts and Issues Not in Dispute with Respect to [Utah L/QQ] (Geotechnical) (Jan. 31, 2002). Thus, no further consideration was given to them.

Section C of Utah L/QQ, which addresses the Applicant's characterization of the proposed site's subsurface soils, includes both the original basis 3 of Utah L, Part A, and the portion of Utah QQ that deals with the Applicant's proposed use of soil-cement. As submitted, Section C reads:

C. *Characterization of Subsurface Soils.*

1. *Subsurface Investigations*

The Applicant has not performed the recommended spacing of borings for the pad emplacement area as outlined in NRC Reg. Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants, Appendix C."

2. *Sampling & Analysis*

The Applicant's sampling and analysis are inadequate to characterize the site and do not demonstrate that the soil conditions are adequate to resist the foundation loadings from the design basis earthquake in that:

- a. The Applicant has not performed continuous sampling of critical soil layers important to foundation stability for each major structure as recommended by Reg. Guide 1.132 Part C6, Sampling.

- b. The Applicant's design of the foundation systems is based on an insufficient number of tested samples, and on a laboratory shear strength testing program that does not include strain-controlled cyclic triaxial tests and triaxial extension tests.
3. *Physical Property Testing for Engineering Analyses*
- a. The Applicant has not adequately described the stress-strain behavior of the native foundation soils under the range of cyclic strains imposed by the [DBE].
 - b. The Applicant has not shown by case history precedent or by site-specific testing and dynamic analyses that the cement-treated soil will be able to resist earthquake loadings for the [Canister Transfer Building (CTB)] and storage pad foundations as required by 10 C.F.R. § 72.102(d).
 - c. The Applicant has not considered the impact to the native soil caused by construction and placement of the cement-treated soil, nor has the Applicant analyzed the impact to settlement, strength and adhesion properties caused by placement of the cement-treated soil.
 - d. The Applicant has not shown that its proposal to use cement-treated soil will perform as intended — *i.e.*, provide dynamic stability to the foundation system — and the Applicant has not adequately addressed the following possible mechanisms that may crack or degrade the function of the cement-treated soil over the life of the facility:
 - (i) shrinkage and cracking that normally occurs from drying, curing and moisture content changes.
 - (ii) potential cracking due to vehicle loads.
 - (iii) potential cracking resulting from a significant number of freeze-thaw cycles at the Applicant's site.
 - (iv) potential interference with cement hydration resulting from the presence of salts and sulfates in the native soils.
 - (v) cracking and separation of the cement-treated soil from the foundations resulting from differential immediate and long-term settlement.
 - e. The Applicant has unconservatively underestimated the dynamic Young's modulus of the cement-treated soil when subjected to impact during a cask drop or tipover accident scenario. This significantly underestimates the impact forces and may invalidate the conclusions of the Applicant's Cask Drop/Tipover analyses.

Unified Utah L/QQ at 2-3.

Section D, which deals with the facility's proposed seismic design and foundation stability, covers the remainder of Utah L, Part A, while Section E, which deals with the seismic exemption, covers what was originally Utah L, Part B. They read as follows:

D. *Seismic Design and Foundation Stability.*

The Applicant, in its numerous design changes and revisions to the calculations, has failed to demonstrate that the structures and their foundations have adequate factors of safety to sustain the dynamic loading from the proposed design basis earthquake, and does not satisfy 10 CFR § 72.102(c) or (d) or § 72.122(b)(2) in the following respects:

1. *Seismic Analysis of the Storage Pads, Casks, and Their Foundation Soils*

The Applicant has not demonstrated adequate factors of safety against overturning and sliding stability of the storage pads and their foundation system for the [DBE] as outlined by NUREG-75/087, Section 3.8.5, "Foundation," Section II.5, *Structural Acceptance Criteria*, because of the following errors and unconservative assumptions made by the Applicant in determining the dynamic loading to the pads and foundations:

- a. In spite of proximity to major active faults, the Applicant's calculations unconservatively assume that only vertically propagating in-phase waves will strike the pads, casks and foundations, and fail to account for horizontal variation of ground motion that will cause additional rocking and torsional motion in the casks, pads and foundations.
- b. The Applicant's calculations incorrectly assume that the pads will behave rigidly during the [DBE]. The assumption of rigidity leads to:
 - (i) Significant underestimation of the dynamic loading atop the pads, especially in the vertical direction.
 - (ii) Overestimation of foundation damping.
- c. The Applicant has failed to provide a realistic evaluation of the foundation pad motion with cement-treated soil under and around the pads in relation to motion of the casks sliding on the pads in that Applicant's evaluation ignores:
 - (i) the effect of soil-cement around the pads and the unsymmetrical loading that the soil-cement would impart on the pads once the pads undergo sliding motion,
 - (ii) the flexibility of the pads under DBE loading, and

- (iii) the variation of the coefficient of sliding friction between the bottom of the casks and the top of the pads due [sic] local deformation of the pad at the contact points with the cask.
 - d. The Applicant has failed to consider lateral variations in the phase of ground motions and their effects on the stability of the pads and casks.
 - e. The Applicant's calculations for cask sliding do not address the frequency dependency of the spring and damping values used to model the foundation soils.
 - f. The Applicant has failed to consider the potential for cold bonding between the cask and the pad and its effects on sliding in its calculations.
 - g. The Applicant has failed to analyze for the potential of pad-to-pad interaction in its sliding analyses for pads spaced approximately five feet apart in the longitudinal direction.
 - h. In an attempt to demonstrate cask stability, the Applicant's calculations use only one set of time histories in its non-linear analysis. This is inadequate because:
 - (i) Nonlinear analyses are sensitive to the phasing of input motion and more than one set of time histories should be used.
 - (ii) Fault fling (i.e., large velocity pulses in the time history and its variation and effects are not adequately bounded by one set of time histories.
 - i. Because of the above errors, omissions and unsupported assumptions, the Applicant has failed to demonstrate the stability of the free standing casks under design basis ground motions. Thus, the Applicant's analyses do not support the Applicant's conclusions that excessive sliding and collision will not occur or that the casks will not tip over. 10 C.F.R. § 72.122(b)(2) and NUREG-1536 at 3-6.
2. *Seismic Analysis of the Canister Transfer Building and its Foundation*

The Applicant has not demonstrated adequate factors of safety against overturning and sliding stability of the CTB and its foundation system for the [DBE] as outlined by NUREG-75/087, Section 3.8.5, "Foundation," Section II.5, *Structural Acceptance Criteria*," because of the following errors and unconservative assumptions made by the Applicant in determining the dynamic loadings to the CTB and its mat foundation:

- a. The Applicant's calculations incorrectly assume that the CTB mat foundation will behave rigidly during the DBE. The assumption of rigidity leads to:

- (i) Significant underestimation of the dynamic loading to the mat foundation.
 - (ii) Overestimation of foundation damping.
- b. The Applicant's calculations ignore the presence of a much stiffer, cement-treated soil cap around the CTB. This soil cap impacts:
 - (i) Soil impedance parameters.
 - (ii) Kinematic motion of the foundation of the CTB.
 - c. The Applicant's calculations are deficient because they ignore the out-of-phase motion of the CTB and the cement-treated soil cap, which potentially can lead to the development of cracking and separation of the cap around the building perimeter.
 - d. The Applicant's calculations unconservatively assume that only vertically propagating in-phase waves will strike the CTB and its foundations, and fail to account for horizontal variation of ground motion that will cause additional rocking and torsional motion of the CTB and its foundations.

E. *Seismic Exemption.*

Relative to the PFS seismic analysis supporting its application and the PFS April 9, 1999 request for an exemption from the requirements of 10 C.F.R. § 72.102(f) to allow PFS to employ a probabilistic rather than a deterministic seismic hazards analysis, PFS should be required either to use a probabilistic methodology with a 10,000-year return period or comply with the existing deterministic analysis requirement of section 72.102(f), or, alternatively, use a return period significantly greater than 2000 years, in that:

1. The requested exemption fails to conform to the SECY-98-126 (June 4, 1998) rulemaking plan scheme, i.e., only 1000-year and 10,000-year return periods are specified for design earthquakes for safety-important systems, structures, and components (SSCs) — SSC Category 1 and SSC Category 2, respectively — and any failure of an SSC that exceeds the radiological requirements of 10 C.F.R. § 72.104(a) must be designed for SSC Category 2, without any explanation regarding PFS SSC compliance with section 72.104(a).
2. PFS has failed to show that its facility design will provide adequate protection against exceeding the section 72.104(a) dose limits.
3. The [S]taff's reliance on the reduced radiological hazard of stand-alone ISFSIs as compared to commercial power reactors as justification for granting the PFS exemption is based on incorrect factual and technical assumptions about the PFS facility's mean annual probability of exceeding a safe shutdown earthquake (SSE), and the relationship between the

median and mean probabilities for exceeding an SSE for central and eastern United States commercial power reactors and the median and mean probabilities for exceeding an SSE for the PFS facility.

4. In supporting the grant of the exemption based on 2000-year return period, the [S]taff relies upon the United States Department of Energy (DOE) standard, DOE-STD 1020-94, and specifically the category-3 facility SSC performance standard that has such a return period, notwithstanding the fact the [S]taff categorically did not adopt the four-tiered DOE category scheme as part of the Part 72 rulemaking plan.
5. In supporting the grant of the exemption based on the 2000-year return period, the [S]taff relies upon the 1998 exemption granted to DOE for the Idaho National Engineering and Environmental Laboratory (INEEL) ISFSI for the Three Mile Island, Unit 2 (TMI-2) facility fuel, which was discussed in SECY-98-071 (Apr. 8, 1998), even though that grant was based on circumstances not present with the PFS ISFSI, including (a) existing INEEL design standards for a higher risk facility at the ISFSI host site; and (b) the use of a peak design basis horizontal acceleration of 0.36 *g* that was higher than the 2000-year return period value of 0.30 *g*.
6. Because (a) design levels for new Utah building construction and highway bridges are more stringent; and (b) the PFS return period is based on the twenty-year initial licensing period rather than the proposed thirty-to forty-year operating period, the 2000-year return period for the PFS facility does not ensure an adequate level of conservatism.

Id. at 3-7.

Hearings on the three sections of the Unified Contention that remained active (C, D, and E) were held in Salt Lake City from April 29, 2002, through May 13, May 16, and May 17, and June 3 through June 8, 2002. An additional 2 weeks of hearings were held in Rockville, Maryland, from June 17 through June 27, 2002.

D. Witness Qualifications

Over the course of our hearing, we heard testimony from a total of twenty-two expert witnesses for the various parties, each of whom assessed the Applicant's seismic design and analysis. The Board finds that all of the experts proffered are well qualified in their fields of expertise.

In support of its seismic design and analysis, the Applicant proffered eleven witnesses in eight panels of one to three witnesses each. These witnesses had degrees in mechanical, civil, structural, and nuclear engineering as well as countless years of expertise analyzing the suitability of structures to withstand the effects of earthquake conditions. The Board finds all of the Applicant's witnesses to be well qualified in their particular fields of expertise.

For its part, the Staff presented eight expert witness in five panels to support its analysis and subsequent approval of the Applicant's proposed seismic design. These witnesses had degrees in various engineering disciplines as well as numerous years of hands-on experience evaluating and analyzing structures and facilities similar in nature to the proposed PFS facility. The Board also finds the Staff's experts to be well qualified in their particular areas of expertise.

Like the Applicant and the Staff, the State also relied upon the testimony of expert witnesses to support its claims. To support its challenges to the Applicant's seismic design, the State relied upon the expertise of six witnesses. The State's experts had various areas of expertise ranging from geotechnical engineering to nuclear physics and they too have logged countless years of experience analyzing structural response to earthquake conditions. As we have found with the Applicant and Staff experts, the Board also finds the State's experts to be well qualified in their fields of expertise.

II. FACILITY DESIGN AND LAYOUT

A. Design and Location

The Applicant proposes to construct and to operate a dry cask storage ISFSI that will store up to 4000 concrete and steel casks of spent nuclear fuel (SNF). If approved, the license would allow the Applicant to store SNF at the site for 20 years, with an option to renew the license for an additional 20 years if needed.

The proposed facility is to be located in the northwest corner of the Reservation of the Skull Valley Band of Goshute Indians. The Reservation itself is located approximately 50 miles southwest of Salt Lake City, Utah. There are no large towns within 10 miles of the proposed facility; the city of Tooele is 27 miles away. The nearest small town, the Goshute Indian Village, which consists of roughly thirty residents, is located 3.5 miles from the facility. *See Findings A.3.*

The proposed facility will contain a restricted zone of approximately 99 acres surrounded by a chain link security fence and an outer link nuisance fence. An isolation zone and intrusion detection system will be located between the two fences as a further security measure. In addition to the storage pads, a Canister Transfer Building (CTB), where the SNF will be transferred from temporary shipping casks to permanent storage casks, will also be located within the restricted area. An overhead bridge crane and a semi-gantry crane that will be used to transfer fuel from shipping to storage casks will be housed in the CTB. *See Findings A.6.*

According to the Applicant's proposal, several organizations are responsible for the design and testing of the proposed facility; representatives of these organizations testified on behalf of the proposed design in this licensing hearing. Holtec International (Holtec) is responsible for the design of the HI-STORM

100 Cask System (HI-STORM 100). Stone & Webster Engineering Corporation (Stone & Webster) is responsible for the proposed facility's design. PFS has the overall responsibility for the planning, design, and operation of the facility and for providing quality assurance services. *See* Findings A.12.

B. General State Concerns

Throughout the course of this licensing proceeding, the State has raised six major areas of concern with the Applicant's seismic design, each of which is discussed herein at the pages listed in the respective footnotes: (1) there is an inadequate characterization of the subsurface soils at the proposed PFS site;⁶ (2) the Applicant's proposed use of soil-cement to overcome foundation sliding during an earthquake is a novel and untested technique;⁷ (3) the Applicant's seismic design is flawed due to several assumptions concerning the behavior of the facility during a seismic event;⁸ (4) the Applicant has not adequately demonstrated the stability of the storage casks during a DBE;⁹ (5) there is a lack of support for the Applicant's exemption request from the deterministic standard that establishes the ground motions for the design of the proposed storage facility;¹⁰ and (6) the proposed facility does not comply with the Commission's established standards concerning radiological dose consequences in the event of a design basis accident at the proposed facility.¹¹

These six State concerns were thoroughly litigated during the course of this proceeding. In the subsequent sections of this decision (Parts III-VIII), we describe and discuss each one and render our rulings. In most instances, further explanation of those rulings is reflected in the detailed analysis and findings contained in Part IX (pp. 371-543).

III. CHARACTERIZATION OF SUBSURFACE SOILS

Section C of the State's unified contention challenges the Applicant's characterization of the subsurface soils located beneath the proposed facility's structures and questions how those soils will perform in the event of a design basis earthquake (DBE). In particular, the State contends that the Applicant has not sufficiently characterized the subsurface soils and should be required to conduct additional

⁶ *See* pp. 316-23.

⁷ *See* pp. 323-31.

⁸ *See* pp. 331-40.

⁹ *See* pp. 340-57.

¹⁰ *See* pp. 357-67.

¹¹ *See* pp. 367-70.

sampling and analyses to demonstrate that the subsurface soils have an adequate margin of safety to protect against potential failure during a DBE.

The Commission's regulations establishing the comprehensive requirements for subsurface soils that are to be used to support proposed ISFSI facilities are found in 10 C.F.R Part 72. These regulations require an extensive site-specific evaluation of subsurface soils if the proposed site's soil characteristics directly affect the safety or environmental impacts of the proposed facility. *See* 10 C.F.R. § 72.102.

In particular, sites located on areas other than bedrock require an evaluation to determine their potential for instability due to vibratory ground motions, and site-specific investigations must be conducted to demonstrate that site soil conditions are adequate to sustain the proposed foundation loads. *See* 10 C.F.R. § 72.102(c)-(d). It is with this regulatory framework in mind that the Board examines the State's challenges to the subsurface soil characteristics of the proposed facility.

A. Subsurface Soils at the Proposed Facility

The Applicant used several techniques to characterize the proposed facility's subsurface soils and to determine their ability to sustain the facility's anticipated foundation loads. These techniques included: (1) soil borings, (2) standard penetration tests, (3) dilatometer tests, (4) cone penetration tests (CPTs), (5) seismic CPTs, (6) downhole measurements, and (7) excavating test pits and trenches. *See* Findings A.3.

The upper layer of the subsurface soil profile, which the Applicant labeled Layer 1, was of the most interest during our proceeding. According to the Applicant's characterization, Layer 1 is approximately 25 to 30 feet thick, consisting of a mixture of clayey silt, silt, and sandy silt that is occasionally intermingled with silty clay and silty sand. In its analyses, the Applicant was able to further divide this significant layer into several sublayers. These sublayers include: Layer 1A, a layer of eolian soils roughly 3 to 5 feet thick; Layer 1B,¹² a layer of silty clay/clayey silt varying from 5 to 10 feet thick; Layer 1C, a mixture of clayey silt, silt, and sandy silt, roughly 7 to 12 feet thick; and Layer 1D, a silty clay/clayey silt mixture with a thickness not exceeding 5 feet. *See* Findings B.5.

B. Factors of Safety of Foundation Soil

Generally, factors of safety are expressed as the capacity of the system to resist failure divided by the demand placed upon the system by foundation loads during

¹²During the proceeding, Layer 1B, which was the most important sublayer for the purposes of this proceeding, was identified differently by each party. The Staff referred to it as Layer 1B, the Applicant as "Layer 2," and the State as the "upper Lake Bonneville clays."

a seismic event. The capacity of the foundation is primarily a function of the soil's shear strength and the type, flexibility, and embedment of the foundation. The demand on the system is primarily a function of the intensity of earthquake ground motion and the mass and frequency of vibration of the system. *See* Findings B.6. Relying on NUREG-0800,¹³ the State contends that for extreme environmental events, such as a DBE, a factor of safety of 1.1 is inviolable. The State challenges the Applicant's demonstration that its proposed facility design can provide a 1.1 factor of safety. In particular, the State insists that the Applicant's description and use of both the capacity of the soils and the dynamic forces involved should be subjected to further scrutiny because there is only a 6% to 15% margin in the Applicant's calculations. *See* Findings B.7-8.

During the hearing, the Staff's expert, Dr. Goodluck Ofoegbu, testified that it is not necessary to meet a factor of safety of 1.1 against soil failure to satisfy NRC requirements in 10 C.F.R. Part 72. *See* Findings B.9. Regardless, the Applicant goes on to demonstrate that its foundation stability analysis of the minimum factors of safety against sliding and bearing capacity of the pad exceed the recommended 1.1 factor of safety. Thus, the Board is satisfied that, irrespective of whether the Applicant must meet a 1.1 factor of safety, the Applicant's analyses demonstrate that its design meets and indeed exceeds that value. *See* Findings B.9-10.

C. Importance of the Shear Strength of the Upper Lake Bonneville Clays

The State insists that an "accurate and adequate" characterization of the upper Lake Bonneville clays is essential to the Applicant's demonstration that the pads and CTB will be supported on a stable foundation during a seismic event. *See* Findings B.12. The parties agree that the soils in the upper Lake Bonneville clay layer are the soils of interest for establishing the minimum value of soil strength, but the parties disagree as to what extent an "accurate" computation of the strength of those soils is necessary. *See* Findings B.11.

In response, the Applicant acknowledged that it has focused its soils investigations — borings, samplings, and laboratory tests — on the upper Lake Bonneville clay layer, and emphasized the conservative approach it used to establish the minimum strength and other characteristics of the site soils. Thus, even if there were some inaccuracies in the Applicant's determination of the strength of the upper Lake Bonneville clays, the conservatism built into its methodology for

¹³U.S. Nuclear Regulatory Commission, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," NUREG-0800 (Aug. 1989). Several sections of NUREG-0800 that pertain specifically to the review of the seismic portion of an applicant's SAR were introduced by the NRC Staff as Exhibits CC, DD, and EE.

determining the soil properties and the factors of safety against soil failure are more than sufficient to assure that the soil conditions are adequate to meet the anticipated foundation loadings. *See* Findings B.13.

D. Specific State Concerns with the Applicant's Testing of the Subsurface Soils

1. Density of Soil Borings

The State asserts that PFS's sampling program does not conform to the density recommended by Site Investigations for Foundations of Nuclear Power Plants, reflected in Regulatory Guide 1.132, Appendix C. In this regard, there is no disagreement that PFS has met the recommended borehole density for the CTB; the issue concerns the borehole spacing used in the pad emplacement area. *See* Findings B.15.

Appendix C of Regulatory Guide 1.132, which is specific to nuclear power plants, provides a table of spacing and depth of subsurface explorations for various types of safety-related foundations. For linear structures such as a row of storage pads, Regulatory Guide 1.132 recommends a spacing of one boring per every 100 linear feet for favorable, uniform geologic conditions, where continuity of subsurface strata is found. *See* Findings B.16.

According to the State, the Applicant drilled nine boreholes (A1, B1, C1, A2, B2, C2, A3, B3, C3) in or near the pad emplacement area for the purpose of retrieving samples for laboratory testing and analysis. These borings, taken together with the CPT soundings, result in a spacing of about one boring or sounding every 221 feet in the pad area.

In rebuttal testimony, the Applicant's expert, Mr. Trudeau, claims that seven additional borings were drilled in or near the pad emplacement area (i.e., boreholes A4, B4, C4, D1, D2, D3, and D4). Reviewing Figure 2.6-19 of the Applicant's Safety Analysis Report (SAR), the State insists that borings A4, B4, and C4 are south of the rail spur and are about 200 feet from the edge of the southern-most row of pads. Furthermore, the State contends that borings D1, D2, and D3 (outside the eastern boundary of the perimeter fence) and D4 (adjacent to the CTB) are about 375 feet or more from the edge of the eastern-most row of pads. *See* Findings B.17. Therefore, these seven additional borings do not change the State's estimate of borehole spacing of about 221 feet for the pad area. *See* Findings B.17-18.

The Board is not persuaded, however, that additional boreholes are necessary. As correctly pointed out by both the Applicant and Staff, Regulatory Guide 1.132 is a guidance document applicable to nuclear power plants and is not necessarily binding upon spent fuel facilities, whose structures are quite different and do not involve interconnected safety systems sensitive to ground motion. *See* Findings

B.19-.21. Moreover, Regulatory Guide 1.132 acknowledges that borehole spacing and depth often vary due to the complex subsurface conditions at each individual site. Thus, applicants are encouraged to “temper” their recommendations with actual site investigations, as performed by the Applicant in this case. *See Findings B.22.* In this instance, the Applicant followed the regulatory guidance for the CTB but developed a different subsurface investigation program for the storage pads. *See Findings B.23.*

Furthermore, the Applicant’s investigations established the horizontal uniformity of the soils and have properly documented the vertical layering of the upper Lake Bonneville clays, and the State has not demonstrated that additional boring holes are necessary. *See Findings B.24-.34.* Thus, the Board finds the Applicant’s borehole spacing to be adequate.

2. *Continuous Soil Sampling*

The State also claims that the Applicant’s investigation did not continuously sample the upper Lake Bonneville clays as recommended by Regulatory Guide 1.132. By not continuously sampling the upper Lake Bonneville clay layer, the State insists that the Applicant has introduced an additional unnecessary level of uncertainty into its estimate of shear strength for the upper Lake Bonneville clays and into the factors of safety calculated for the sliding and bearing capacities of the storage pads. According to the State, the CPTs — conducted by the Applicant in lieu of continuous sampling — do not obtain undisturbed samples of soil for laboratory testing and are not as accurate a measure of the soil shear strength as continuous sampling. *See Findings B.43-.46.* The State also contends that the CPT testing was conducted after the limited laboratory samples were obtained and, therefore, the CPT data could not have been used to designate the weakest soil zone for laboratory shear testing, as claimed by the Applicant. *See Findings B.48.*

The purpose of continuous sampling, as recommended by Regulatory Guide 1.132, is to identify potential relatively thin zones of weak or unstable soil contained within otherwise stable soil zones. *See Findings B.50.* The soil characterizations conducted by the Applicant, both through borehole drillings and CPT tests, indicate that no such zones of weak or unstable soil exist under the pad emplacement area. *See Findings B.50-.51.* Both the Applicant and the Staff agree that such layers would have been detected through changes in cone tip resistance measured by the CPT tests. *See Findings B.52.* Furthermore, as previously indicated, Regulatory Guide 1.132 is to be used only as a guidance document and is not binding upon this proceeding. *See Findings B.49.* For these reasons, the Licensing Board finds that the Applicant’s cone penetrometer tests achieve the objective of the tests recommended in Regulatory Guide 1.132 and additional continuous sampling is not necessary in this case.

3. *Undrained Shear Strength Determination*

All three parties agree that the undrained shear strength is an important characteristic of soils in the seismic analysis with respect to horizontal and vertical loadings. In testing for shear strength, the Applicant selected a single soil sample of the upper Lake Bonneville clays from the quadrant in the pad emplacement area that was determined by CPT to be the weakest portion of the weakest layer of the soil profile. The Applicant then performed laboratory tests on three specimens taken from this soil sample. Using its CPT tests at thirty-seven different locations in the pad emplacement area, the Applicant later confirmed that the sample tested had the minimum value of shear strength for the entire pad emplacement area. *See Findings B.54-.56.*

The State argues, however, that the Applicant's reliance on the laboratory analysis of only a single borehole sample is insufficient to establish a lower-bound undrained shear strength for the upper Lake Bonneville layer, and that because of the potential for considerable variability in the upper Lake Bonneville layer, locations may exist in the pad area that have lower shear strengths than that established by the Applicant's one sample. *See Findings B.57.* Moreover, the State contends that although the Applicant claims that the borehole sample came from the weakest zone of the pad emplacement area, the Applicant should have conducted additional laboratory tests on samples from other locations to confirm this assertion. *See Findings B.58.* The State also attacks the Applicant's reliance on CPT tests to obtain its shear strength values. *See Findings B.59-.63.*

We find the Applicant's process for determining the minimum shear strength to be technically sound. Using a predetermined location to obtain a single borehole sample based on the weakest portion of the weakest layer of the soil profile (Layer 1B) is a sensible approach if the goal is simply to determine a lower limit of shear strength for the pad emplacement area. The Applicant's choice of this location for its borehole sample is independently supported both by the fact that the soil sample obtained from this location exhibits the highest void ratio of all the samples tested in the pad emplacement area, indicating the lowest density and hence lowest shear strength among the tested samples, and by the subsequent CPT measurements at thirty-seven locations in the pad emplacement area, which correlate well with the measured shear strength at the single borehole sample. *See Findings B.54-.55.*

The State claims that there can be considerable horizontal variability in the shear strength of the upper Lake Bonneville soils across the pad emplacement area. But the CPT data demonstrate relatively low variability in the pad emplacement area. *See Findings B.64.*

We, therefore, find the number of samples obtained by the Applicant sufficient to demonstrate the minimum soil shear strength for the proposed facility. Moreover, the Board agrees with the Applicant that even if soils of lower strength were

to exist in the pad emplacement area, the conservatisms in the overall seismic design of the pad would more than compensate for any difference in the soil strength. *See Findings B.65.*

4. Additional Tests (Cyclic Triaxial and Triaxial Extension Tests)

Finally, the State contends that the Applicant has failed to conduct a complete analysis of the subsurface soils, because the Applicant failed (1) to include a strain-controlled cyclic triaxial test in its laboratory shear strength testing program and (2) to analyze fully the stress-strain behavior of the native foundation soils under a range of cyclic strains imposed by the design earthquake. *See Findings B.65.*

According to the State, earthquake motions are cyclic in nature and may reverse the direction of loads several times during a large earthquake. The State claims that the Applicant's tests do not adequately describe this cyclic stress-strain behavior of the upper Lake Bonneville clays and suggests, as a remedy, that the Applicant should conduct strain-controlled cyclic triaxial tests that will ensure that there is no significant loss or degradation of shear strength due to cycling. *See Findings B.67-.68.* The State believes this test is important, because if earthquake cycling does cause a degradation in the shear strength of the Lake Bonneville clays, then an "unconservatism" will be introduced into the Applicant's sliding calculations. *See Findings B.68.*

Although the Applicant did not conduct the strain-controlled cyclic triaxial tests requested by the State, it did conduct resonant column tests, which are a form of strain-controlled cyclic triaxial tests recommended in NRC Regulatory Guide 1.138, Appendix B. These resonant column tests provide the information requested by the State for the range of strain levels adequate to account for any potential degradation in the shear strength of the Lake Bonneville clays. This is demonstrated by the Applicant's site response analysis conducted by Geomatrix, which indicates that, for soils in the greatest effective shear strain layer (Layer 1B), the effective shear strains under design basis seismic loadings are within the range of strains measured directly in the resonant column tests. While strain-controlled triaxial tests can measure soil properties at a much higher strain level than the resonant column tests, these tests are unnecessary for the PFS site because the resonant column tests demonstrate that such high strain levels will not be reached there. *See Findings B.69-.70.*

Finally, the Applicant has conducted stress-controlled cyclic triaxial tests to assess the collapse potential of the soil, and no degradation of the shear strength of the samples tested was observed throughout 500 cycles of loading at extremely high cyclic stress ratios. Therefore, it can be concluded that the resulting cyclic strains were small, hence no strain-controlled cyclic triaxial tests are needed. *See Findings B.71.*

The State also contends that the Applicant has failed to test the soils adequately to determine whether the soils are subject to failure due to tension loadings. The Applicant used triaxial compression tests to determine the soils' resistance to bearing capacity failure or tension loading. The State argues, however, that if significant anisotropy is present, then the triaxial compression tests will overestimate the average shear strength resistance and undermine the Applicant's bearing capacity calculations. *See* Findings B.73. Instead of the triaxial compression tests, the State insists that the Applicant should have used triaxial extension tests, which measure the degree of anisotropy in the soils by causing them to fail in tension. *See* Findings B.76.

The Applicant's tests demonstrate that the minimum vertical and horizontal shear strengths are almost identical, which in turn establishes that the anisotropy at the proposed facility is insignificant. *See* Findings B.74-.75. Furthermore, the Applicant's bearing capacity analysis provides a large margin of safety against bearing capacity failure and eliminates the need for additional tests such as the triaxial extensions. *See* Findings B.76. Thus, the Board finds that the State requests for the additional tests are unnecessary.

E. Board Conclusions

The Board finds that the soil tests conducted by the Applicant are adequate to demonstrate that the subsurface soils at the proposed site will withstand the proposed foundation loadings during a DBE. Thus, the Board finds that the Applicant's geotechnical site characterization is sufficient to demonstrate compliance with the Commission requirements established in 10 C.F.R. § 72.102(c)-(d) and 72.122(b).

IV. USE OF SOIL-CEMENT AND CONSTRUCTION PROCESS

A. Background and Proposed Uses

1. Design Description

Both soil-cement and cement-treated soil are created by blending, compacting, and curing a mixture of soil, portland cement, other admixtures, and water to produce a hardened mixture with a greater strength than the original native soil. *See* Findings C.1. As explained by the Applicant's experts during the hearing, there is a distinction between the two types of mixtures. Soil-cement has greater degrees of stabilization and/or durability and is expected to pass durability tests by reason of its ability to retain its properties after long periods of exposure to the weather. On the other hand, cement-treated soil has less strength than soil-cement, and so is not expected to pass durability tests. *See* Findings C.2.

The Applicant intends to use soil-cement and cement-treated soil at the site to perform three basic functions: (1) placed directly *underneath* the cask storage pads, cement-treated soil will act as a cohesive material that will resist the sliding ground forces generated by a seismic event; (2) placed *between* the pads, soil-cement will provide support for the transporter vehicle that will deliver the storage casks to the pad area; and (3) placed around the CTB, soil-cement will provide additional passive resistance to sliding during a DBE. *See* Findings C.3.

2. State's General Concerns

The State raises several general concerns with the Applicant's proposed use of soil-cement¹⁴ to bolster the foundations of the storage pads and the CTB. First, the State contends that to satisfy the requirements of 10 C.F.R. § 72.102, the Applicant must demonstrate that the soil conditions at the site are adequate, with the addition of soil-cement, to sustain the proposed foundation loadings. The State believes the Applicant's planned testing programs contain too many uncertainties to allow the Board to find that the Applicant has satisfied this burden. Moreover, the State argues that because the NRC inspection programs are not designed to detect latent defects or to serve as a "construction watchdog," the Applicant and Staff cannot rely upon the Staff's post-licensing inspection programs to assure the Licensing Board that the Applicant's programs will meet their intended safety goals. *See* Findings C.7.

In addition, the State claims that several of the tests already completed by the Applicant either cannot be relied upon to support its assertions, or indeed cut against them by demonstrating that the proposed design will not satisfy the Commission's safety requirements. First, the State insists that Applicant's sliding stability calculations are unreliable because they are not based upon site-specific investigations and laboratory analysis. The State also claims that the Applicant has not adequately demonstrated that the shear strength of the cement-treated soil will meet the necessary 1.1 factor of safety required by the NRC Staff. Finally, the State claims that, even if the Applicant can demonstrate that its design concept is adequate, there is evidence to indicate that significant degradation due to cracking, debonding along interface layers, and moisture infiltration will erode its ability to meet the proposed foundation loadings. *See* Findings C.8.

¹⁴ In its arguments concerning this matter, the State makes no distinction between soil-cement and cement-treated soil, and we discuss its arguments accordingly.

B. Specific State Challenges

1. Potential Problems with the Construction Process

As explained by the Applicant's experts during the hearing, the cement-treated soil that will be placed underneath the concrete pads will be created by removing the top layer of soil at the site and mixing it with the appropriate portions of cement at a processing plant constructed on the site. The proposed design requires between a 1- and 2-foot thickness of cement-treated soil to be placed under each storage pad, depending upon the pad location. *See* Findings C.11-12.

The State asserts that the process of removing the overlying soils may inadvertently cause the underlying soils to lose strength, which in turn could undermine the validity of the Applicant's soil test results. For example, the State claims that once the overlying soil layer is removed, the underlying soil will be exposed to the elements, which may cause the soil to dry out due to excessive heat or to gain moisture due to rain. If these events occur, the State believes that the underlying soil would weaken and the Applicant's original soil tests would be no longer representative of the soil's strength. Thus, the State argues that the upper Lake Bonneville clay layers used by the Applicant in its study may not be representative of the soil that will ultimately underlie the pad emplacement. *See* Findings C.9-10.

The Board finds inadequate support for these allegations regarding the adverse impact of the construction process on soils. Instead, we find the Applicant's commitment to use proper construction techniques to minimize potential damage to the underlying soil and to establish field-quality-control requirements that will ensure that any potential contractor will be mindful of the potential adverse effects of the construction process, sufficient to address the State's concerns. *See* Findings C.13-14.

2. Design Problems Affecting the Native Soil and Concrete Storage Pad

The State raises several potential problems that may occur after the soil-cement is added to the pad emplacement area. First, the State claims that the soil-cement is prone to cracking which could affect its ability to function as intended. The State also claims that the infiltration of moisture could potentially cause problems for the design. Finally, the State asserts that the different masses of the pads, casks, and soil-cement will behave differently during a DBE, which would affect the transfer of the anticipated dynamic loads from the casks to the pads. We discuss each of these potential problems below.

a. Cracking

The State is concerned that the soil-cement will crack, causing a loss of tensile strength. The State argues that this loss in tensile strength will decrease the structural competency of the soil-cement layer. *See* Findings C.15. Furthermore, the cracks in the soil-cement could allow water infiltration, which the State believes could also have adverse effects upon the foundation. *See* Findings C.17.

If water infiltration were to occur, as discussed below, it would not have a significant impact upon the cement-treated soil or the underlying soils. *See* Findings C.18. Thus, the only remaining consequence of the potential cracking is the loss of tensile strength. The Applicant does not rely, however, upon the tensile strength of the soil-cement for any of its safety analyses, so the potential loss of this tensile strength is of no consequence. *See* Findings C.19. The Board finds the State's concerns about tensile strength to be unfounded.

b. Moisture

The State argues that the soil-cement or the cement-treated soils are susceptible to water infiltration through cracks in the slabs, shrinkage cracks between the soil-cement and the structure, or standing water that may form in the rows between the pads. Such infiltration, the State believes, could potentially degrade the soil-cement and underlying soil and affect the soil's ability to maintain the proposed foundation loads. *See* Findings C.20.

The Board finds, however, that water infiltration will not be a problem at the site for two reasons. First, the Applicant has sufficiently demonstrated that the potential mechanisms of water infiltration are either extremely unlikely or inconsequential. *See* Findings C.22-.26. In addition, because the storage casks provide a source of heat that will be transmitted downward through the soil-cement, the area beneath the pads will be warmer than the surrounding areas. The warmer soil-cement will cause the moisture to migrate to the surrounding areas and away from the underlying soil-cement. *See* Findings C.21.

c. Pad-to-Pad Interactions

The State argues that the casks, pads, soil-cement, and the underlying soils have different masses that will behave differently during a DBE. The State insists that the inertial effect of these different masses will introduce tension and compression into the system and cause the various masses to have out-of-phase motions. Consequently, the State contends that because the pad and the soil-cement will be acting out of phase, the weaker soil-cement will act as a strut for the dynamic load and transfer it laterally instead of downward to the underlying soil as predicted by the Applicant. *See* Findings C.27-.28.

The record before us indicates that a concrete storage pad will not slide in the event of a design basis earthquake. *See* Findings C.30. One would, therefore, expect the pad and the underlying soils to move together under seismic loadings. In turn, we find that the Applicant has adequately demonstrated that there will be no out-of-phase motion of the pads relative to the underlying soil. In addition, the Applicant performed computer simulations to demonstrate that even if the out-of-phase motions were to occur as hypothesized by the State, the dynamic load transfer between the pads would be minor. *See* Findings C.31-.32. In sum, the Board finds that pad-to-pad interactions are unlikely to happen during a design basis earthquake and the effects of pad-to-pad interactions, if they were to occur, would be of no safety consequence to the proposed PFS site.

C. Testing of the Soil-Cement

1. Adequacy

The Applicant plans to establish the appropriate soil-cement formulation for each of its proposed applications through a series of laboratory tests. These tests include, *inter alia*, soil index property tests, moisture-density tests, and durability tests. *See* Findings C.33-.44. All the parties agree that the Applicant has developed a suitable program, based on appropriate industry standards, for testing the properties of the soil-cement. *See* Findings C.47-.49. The disagreement centers instead on the timing of the testing. As we discuss below, the State insists that the proposed tests, to demonstrate that the soil-cement will perform as intended, should be performed prior to facility licensing, and the Applicant and Staff believe that such testing can be conducted in a post-licensing period.

2. Proof of Design and Timing

The State argues that allowing the Applicant to defer the testing, analysis, and implementation of the soil-cement, as the Staff would do, effectively truncates the State's hearing rights guaranteed to it by the Atomic Energy Act (AEA). According to the State, the AEA, as interpreted by the Court of Appeals for the District of Columbia Circuit, requires a hearing that offers the intervening party a meaningful opportunity to participate. *See* [State] Reply to Proposed Findings of Fact and Conclusions of Law of the Applicant and NRC Staff on Unified Contention Utah L/QQ (Oct. 16, 2002) at 27 [hereinafter State Reply] (citing *Union of Concerned Scientists v. NRC*, 735 F.2d 1437 (D.C. Cir. 1984)). The State contends that by relying upon the Applicant's commitments to provide adequate assurance that the soil-cement will achieve its intended safety function, the Staff is denying the State its opportunity to address the results of the Applicant's final analysis of the soil-cement. State Reply at 27-28.

The State also believes the Applicant's commitments do not address the requirements of 10 C.F.R. § 72.102, which call for a site-specific investigation and laboratory analysis showing that the soil conditions will sustain the proposed foundation loadings. *See* State Reply at 28. It is the State's opinion that the regulation requires an adequate demonstration of soil suitability before the granting of a license. *Id.*

In support of its argument, the State points to prior Commission decisions, which establish that post-hearing resolution should be employed sparingly and only to resolve minor procedural deficiencies. *See id.* at 32-33 (citing *Consolidated Edison Co. of New York* (Indian Point Station, Unit 2), CLI-74-23, 7 AEC 947, 951-52 (1974); *Long Island Lighting Co.* (Shoreham Nuclear Power Station, Unit 1), LBP-83-57, 18 NRC 445, 543-44 (1983)). According to the State, in a previous ruling in this case, the Commission has established the test for determining whether post-hearing deliberations are appropriate to be "whether the NRC Staff inspectors are expected to engage in 'ministerial'-type compliance checks not suitable for hearings or are expected to themselves exercise a form of adjudicatory discretion." State Reply at 33 (*quoting* CLI-00-13, 52 NRC 23, 33 n.3 (2000)). The State contends that the analysis and tests proposed by the Applicant, which will be reviewed by the Staff, are far too complex to be "rubber stamped" by Staff inspectors. *See* State Reply at 36-37. Thus, the State urges the Board to require the Applicant to conduct its tests, the results of which would be subject to further adjudicatory proceedings before this Board, prior to the issuance of the Applicant's license. *Id.* at 40.

In responding to the State concerns, the Applicant insists that there is no regulation that requires testing of the soil-cement prior to the issuing of a license. To the contrary, as the Staff sees it, once the proposed design requirements have been established and accepted, the actual testing of the soil-cement may be postponed until after the license has been issued. *See* Findings C.52-.53. In this regard, the Applicant notes that, assuming the design requirements for its proposed facility are accepted, the Applicant has committed itself to performing the necessary tests to demonstrate that the soil-cement will meet these requirements. The Applicant believes that these commitments provide us the necessary assurance that the soil conditions at the PFS site will sustain the proposed foundation loadings and that there is no need for us to impose any additional requirements on its pending license.

Commission precedent appears to support the Applicant's position. The former NRC Appeal Board confronted a similar issue when a licensing board allowed testing to be conducted after the hearing that confirmed the ability of emergency diesel generators to operate pressurized heaters that the Applicant proposed to use in the event of a reactor emergency. *Metropolitan Edison Co.* (Three Mile Island Nuclear Station, Unit 1), ALAB-729, 17 NRC 814, 885-87 (1983). In that case, after a full hearing on the applicant's proposed design, the Licensing Board

had concluded that the pressurized heaters could be connected to the emergency power supply without harming capacity and that the actual tests confirming this proposal could be left to the monitoring of the Staff after the license was granted. *Id.* at 886. On appeal, the intervenors argued that the Licensing Board had improperly “delegated” to the Staff responsibility to resolve this “disputed substantive technical” issue. *Id.* at 885. The Appeal Board found, however, that the monitoring and evaluation of the applicant’s test results do not “involve decisional responsibility, and is within the authority conferred upon the [S]taff.” *Id.* at 887.

Here we are faced with a similar situation, in which the Applicant proposes to defer the testing of the soil-cement until after the license has been granted. We find this approach to be fully supported by the Appeal Board’s decision in *Three Mile Island*.

This practice of post-hearing verification finds further support in the regulatory history surrounding the Commission’s promulgation of the rules governing ISFSIs in Part 72. In the *Federal Register* Notice adopting Part 72, the Commission noted that spent fuel storage in an ISFSI is “a simple operation [that] does not require a complex plant and is subject to few controversial technical issues.” 45 Fed. Reg. 74,693, 74,964 (Nov. 12, 1980). And for this reason, “a one step licensing procedure requiring only one application and one SAR was adopted in Part 72.” *Id.*

Although we agree in part with the State’s concerns and have considered the benefits of a license condition in this situation, we cannot overlook the Commission precedent that weighs heavily in favor of the Applicant’s and Staff’s proposed post-licensing testing of the soil-cement. Thus, given the strength of the support for the Applicant and Staff’s position, we find a license condition unwarranted and the Applicant’s proposal to test the suitability of the soil-cement after the issuing of the license, subject to Staff review, to be sufficient to satisfy the requirements of 10 C.F.R. § 72.102.

D. “Unique” Use of Soil-Cement

The State argues that the Applicant’s use of soil-cement at the PFS site is unique. The State contends that although soil-cement may have been used in previous projects, the Applicant’s proposal to use the soil-cement to create in shallowly embedded foundations additional seismic sliding resistance to, and stability in the face of, strong ground motions is an unprecedented application. *See* Findings C.63. Because of this proposed unusual use of the soil-cement, the State insists that the Applicant’s proposal to complete testing of the soil-cement post-licensing should be denied and the Applicant should be required to perform its tests prior to the issuance of its facility license. *See* Findings C.64.

With the assistance of the Staff's review and the State's critique, the Applicant's design has been thoroughly scrutinized over the course of this proceeding.¹⁵ As our discussion on the soil-cement demonstrates, the Board has also carefully reviewed the Applicant's proposal and found the design to be adequate. There is no Commission regulation that requires the suitability of a proposed design, if otherwise found acceptable, to have been demonstrated through prior use. *See* Findings C.67. Instead, the Board relies on the requirement that the proposed uses — unique though they may be — will be completely tested to support its finding that the soil-cement will respond adequately in the event of a DBE at the PFS site.

E. Young's Modulus

The State raises two issues regarding Young's Modulus.¹⁶ First, the State argues that it will be difficult for the Applicant to achieve its design requirements for cement-treated soil that has a minimum compressive strength of 40 pounds per square inch (psi) and a Young's Modulus having a maximum value of 75,000 psi. *See* Findings C.68. Second, the State asserts that the test to determine the soil's Young's Modulus must be performed using a dynamic rather than a static load, because the static load will be much lower. *See* Findings C.71.

Contrary to the State's arguments, the Board agrees with the Applicant's expert testimony that obtaining a Young's Modulus of less than 75,000 psi for cement-treated soil with a compressive strength of more than 40 psi is achievable. *See* Findings C.68-.70. Furthermore, the Board finds immaterial the State's contention that a distinction exists between the static and dynamic loads. As indicated by the Applicant's experts, the important difference is the proper strain level that will be achieved by the proposed test. The Applicant plans to determine Young's Modulus by using the soil strain level as a reference point. Furthermore, the Sandia National Laboratories paper that provided the necessary data for the cask drop analysis used static moduli of elasticity for the soils underlying the pad. This demonstrates a good agreement between the analytical results and the experimental results, which indicates that large-strain moduli are appropriate for such analyses. *See* Findings C.71. Thus, the Board finds that the Applicant has adequately addressed the State's concerns regarding this issue.

¹⁵ For a more complete discussion on this matter, *see* Findings B.1-.76, and C.1-.67.

¹⁶ Named after Thomas Young, the Young's Modulus, defined as the ratio of stress over strain, provides a measure of material stiffness and strength. For more discussion on the Young's Modulus, *see* Findings C.68-.72.

F. Board Conclusions

After carefully reviewing the evidence presented by all parties, we are confident that the soil-cement and cement-treated soil will adequately sustain the Applicant's proposed foundation loadings. Although the State raised several important concerns during the course of this proceeding regarding the Applicant's use of the soil-cement and cement-treated soil, the Applicant has met its burden in addressing each of these concerns. Thus, the Board concludes that the Applicant's design and use of soil-cement and cement-treated soil will adequately support the facility's anticipated foundation loads.

V. SEISMIC DESIGN AND FOUNDATION STABILITY

A. Overview of the Pad Storage System

1. Proposed Design Concept for the Pad Storage System

The Applicant plans to store the SNF in large storage casks placed on 3-foot-thick reinforced concrete pads.¹⁷ Each pad will be 30 feet wide and 67 feet long and will support eight storage casks, arranged in a 4 × 2 array.¹⁸ The pads will be placed 35 feet apart in the east-west direction and 5 feet apart in the north-south direction. At maximum capacity, the facility will contain 500 such pads. *See* Findings D.1-.2.

2. State's General Concerns with the Applicant's Proposed Pad Design System

The State contends that the Applicant's design is unprecedented and unconventional and highlights several unproven features that the Applicant relies upon in its design proposal. According to the State, these features include: unanchored casks, acceptance of cask sliding on the pads and use of this as a design feature in its seismic design, shallowly embedded pads on compressible clay, and use of soil-cement as a structural element. Furthermore, the State claims that the Applicant uses the nonlinear cask stability analysis conducted by its cask vendor, Holtec, to support most of its design calculations, which the State asserts is highly sensitive to input parameters. The State notes that there are tests available that could supply the necessary experimental test data to verify the Applicant's

¹⁷The Applicant has contracted with Holtec to use its HI-STORM 100. For a complete description of the HI-STORM 100 and an analysis of the State's concerns regarding this cask system, *see* Section VI on Cask Stability, below.

¹⁸For a more in-depth description of the Applicant's storage pad system, *see* section 4.2.1.5.2 of the Applicant's SAR.

nonlinear models and input parameters and that the Board should require such testing rather than allow the Applicant to rely on its asserted “engineering judgment” to support its analysis. *See* Findings D.3-.8.

B. Specific State Concerns with the Applicant’s Pad Stability Analysis

1. Concerns with the Applicant’s Methodology

The State asserts that the Applicant’s design is full of disparate pieces that have evolved in response to cost-cutting measures and, therefore, have not been fully integrated into a cohesive and rigorous design. For example, the State notes that there is a lack of independent verification or checks on the input parameters used in various design calculations, because many of the Applicant’s consultants received input parameters from other consultants on the Applicant’s team without independently verifying the data source. The State also notes concern with the Applicant’s decision to treat the foundation soils with cement rather than bypass the weaker Lake Bonneville clay soils and embed the pad in deeper, stiffer soil. In addition, the State believes that the Board should be reluctant to approve the Applicant’s analysis of the complex soil properties and its reliance upon engineering judgment concerning the proposed, unprecedented design features. The State also cautions the Board to be hesitant to rely upon Holtec’s nonlinear analysis of the soil behavior beneath the proposed foundation system during a DBE. *See* Findings D.9-.14.

In responding to the State’s claims, the Applicant asserts they were never introduced at trial and are outside the scope of the State’s original contention. Furthermore, the Applicant argues that the State’s claims have no support in the record and should be rejected on this basis as well. *See* Applicant’s Reply to the Proposed Findings of Fact and Conclusions of Law of the State of Utah and the NRC Staff on [Unified Utah L/QQ] (Oct. 16, 2002) at 99-100 [hereinafter Applicant Reply].

The Board need not address the Applicant’s complaints on scope and timeliness. For, although we agree that the Applicant has taken a somewhat unconventional overall approach to its design and analysis, we have examined each of the component parts of its approach and found them to pass muster. Although the overall approach may not have previously been tested in practice, the State has failed to provide any specific evidence demonstrating deficiencies in particular aspects of the Applicant’s presentation that would cause it not to satisfy the Commission’s licensing regulations. In this circumstance, we cannot rely on general methodological concerns to avoid finding that the Applicant’s proposal is adequate to protect public health and safety.

2. *Cask Sliding as a Design Concept*

As previously indicated, the State challenges the Applicant's reliance upon cask sliding as a mechanism to reduce seismic loadings. According to the State, if the casks were not allowed to slide freely on the pad, the forces transmitted to the pad and the underlying soils would be significantly greater. The State asserts that the sliding of safety structures in earthquake resistance design is not a common practice, especially with no experimental or reliable performance data to support the Applicant's prediction of cask performance and its reliance on a credit for a reduction in forces due to the anticipated cask sliding. *See Findings D.15-.16.*

The evidence presented during the course of the hearing demonstrates that the sliding of the casks on the concrete storage pads will involve small displacements, and such small displacements will also reduce the loads to which the cask is subjected. *See Findings E.17-.18.* In any event, we note that sliding is not a feature of the Applicant's design, but is rather a beneficial consequence of cask reaction during a DBE. *See Findings D.17-.18.* Therefore, we conclude that the record supports a finding that the Applicant's design is adequate.

3. *Flexibility of the Storage Pads*

The State has two apparent concerns regarding the Applicant's characterization of the flexibility of the storage pads. First, the State contends that the Applicant's pad design has conflicting requirements, i.e., that the pads be *rigid* enough to allow smooth cask sliding yet *flexible* enough to allow for tip-over without damaging the cask. In a similar argument, the State contends that although the Applicant has not demonstrated that the pads are rigid, it takes full credit for a significant amount of radiation damping from a rigid pad, which allows the soils to play a major role in dissipating energy. The State argues that this assumption is contradicted by the Applicant's conclusion that the pads are also flexible enough to absorb a sufficient amount of energy from cask impact to prevent damage in the event of a cask drop or tip-over event. To solve this apparent contradiction, the State notes that the Applicant could have easily quantified the pad stiffness through an industry standard computer program for soil structure interaction analysis, such as SASSI, that analyzes soil structure interaction (SSI) rather than rely on its assumptions. *See Findings D.20-.25.*

Although the State raises a pertinent issue, the Board is persuaded that this issue has been satisfactorily resolved for two reasons. First, the seemingly conflicting requirements regarding pad characteristics can be resolved by the use of appropriate materials and substantiated by appropriate tests. *See Findings D.29.* Second, and more importantly, as highlighted by the Applicant, there is no design requirement that the pad be rigid to assure smooth sliding of the cask and,

in fact, the effect of pad flexibility on the sliding of the casks is insignificant. *See* Findings D.27, D.30.

Furthermore, regarding the Applicant's use of radiation damping in its analysis, we find that the Applicant has adequately demonstrated through its dynamic analyses that the pads are rigid enough to limit the maximum displacements of the pad during earthquake conditions to on the order of $\frac{3}{8}$ of an inch. *See* Findings D.28. Finally, the Applicant's analysis demonstrates that the effect of the pad's flexibility on its foundation-damping properties is insignificant in the range of frequency important to the cask response. *See* Findings D.27. Thus, the Board finds the record demonstrates that the Applicant's characterization of the flexibility of its storage pads is sufficient.

4. Soil-Structure Interaction Analysis

According to the State, when an external force caused by an earthquake is applied, both the structure in question and the ground will deform and move in a compatible manner because neither the structural displacement nor the ground displacements are independent of each other. Because of this SSI, the State claims the motion of the foundation will be different from the motion of the supporting soil without the structure located on top. The State argues that the Applicant, in accounting for this notion, has failed to conduct a comprehensive and accurate SSI analysis of the proposed site. Furthermore, the State contends that in response to its concerns, the Applicant relies upon the testimony of the Applicant's expert, Mr. Trudeau, who, the State argues, has no expertise regarding SSI. *See* State Reply at 41-47.

In response, the Applicant claims that the alleged need for an SSI analysis and the alleged incorrect use of peak ground acceleration in calculating pad stability, are outside of the scope of Utah L/QQ. The Applicant argues that these two issues were raised for the first time in the hearing in the testimony of State witnesses. *See* Applicant Reply at 112. Despite the Applicant's claim that the State's concerns are new, late, and outside the scope of Utah L/QQ, the Applicant goes on to address and dismiss the merits of these claims. Without ruling on the timeliness of these two issues, we focus our attention on their merits below.

a. Geomatrix Analysis of Soil Column

During its testing of the facility, the Applicant performed a soil column analysis to obtain the strain-compatible soil properties in the free field using a common industry computer program, SHAKE. The State argues that the SHAKE program, being done in the free field, does not account for the SSI. Due to the complexity

of SSI, the State contends that a SHAKE analysis cannot be substituted for an SSI analysis. *See Findings D.31-.32.*

Although the State argues that the Applicant's testing program should have included an SSI analysis, there is no regulatory requirement for such a test. In that regard, the State does not claim that the design inputs for SHAKE provided by Geomatrix were incorrect. More importantly, there is no claim by the State that the Holtec analyses of the cask and pad stability were deficient, nor that the pad is ultimately incorrectly designed, due to this particular alleged SSI deficiency. Thus, the Board denies the State's request for an SSI analysis. *See Findings D.33.*

b. Pad Acceleration

The State also attacks the Applicant's pad stability analysis. According to the State, instead of obtaining the pad acceleration from Holtec in the cask stability design calculations, the Applicant witness Paul Trudeau assumed a peak ground acceleration of 0.7g for a design input in the pad sliding analyses, based upon a presumed high value of radiation damping at the site. Because peak ground acceleration is the ground motion in the free field and does not account for SSI effects, the State argues that the use of peak ground acceleration for the pads is not appropriate for the PFS site unless it is a bedrock site. *See Findings D.39.* The State contends that its expert on SSI, Dr. Ostadan, also found Mr. Trudeau's assertion of such high damping values unusual for this type of foundation system. *See Findings D.40.* The State thus contends that the record contains ample evidence to suggest that the actual pad accelerations may be much higher than estimated by the Applicant. *See Findings D.41.*

During the hearing, the Applicant defended the use of peak ground acceleration by conducting a confirmatory analysis using the forces developed by Holtec cask stability analysis. The factor of safety against sliding of pads would be reduced only by a small amount (from 1.27 to 1.25) when the Holtec data are considered. *See Findings D.46.* Additionally, after the issue was raised by the State, the Applicant reran its original analysis using the value for horizontal response acceleration suggested by Dr. Ostadan's critique. Using this number, the Applicant determined that, although the factor of safety against sliding would decrease slightly (from 1.27 to 1.22), it would still exceed the 1.1 factor of safety recommended by the Commission. *See Findings D.43.*

Here, the State did nothing more than suggest that the pad accelerations might be higher than those used in the Applicant's analysis without providing data to demonstrate the actual increase. With the Applicant providing two confirmatory analyses to support its original analysis, the Board finds the Applicant's analysis regarding pad acceleration to be adequate. *See Findings D.43-.50.*

5. *Pad-to-Pad Interaction*

During the hearing, the State's experts also argued that the Applicant's analysis did not account for potential pad-to-pad interaction. According to the State, the Applicant's assumption that 100% of the load forces will be transferred straight down to the underlying soil instead of laterally is neither realistic nor conservative given the unprecedented nature of the PFS design. *See Findings D.51-.56.*

Furthermore, the State argues that the Applicant's analysis incorrectly assumes that the storage pads will move in phase with the surrounding pads and the underlying soil. The State also believes that the Applicant has not accounted for the potential that the underlying soil-cement will act as a strut and transfer the loads horizontally from one pad to another. *See Findings D.53.* The State contends that this transferring of the inertial force through pad-to-pad interaction could significantly undermine the Applicant's analysis, given what the State claims is the already slim margin for error in the Applicant's design. *See Findings D.55.*

Moreover, the State argues that the Applicant wrongfully assumed that its high factor of safety against pad sliding will counter any potential for pad-to-pad interaction, because the State's experts contend that the pads can still interact even without pad sliding. According to the State, this seismically induced interaction can occur between adjacent pads even if the pads do not slide, because of two different mechanisms: (a) the weakness, deformability, and lack of uniformity of the soils beneath the pads; and (b) the differences in the number of casks loaded in adjacent pads. The State believes that both of these mechanisms can lead to out-of-phase motion of adjacent pads and to dynamic loadings of one pad on another pad. *See Findings D.56.*

In response to the State's concerns, both the Applicant and Staff produced experts who insisted that the soils beneath the pad foundations are essentially uniform across the pad emplacement area and have sufficient strength to withstand the forces of the DBE without significant deformation (i.e., seismically induced strain). The Applicant's testimony established an estimated value of this deformation of the order of 0.1%, which refutes the first aspect of the State's attack, discussed above. *See Findings D.57-.58.*

Regarding the second mechanism — the number of casks loaded in adjacent pads — the Applicant highlights two Holtec simulations that modeled two adjacent pads, 5 feet apart. One pad was fully loaded with eight casks; the other had only a single cask. The simulations also included a representation of the soil-cement between the two pads. In one simulation, the soil-cement between the pads was assumed to retain its integrity and therefore be able to transmit both tensile and compressive forces. In the other the soil-cement was assumed to be cracked and thus able to transmit only compressive forces. *See Findings D.60.*

In these two simulations, the Applicant also maximized the potential for pad-to-pad forces in the following fashion: (1) no forces were absorbed by

the soil-cement, (2) no forces were transmitted downward to the cement-treated soil and to the soils beneath, (3) no damping was included in the model, (4) a maximum value of Young's Modulus was assumed for the soil-cement, and (5) no credit was taken for the potential crushing of the soil-cement by the forces going from one pad to the other. Yet even with these conservative assumptions to maximize pad-to-pad interactive forces, the maximum estimated force in the soil beneath the pads was less than the minimum required to initiate pad sliding. *See Findings D.61.*

Finally, the Applicant compared the forces observed above and associated cask motions with prior simulations that did not account for pad-to-pad interactions, and found that cask motions in both cases are of the same order — mere inches. This, the Applicant argues, resolves in its favor the State's second mechanism for pad-to-pad interactions. *See Findings D.61.*

Furthermore, the Applicant goes on to address the State's concern that the pad-to-pad interactive forces resulting from the two Holtec analyses referenced above would add to those forces in the Applicant's sliding stability calculation and cause the interactive forces to exceed the available resisting forces, thereby inducing pad sliding. First, the Applicant notes that the Holtec model already accounts both for the seismic forces acting directly on the pads and for the effects of pad-to-pad interaction. In addition, the Applicant explains that the maximum seismic forces acting on the pad and the maximum pad-to-pad interaction forces would occur at different times and, depending on the direction of the pad motion, would not necessarily be additive. *See Findings D.64.*

In summary, the Board is persuaded that the evidence presented by the Applicant adequately responded to the State's concern of pad-to-pad interaction by demonstrating both qualitatively and quantitatively, as described above, why pad-to-pad interactions do not undermine the Applicant's analysis.

6. Pad Settlement

The State's experts also attacked the Applicant's analysis because of a purported failure to consider long-term pad settlement in its structural design or in its subsequent analysis of pad behavior during a DBE. The State notes that the Applicant's estimation of pad settlement has gradually decreased over the course of this proceeding from an initial 5 inches down to 1/2 inch during the Applicant's rebuttal case. *See Findings D.71-.72.* The State believes that a few inches of pad settlement is a significant number, because the Applicant's stability analysis assumed a perfectly planar surface for its cask sliding and stability analyses. *See Findings D.74.*

The Board finds the State concerns regarding long-term pad settlement to be unfounded. As demonstrated by the Applicant, given the stiffness contrast between the pads and the underlying soil, the long-term settlement of the pads

will likely be uniform, thereby reducing the supposed effect of “dishing”¹⁹ or “tilting.” *See* Findings D.81. Moreover, it is apparent that the impacts of long-term settlement on the pads will be minimal as well. As noted by the Applicant, the long-term settlement of the pads was computed to be approximately 1.75 inches, and may be realistically expected to be approximately ½ inch. This range of values for pad settlement — keeping in mind each concrete pad is a structure measuring 67 feet long, 30 feet wide, and 3 feet thick — introduces a very small angle of tilting or a very small amount of “dishing.” The Applicant also accounted for a slight amount of tilting in its cask stability analysis and the results demonstrated that slight tilting had no effect upon the cask stability. Thus, without further evidence to demonstrate that significant settlement will occur and will have a negative effect on the Applicant’s analysis, the Board finds the Applicant’s design has adequately addressed any potential problems regarding foundation settlement. *See* Findings D.75-.85.

7. CTB Analysis

The CTB, the parties seem to agree, conforms with the industry’s standards regarding buildings of its design and intended function. There is no concern about potential overturning of the CTB under DBE loadings. Nor is there concern about CTB bearing capacity failure. *See* Findings D.91. The State’s major concern regarding the CTB is its potential for sliding during a DBE. In that regard, the State argues that the Applicant cannot meet the Commission’s recommended 1.1 factor of safety against sliding without the buttressing effects of the soil-cement and that the Applicant will not acquire any data that can be relied upon to support its use of soil-cement until after the Commission has issued its license. Thus, the State insists that the proposed tests be completed prior to the licensing of the proposed facility. *See* Findings D.87-.90.

Contrary to the State’s argument, the Board finds the Applicant has adequately demonstrated that the design for the CTB has a sufficient factor of safety to resist sliding in the event of a DBE. Although the Applicant has not completed the analysis for the soil-cement, the analysis done for the CTB does demonstrate that it will be able to meet the Commission’s recommended factor of safety of 1.1. Furthermore, even if the CTB were to slide during an earthquake, there will be no safety consequence because there are no safety-related structures connected to the building that could be adversely impacted by the sliding. Finding D.91-.92. For these reasons, the Board finds the Applicant’s CTB design to be adequate.

¹⁹ “Dishing” refers to a phenomenon in which the middle of the pad settles more than the edges, deforming the pad into a concave-up shape.

8. *Transfer Operations*

According to the Applicant's SAR, the Applicant claims that a single cask transfer (transferring a multipurpose canister (MPC) from the shipping cask to a storage cask) will require 20 hours to complete. *See* Findings D.93. The State, however, believes that this estimate contains several shortcomings. The State argues that the Holtec study, which the Applicant relies upon to determine its transfer times, is not based upon actual Holtec cask transfer operations, but was intended only to estimate onsite worker dose assessment. Furthermore, the State contends that although the Applicant claims that a single-cask transfer will require 20 hours of operations to complete, those 20 hours will occur over a 3-day period. In addition, the State notes that there is no regulatory requirement prohibiting the Applicant from leaving an MPC in an unsealed HI-TRAC²⁰ transfer cask for an extended period of time, such as overnight. *See* Findings D.96-100.

The State's argument implies that the alleged shortcomings in the Applicant's estimate could lead to an increase in the dose exposure for site workers and could increase the amount of time the unsealed cask is vulnerable in the event of a DBE. At the hearing, however, the Applicant established that the transfer operation will be completed in 20 hours and has documented the entire operation in SAR Table 5.1-1. *See* Findings D.98. Furthermore, the Applicant stated that there was no condition under which the MPC would be allowed to remain outside the protection of a shipping or storage cask overnight. *See* Findings D.99. The State's insistence that there are shortcomings with the Applicant's analysis is not supported by the record. Thus, the Board finds that the Applicant's analysis of the cask transfer operation time is supported by the preponderance of the evidence.

C. **Board Conclusions**

After carefully reviewing the record before us, we find that the Applicant has demonstrated that the proposed facility's storage pad, CTB, foundation system, and storage casks demonstrate an adequate factor of safety to sustain the anticipated dynamic loads from a 2000-year return period DBE. Although the State raises several concerns in its attempt to support its claim that the Applicant's proposed design is unconventional, unprecedented, and unproven, we find that the Applicant has demonstrated that its seismic design will adequately withstand a 2000-year return period DBE. In that regard, we also find that, contrary to the State claims, no further tests of the Applicant's seismic design or its input parameters are necessary. We find the Applicant's seismic design and proposed

²⁰For a full description of the various components of the MPC, including the HI-TRAC transfer cask, *see* Findings A.7.

foundation system to be suitable to sustain the dynamic loads anticipated as a result of a 2000-year return period DBE.

VI. CASK STABILITY

A. General Overview

According to its design proposal, the Applicant intends to store the spent nuclear fuel (SNF) in the HI-STORM 100 designed by Holtec. The HI-STORM 100 is a massive steel and concrete cylindrical storage cask that surrounds the MPC in which the SNF was sealed at the originating reactor site. Each cask is approximately 20 feet tall and 11 feet in diameter and will weigh approximately 180 tons when fully loaded with SNF. *See* Findings E.1. The casks are configured with four air inlets at the bottom of the cask and four air outlets at the top of the cask. This configuration circulates the air through the cask and cools the MPC by allowing the air to enter the inlets at the bottom, rise as it is heated by the MPC, and exit the outlets at the top. *See* Findings E.2.

Holtec used its own computer program, DYNAMO, to conduct the seismic analysis of its HI-STORM 100 at the PFS site. The DYNAMO system was previously approved as support for Holtec's SAR, which was submitted to the Agency in support of Holtec's request for a Certificate of Compliance (CoC) for its HI-STORM 100. Approval required DYNAMO to be validated through a series of NRC Staff tests and experiments. *See* Findings E.10-.12.

To perform its review of the PFS site, Holtec used the data it received from Geomatrix, a group hired by the Applicant to conduct a soil analysis of the proposed PFS site, to characterize the earthquake excitation and the soil response, but selected its own damping coefficients and spring constants. Using these data, Holtec modeled various configurations of casks, up to eight casks on a pad, using coefficients of friction that varied from 0.2 to 0.8. *See* Findings E.14-.17.

According to the results of the Holtec analysis, the maximum cask displacement for a 2000-year return interval DBE was on the order of 3 to 4 inches with a maximum angle of tilt of about 1 degree. Holtec hypothesized that this result provides a factor of safety in the angle of tilt of approximately 28 against cask tip-over (by observing that the angle of tilt for cask tip-over is about 29 degrees). *See* Findings E.18. Holtec also computed several analyses for a 10,000-year return interval earthquake using a computer code, VisualNastran. This analysis demonstrated some cask rotations of roughly 10 to 12 degrees, but these large cask rotations still left the casks with a factor of safety in the angle of tilt against cask tip-over — of the order of 2. *See* Findings E.19, E.21.

B. Drs. Singh and Soler

To support its cask stability analysis, the Applicant relied upon the expertise of Drs. Krishna P. Singh and Alan I. Soler. Dr. Singh, who holds a Ph.D. and Masters of Science in Mechanical Engineering, is the President and CEO of Holtec. Dr. Soler, who also holds a Ph.D. and Masters of Science in Mechanical Engineering, is the Executive Vice President and Vice President of Engineering for Holtec. Dr. Soler is also the lead structural discipline expert responsible for the design and analysis of the HI-STORM 100 system. *See Applicant's Proposed Findings of Fact and Conclusions of Law on [Utah L/QQ] (Sept. 5, 2002) at 14-15 [hereinafter Applicant Findings].*

1. Asserted Conflict of Interest for Drs. Singh and Soler

The State argues that Drs. Singh and Soler have a unique interest in the outcome of the hearing, because they have an extensive financial interest in the Applicant receiving a license to construct and operate the PFS facility. Drs. Singh and Soler and one other unnamed individual hold sole interest in the privately owned Holtec company. *See Findings E.22.* At the time of the hearing, Holtec had only twelve storage casks in use, but if the Applicant's facility is approved, Holtec could sell up to 4000 HI-STORM casks to PFS. According to the State, the sale of these casks could total hundreds of millions of dollars, which would produce a substantial financial benefit for the three sole owners of Holtec. *See Findings E.23.* Accordingly, the State requests that the Board consider the biases and interest of the Holtec witnesses in our deliberation of the weight to accord their testimony.

In response, the Applicant raised numerous objections to the State's attack on its witnesses. Although the Board recognizes the Applicant's need to defend its witnesses, its claim that the State's attacks are "irresponsible if not reprehensible" is itself overstated. *See Applicant Reply at 36.* In that regard, the Board notes that the State has a legitimate concern that the potential for such a substantial financial gain may cloud the judgment of the Applicant's witnesses, and that this potential is a legitimate subject of our consideration.

The answer is not to reject the accusations but to scrutinize the witnesses' demeanor and the substance of their testimony with particular care. Having done so, the Board perceives no disqualifying bias on the part of Dr. Singh and Dr. Soler. Indeed, as the Applicant correctly notes, it is typical in Commission proceedings to have equipment vendors testifying on the technical capacity of their equipment, even if those vendors may receive substantial benefits as a result of a decision in their favor. Furthermore, previous licensing boards have also refused to act on allegations of bias without substantial evidentiary support. *See Long Island Lighting Co. (Shoreham Nuclear Power Station, Unit 1), LBP-85-12,*

21 NRC 644, 665 (1985). Thus, although the Board acknowledges the State's concern, the Board finds no reason to disregard the testimony of Drs. Singh and Soler.²¹

2. Experience of Drs. Singh and Soler

In addition to its claims of bias on the part of Drs. Singh and Soler, the State also contends the Board should be mindful of the fact that they do not have any relevant experience regarding site-specific cask stability analysis for sites similar to the PFS site. According to the State, Drs. Singh and Soler do not have previous experience conducting nonlinear seismic analyses of freestanding casks that equal or exceed the expected ground motions for a DBE at the PFS site. Nor do they have experience conducting seismic analyses of sites that store SNF in unanchored casks on concrete pads supported by soil-cement. Finally, the State argues that neither Dr. Soler nor anyone who assisted him in authoring the various cask stability reports had experience in analyzing soil dynamics and foundation design. Thus, the State requests that the Board be mindful of Holtec's limited experience in assessing the weight to be given the various issues the Holtec witnesses address. *See Findings E.27-.31.*

Although the State raises several claims regarding the purported lack of experience of Drs. Singh and Soler, the Board finds that they have ample experience to support their analyses. *See Findings E.32.* Both Drs. Singh and Soler have demonstrated specialized technical experience analyzing the response of Holtec storage casks during a seismic event. Although, as noted by the State, the parameters may not have been exactly the same as those expected at the PFS site, the technical experience and expertise demonstrated by Drs. Singh and Soler in their professional careers performing similar types of technical analyses are sufficient to provide the Board with confidence in Drs. Singh's and Soler's analyses in this case. Furthermore, both Dr. Singh and Dr. Soler have extensive experience in the design, construction, and installation of the HI-STORM 100 system. Thus, the Board finds the witnesses' experience adequate to support their seismic analysis of the HI-STORM 100 at the PFS site. *See Findings E.32.*

C. Reliability of the Analysis

1. DYNAMO Program

Among its many criticisms of the Applicant's analysis, the State criticizes Holtec for using its DYNAMO code to generate the results in its 2000-year

²¹ For these same reasons, the State's challenge (*see State Reply at 77*) to Dr. Soler's use of a program that he authored, DYNAMO, to analyze the cask response to a DBE does not succeed.

return interval report. According to the State, the DYNAMO program is a “small deflection” program that is not capable of processing large cask rotations. Moreover, the State continues, Holtec has never used the DYNAMO program to analyze the stability of freestanding casks where the ground motions are equal to or greater than those for the 2000-year DBE at the PFS site. *See Findings E.33-.35.* The State also contends that it did not have ample opportunity to test the reliability of the DYNAMO program due to Holtec’s proprietary claim. Thus, the State insists that the Board view Holtec’s findings using DYNAMO as suspect. *See Findings E.37.*

The Board agrees that the DYNAMO program is a small-deflection program and is, as the State claims, not capable of handling large cask rotations. Precisely for this reason, however, we find that it was adequate for the seismic analysis of the casks at the PFS site for the DBE. As demonstrated by the Holtec analysis, in the event of a DBE, the casks will undergo only small rotations with displacements of a few inches and maximum rotation of about 1 degree. *See Findings E.49.* This is well within DYNAMO’s capabilities. Furthermore, Holtec performed a confirmatory analysis of the DYNAMO results using another industry-recognized program, VisualNastran. VisualNastran predicted small cask displacements similar to those predicted by DYNAMO, thus confirming for the Board that the DBE analysis was well within DYNAMO’s capabilities. *See Findings E.48-.50.*

2. *VisualNastran Results*

As a result of the State’s concerns, raised in Part D of Contention Utah L/QQ, Drs. Singh and Soler conducted additional simulations using the computer program, VisualNastran, to address the issues raised by the State. *See Findings E.51.* Using VisualNastran, Holtec analyzed eleven different computer simulations that addressed cask reaction to ground motions with varying pad stiffness, damping, and coefficients of friction. The results of the VisualNastran study demonstrate that the casks, even under the worst possible conditions, would not tip over. *See Findings E.52.*

The State argues, however, that the Board should limit its reliance on the VisualNastran results, because the State was not given an opportunity to challenge sufficiently these results through an informed cross examination. According to the State, no document in evidence lists all of the input values for the VisualNastran simulations. Without these input values, the State insists that its ability properly to cross examine the Applicant’s witnesses on the results of the VisualNastran analysis was severely limited. *See Findings E.55-.56.*

In addition, the State argues that the VisualNastran results are not testable. The State notes that when asked, Dr. Soler could not produce the critical damping value for a specified analysis case, nor could he remember the equations for the

equilibrium of rigid bodies built into the VisualNastran code. Finally, the State criticizes Holtec for failing to identify the actual deflection or angle of rotation for each of the casks used in its VisualNastran simulations. *See* Findings E.55-.56.

Because of the limited data presented by the Applicant to support its VisualNastran analysis and the “untestability” of the VisualNastran results, the State argues that its ability to probe Holtec’s results has been severely limited. Thus, the State requests the Board to limit the support that it finds in the Holtec VisualNastran analysis. *See* Findings E.57-.58.

The Board finds the State’s challenge to Holtec’s use of VisualNastran to fall short. The Board notes that although the State did not have the input parameters for the VisualNastran simulations prior to the hearing, the Applicant did provide the State with these reports during the hearing.²² Furthermore, as indicated by the Applicant, Dr. Soler was not able to produce the percentage of critical damping used in the analysis because the VisualNastran program uses the actual damping values instead of the percentages. In that regard, Holtec did provide the actual value of critical damping for each analysis run. *See* Findings E.62. Moreover, regarding the State’s request for the equations for the equilibrium of rigid bodies, the Board notes that the Applicant’s witness responded by claiming that these equations were built into the computer program. Therefore, he did not need to remember the equations, because they were performed by the commercially acquired, preprogrammed VisualNastran computer program. *See* Findings E.63. Finally, the Board notes that although the Applicant did not provide the cask displacements for each of the casks, Dr. Soler did provide the displacements for one of the casks and offered, if needed, to provide the displacements for the remaining casks.²³ *See* Findings E.59-.60.

Although the Board has addressed each of the individual claims raised by the State, the Board stresses that such a response was not necessary for the 10,000-year return interval earthquake. As indicated by the Applicant, the VisualNastran program was used to predict the response of the pad system during a 10,000-year return interval earthquake. As we discuss later, because the Staff granted the Applicant an exemption which we also find in this order to be adequately justified, the Applicant did not need to confirm that the pad system would resist such an earthquake.

²²The Board recognizes the State’s frustration with being given the Applicant’s report at trial without as much time as ideally could have been used to prepare with such a report. The Board does note, however, that because the trial spanned the course of several months, the State did have the opportunity to use the data during recross at the later stages of the trial.

²³The Board delayed its request for the additional displacement values due to the amount of time required to produce such values. As the hearing progressed, the Board realized that such values were not necessary for the Board to determine that the VisualNastran analysis was adequate. For this reason, the Board saw no need to require Dr. Soler to produce the additional results as offered.

For these reasons, the Board finds that the Applicant's use of VisualNastran was technically sound. The Applicant's uses of VisualNastran (a) to confirm that the seismic responses of the casks during the 2000-year return interval DBE involve only inches of displacement as predicted by DYNAMO, and (b) to determine if the casks would tip over under the 10,000-year earthquake under different bounding, worst-case assumptions, have been well justified.

3. *Input Parameters*

In addition to challenging the use of DYNAMO and the testability of VisualNastran, the State also asserts that nonlinear analyses — such as the one used by Holtec to analyze the seismic stability of the PFS site — are sensitive to some input parameters, particularly the choice of contact stiffness and damping value. We address the State's concerns below.

a. *Contact Stiffness*

The State's expert Dr. Khan argues that nonlinear mathematical models are highly sensitive to an assumed contact stiffness between the cask and the storage pad. According to Dr. Khan, high contact stiffness values can absorb high amounts of energy before actual sliding occurs, thereby reducing instantaneous velocities. As a result, Dr. Khan argues that high contact stiffness can cause a study to underestimate the actual vertical displacement of the subject casks. *See Findings E.67-.68.*

Dr. Khan acknowledged that prior to his study, in preparation for this proceeding, he had never attempted to select a contact stiffness value for cask sliding or tipping, but the State argues the same can be said for the Applicant's experts, Drs. Singh and Soler. *See Findings E.70.* In that regard, Dr. Khan insists that the contact stiffness selected by Holtec is too high because it makes the vertical frequency of the casks too rigid, which in turn may underestimate the vertical displacement of the casks. Furthermore, Dr. Khan notes that the Applicant has offered no test data, such as the results of a shake table test, to support its stability results. A more appropriate contact stiffness for unanchored casks, such as those proposed at the PFS site, Dr. Khan contends, should correlate with a frequency that falls within the amplified range of the response spectra curve. *See Findings E.71-.73.*

Using an established method for calculating contact stiffness between two objects, Holtec calculated the contact stiffness used in its DYNAMO design basis analysis for the PFS site. This calculation is consistent with the guidance given in the computer code ANSYS training manual. *See Findings E.81.* During their testimony, Drs. Singh and Soler noted that as a practical matter, analysts often

use contact stiffness values that are much less than the actual calculated value of the stiffness to reduce the computing time necessary to compile the results, but yet not so low as to corrupt the results. For the 2000-year DBE, Holtec was able to arrive at a converging solution even when it used a contact stiffness value high enough to resemble its actual value. Hence, Holtec did not significantly lower the contact stiffness value. *See Findings E.91-.92.* For the 10,000-year earthquake, because of the amount of data involved, Holtec used a low contact stiffness value to reduce the amount of computing time using VisualNastran. But Holtec notes that it did several test runs to ensure that the lower contact stiffness would not significantly alter the test results. Holtec observes that there is a relatively large range of contact stiffness values over which the solution does not change appreciably. *See Findings E.90-.92.*

The Board finds that the Applicant's use of a lower contact stiffness value was, contrary to the State's claims, technically defensible. The Applicant's argument demonstrates that its use of contact stiffness values was justified both on fundamental principles and practical engineering considerations. The Board is persuaded that the Applicant has performed its analysis in a deliberate and rational way to achieve an appropriate balance between obtaining computational convergence and ensuring the integrity of its technical solution. *See Findings E.91-.92.*

b. Damping Values

For its 2000-year DBE analysis, Holtec used a 5% value of damping to represent the dissipation of energy that occurs when the cask impacts the concrete pad during a seismic event. This 5% damping value is used in Holtec's analysis to account for the loss of energy in the impact between the cask and the pad, but is not involved in any horizontal sliding calculations. *See Findings E.93.* For its 10,000-year earthquake analysis, however, Holtec used a 40% damping value. Holtec explained this disparity in its input values by noting that an increase in ground motion caused by the 10,000-year earthquake will increase the damping value between the cask and pad. *See Findings E.93.* The State disagrees with this claim and notes that an overestimate in the damping value could cause an underestimation of the actual dynamic response of the casks. *See Findings E.102, E.104.*

Furthermore, the State contends that the Applicant presented no support for the damping values it used. During the hearing, the Applicant explained that it correlated the damping values used in its analysis with a study performed by the NRC Staff that measured the damping value of steel "billets" dropped onto a concrete pad. The State argues, however, that the Applicant has not offered any evidence to support the impact test and to demonstrate how the Staff's steel "billet" test correlates to the HI-STORM casks. *See Findings E.97.*

In response to the State's concerns, the Applicant's experts produced a computer animation that depicted spheres with varying damping percentages dropped from a height of 18 inches to demonstrate the effects of damping. *See Findings E.94-96.* The State argues, however, that the animation does not support the Applicant's damping values. *See Findings E.98.*

According to the State, although the Applicant's animation varied either the damping value or the contact value, it never varied both. The State contends that such an analysis is thus insufficient to demonstrate that the results are not sensitive to both a low contact stiffness and a low damping value. *See Findings E.107.* Furthermore, the State argues that because the casks will move horizontally as well as vertically, an animation such as the one used by the Applicant that depicts cask movement only in the vertical direction is not an accurate representation of the actual cask movements. For these reasons, the State believes that the evidence presented does not support the damping values used by Holtec for its 2000-year DBE and 10,000-year earthquake analyses. *See Findings E.98.*

In response to the State's claims, the Applicant's witnesses turned to the Commission's Regulatory Guides for support. In particular, the Applicant points to Regulatory Guide 1.61, which allows a greater percentage of critical damping for a safe shutdown earthquake than for an operational earthquake. *See Findings E.103.*

The Board is persuaded by the evidence before us that a 5% impact damping value is not so high that it supports the State's concern that the high damping value would underestimate dynamic response of the casks. The State has not offered any specific evidence that established that there is a deficiency if a 5% impact damping value is used in the 2000-year DBE analysis. Instead, the State focused its critique on the use of a 40% impact damping value in the 10,000-year earthquake analysis.

The 40% impact damping may well be an acceptable value to use in the 10,000-year earthquake, based on the explanation provided by the Applicant's witnesses (*see Findings E.105-.106, E.108-.110*); however, the Board finds it unnecessary to rule on this point, given that the issue is mooted by the Board's finding that the Staff's granting of the exemption request is appropriate. *See below, p. 366.*

4. Angle of Rotation

According to the Applicant's expert Dr. Soler, the HI-STORM 100 will tip over if the cask is tilted at an angle of roughly 29 degrees from vertical. *See Findings E.111.* The State contends, however, that in a publication concerning the HI-STAR 100 system, Drs. Singh and Soler recommended that the maximum rotation of the cask be set to 25% of the ultimate cask tip-over value. Based upon this recommendation, the State argues that the maximum allowable tip-over

value for the HI-STORM 100 cask should be 8.15²⁴ degrees from vertical and that Holtec's estimated maximum cask rotation for its 10,000-year earthquake analysis exceeds this maximum allowable cask rotation value. *See* Findings E.112-.114.

Assuming that the maximum angle of rotation of 8.15 degrees applies as claimed by the State, the Board finds that the Applicant has demonstrated that the HI-STORM cask will meet this standard in the event of a DBE at the PFS facility. Because of the seismic exemption granted by the Staff, the Applicant need only design its facility to withstand a 2000-year DBE, and the results of the Applicant's analysis for this DBE demonstrate that the maximum angle of rotation from vertical will only be between 1 to 2 degrees, well within the 8.15-degree limit. *See* Findings E.117. Furthermore, although the Applicant's study demonstrates that the casks may exceed the 8.15 degrees in a 10,000-year earthquake, the Board finds that the 8.15-degree standard is a conservative lower bound and the analysis demonstrates that the casks will not exceed the actual calculated tip-over value of 29 degrees from vertical. *See* Findings E.111.

5. Time Histories

Section D.1.h of Utah L/QQ contends that the Applicant's cask stability calculations are insufficient because they use only one set of seismic time histories in their analysis. *See* above, p. 312. The State contends that more than one set of time histories should be used, because nonlinear analyses are sensitive to the phasing of input motion and large velocity pulses, and their variation and effects are not adequately bounded by one set of time histories. *See* Findings E.118.

The NRC's regulatory guidance has established two methods for developing time histories.²⁵ Applicants can either use a multiple set of time histories that in the aggregate envelop the design response spectra or, in the alternative, applicants can use a single set of time histories that envelop the design response spectra as well as power spectral density functions. *See* Findings E.120. In this case, the Applicant chose the latter and developed a single set of time histories consistent with Agency recommendations. *See* Findings E.121. The Board finds this approach to be adequate and in compliance with regulations. *See* Findings E.172.

6. Cold Bonding

The State also raised the issue that the Applicant has failed to consider the potential for cold bonding between the cask and the pad and its effects on cask sliding. *See* above, p. 312. According to the State's witness, cold bonding occurs

²⁴ *See* Findings E.113.

²⁵ *See* NUREG-0800, § 3.7.1, and NUREG-1567, § 5.

when two bodies with large loads are in contact with one another for a long period of time. As a result, local deformations and redistribution of stresses may occur, which may create a bond between the two objects. *See* Findings E.123.

The Applicant argues that cold bonding between the cask and pad will not occur for two reasons. First, the pressure at the interface between the steel base of the cask and the pad is between 26 and 40 psi, well below the allowable bearing stress of 1785 psi in a concrete pad with a compressive strength of 3000 psi. The 26- to 40-psi pressure is comparable to a 200-pound man standing on one foot; hence it is not expected to create cold bonding between the steel bottom of the cask and the concrete pad. *See* Findings E.124. Secondly, the Applicant highlighted an analysis performed by the Staff, which established the total deformation in the concrete caused by the cask being on top of the pad to be on the order of 972 microinches, a very small deformation insufficient to cause cold bonding. *See* Findings E.126. Therefore, the Board is persuaded that cold bonding will not occur.

Even assuming that cold bonding may occur, however, the Board finds that it will not have a significant impact on cask sliding. Because the anticipated seismic forces during a 2000-year DBE are significant, the seismic forces would be expected to break a cold bond formed between the cask and the pad, allowing the cask to slide. Thus, the cold bonding effect would be limited. Finally, any cold bonding effects, if they were to occur, would ultimately be subsumed in the Applicant's use of a conservative upper-bound coefficient of friction estimate in which frictional forces represented by a high friction coefficient would certainly dominate any cold bonding effects. *See* Findings E.52, E.124-.127. For this reason, the Board finds cold bonding will not materially affect the casks during a DBE.

D. Khan Report

In response to the Holtec study, the State requested that its expert, Dr. Mohsin Khan, conduct a parametric study modeling the seismic reaction of a HI-STORM 100 cask during a DBE. Dr. Khan used a finite-element structural analysis code, SAP2000, to model a single HI-STORM 100 cask as beam elements in which the base of the cask was depicted as connected to the pad using nonlinear elements.²⁶ *See* Findings E.128. Dr. Khan performed several case studies using three mathematical single-cask models by varying the input parameters for contact stiffness, coefficient of friction, and damping. *See* Findings E.129.

²⁶ For a complete description of Khan's analysis as well as a full report of the results, *see* Analytical Study of HI-STORM 100 Cask System Under High Seismic Condition, Technical Report No. 01121-TR-000, Rev. 0 (Dec. 2001) (State Exh. 122).

The results of Dr. Khan's analysis ranged widely from a cask displacement of several inches to a cask displacement of 40 feet. During the hearing, Dr. Khan admitted that such large cask displacements were unrealistic, but he asserted that his analysis served as a valid example of the sensitivity of nonlinear analyses to input parameters in these types of simulations. Tr. at 7177-79 (Khan). Although his analysis demonstrates the importance of using proper input parameters, he did not demonstrate that the input parameters used by Holtec were invalid. *See Findings E.133.*

More importantly, as noted by the Applicant's experts, the SAP2000 program, used by Dr. Khan, is not designed to accurately model nonlinearities, such as those involved in large-cask motions. Thus, when the SAP2000 computer code, which is a small-deflection program, predicts large displacements, the results should be closely examined. *See Findings E.131-.132.* The Applicant's experts also highlighted the fact that Dr. Khan did not use his models to benchmark his solutions with known classical solutions.²⁷ *See Findings E.133-.135.* These flaws in Dr. Khan's analysis are illustrated by several of the SAP2000 results which depicted casks lifting roughly 1 to 2 feet off the ground and moving roughly 30 to 40 feet. *See Findings E.133.* These casks, which are massive structures that measure 11 feet in diameter, are 20 feet tall, and weigh some 180 tons, are not expected to have this type of movement under the postulated seismic loads. *See Findings E.1.*

Finally, the Applicant reran VisualNastran, using Dr. Khan's input parameters (1 million pounds/inch contact stiffness and 1% damping at the cask-pad interface) for run 3 of Dr. Khan's third model, and did not observe the large displacements Dr. Khan obtained. Instead of observing Dr. Khan's prediction of cask vertical movement of 1 to 2 feet with lateral displacement of 25 feet, the Applicant's analysis showed a slight bouncing of the cask, with lateral displacement of a foot or two. *See Findings E.136-.137.* Thus, the Board is not persuaded by the results of Dr. Khan's analysis. To the contrary, based on the evidence before us, the Board finds that the Applicant's cask analysis conducted by Holtec is adequate to demonstrate that the casks will not tip over during a 2000-year DBE.

E. State's Request for a Shake Table Analysis

The State claims that the only way accurately to validate the Holtec cask stability analysis is to benchmark the cask displacement with actual shake table test data. *See Findings E.139.* As the principal support for this assertion, the State points to the Applicant's own expert's testimony about the need for validation

²⁷The NRC Staff required Holtec to benchmark DYNAMO's solutions in the manner of ASME NQA-2a-1990. *See Findings E.135.*

when conducting complex nonlinear studies such as the cask stability analysis.²⁸ Thus, the State contends that a proper cask stability analysis cannot be completed without a validation of the analysis results with actual shake table test data. *See Findings E.147.*

In this instance, the Licensing Board finds that a shake table test is unnecessary to validate the results of Holtec's cask stability analysis. Although the State claims that the Applicant's experts support such an analysis, a review of the testimony indicates that the degree of such support is quite limited.

During his testimony, Dr. Luk indicated that a shake table test might be helpful, but he also stressed that a shake table test of the PFS facility would have limitations that could not be technically overcome. For example, Dr. Luk explained that in-situ soil conditions cannot be re-created on a shake table test, hence one would not be able to incorporate the effects of SSI in a shake table test. Additionally, he declared that a shake table test large enough to accommodate a full-sized cask may not be available. *See Findings E.148.*

Dr. Cornell also expressed concerns about a shake table test. During his testimony, Dr. Cornell noted that although a shake table test may provide some useful information, because it is a model with its own uncertainties, it would also introduce a different set of uncertainties to the analysis. Thus, Dr. Cornell stressed that it may not be as useful as the State's experts imply. *See Findings E.149-150.*

In his testimony, Dr. Singh stressed the difficulty in simulating the condition of a freestanding cask on a pad in a shake table test. As a key example, he emphasized the difficulty in experimentally controlling the coefficient of friction between the freestanding cask and the pad to provide a meaningful correlation with a computer analysis. He noted that one could not design a shake table test that accounted for all of the critical variables that were used in the Holtec computer simulation. Absent such correlation, Dr. Singh stated that the use of the shake table test data would not be a "reliable benchmark" for analysis of freestanding casks on a pad. *See Findings E.151.*

The Board is persuaded by the testimony provided by the Applicant and Staff experts, Drs. Luk, Cornell, and Singh. Although at first glance a shake table test appears to offer some hope of validating a complex, nonlinear seismic analysis of cask displacement, closer examination of the shake table test indicates that

²⁸ *See Findings E.139-141.* The State also argues that, although the Holtec experts testified at trial that a shake table test was unnecessary, in a November 1997 letter, Dr. Singh sought Commission funding to validate its analysis through a model shake table test. *See Findings E.144.* The Board notes that Dr. Singh's request for funding for a shake table test was in conjunction with Holtec's application for a Certificate of Compliance (CoC). The Staff ultimately approved Holtec's application for a CoC for the HI-STORM 100 without requiring a shake table test to validate Holtec's supporting analysis. *See Findings Staff Exh. FF.* Similarly, the Board is not persuaded that a shake table test is necessary here.

it has its own limitations, including: (1) the inability to model SSI, (2) the unfeasibility of controlling the cask–pad friction coefficient, (3) the unavailability of an appropriately sized table, and (4) the introduction of uncertainties associated with the shake table test itself. Given these limitations and the large safety margin in the Applicant’s design discussed throughout this opinion, the Board concludes that a shake table test is unnecessary to establish reasonable assurance that the cask would not tip over during a 2000-year DBE.

F. The Staff-Sponsored Sandia Report Conducted by Dr. Vincent Luk

To confirm the Holtec cask stability analysis, the Staff commissioned Dr. Vincent Luk to conduct an independent evaluation of the PFS project. Dr. Luk directed a team of experts in developing a three-dimensional finite-element model of the proposed dry cask storage system to examine the nonlinear dynamic behavior of the casks and to simulate the effects of SSI under the postulated seismic conditions. *See* Findings E.152. Dr. Luk modeled the casks using three different sets of seismic conditions at the PFS site: (1) the 2000-year return period earthquake at the PFS facility; (2) the 10,000-year return period at the PFS facility; and (3) a sensitivity study based on the 1971 San Fernando earthquake (Pacoima Dam record). *See* Findings E.154.

The results of Dr. Luk’s analysis confirmed Holtec’s conclusion that the casks would not tip over during either a 2000-year return or 10,000-year return earthquake. Furthermore, the Luk study demonstrated that at no time during either the 2000-year or the 10,000-year earthquake would the casks collide. Dr. Luk’s study also showed that the maximum cask rotation during the 10,000-year event simulation was 1.16 degrees, which is well within Holtec’s recommendation that the maximum rotation of the cask be set to 25% of the cask tip-over angle of 29 degrees from vertical (which is 7.25 degrees from vertical). Thus, based on the Luk Report, the Staff concluded that Part D.1.i of Utah L/QQ does not present a valid concern. *See* Findings E.171-.174.

Although the State contests the validity of the Luk study on several grounds, as we discuss below, we do not find its claims to be supported by the record.

1. Conflict of Interest with Study’s Advisory Panel

The State first argues that because certain members of the panel who served as advisors for Dr. Luk’s study were affiliated with the Applicant, there was a conflict of interest in Dr. Luk’s assessment of the PFS facility. During the hearing, Dr. Luk testified that a review panel consisting of three NRC Staff members and four industry representatives provided technical advice and input to his cask stability analysis. According to Dr. Luk, the advisory panel members

provided recommendations concerning the analysis methodology and range of input parameters used in his study. Further inquiry by the State revealed, however, that two members of the advisory panel were from Southern Company and Southern California Edison, both members of the PFS consortium. *See Findings E.175.*

Because two PFS member company employees serving as members of the Luk study advisory review panel were not disclosed until the hearing, the State argues that it had little or no opportunity to probe the background and influence of the panel members upon Luk's study. As a consequence, the State asserts that, in assessing the Luk study, the Board should weigh negatively the potential conflict of interest from the PFS member companies. *See Findings E.176.*

Although this potential for a conflict of interest should have been disclosed prior to the hearing, the Board has no reason to believe, based on the record developed at the hearing, that the results of the Luk Report have been tainted. The potential conflict was probed extensively by the State during the trial, and Dr. Luk answered all of the State's questions with apparent candor and objectivity. Dr. Luk indicated that the choice of representatives from Southern Company and Southern California Edison as members of the review panel had nothing to do with the PFS proceeding. Rather, the choice was made in anticipation that the Sandia National Laboratory (Sandia) would be performing seismic stability analyses for their respective plants, Hatch and San Onofre, and before it was even contemplated that there would be a PFS-related analysis. Sandia ultimately did perform such an analysis for these two plants. *See Tr. at 7081-82 (Luk).* By the time the site-specific analysis for the PFS site was initiated, the composition of the review panel was established and already included representatives from Southern Company and Southern California Edison. *See id.* During his testimony, Dr. Luk also indicated that the review panel did not provide any inappropriate advice. *See Findings E.179.* In addition, the Staff provided the minutes of the meetings in which the panel discussed the Luk Report, which contained no indication that there was undue influence upon the Luk study from any industry member. *See id.; Staff Exh. GG.*

Although the Board is fully aware of the appearance of a conflict of interest here, after intensively probing Dr. Luk and the Staff during the trial and examining the record before us, we find no evidence that improper bias has had any actual impact on the report. The advice provided by the review panel — as described by Dr. Luk under cross examination by the State and Board questioning, and confirmed by the written meeting minutes — does not evidence any inappropriate influence that would taint the technical independence of the Luk Report. *See Findings E.178-.179.* Indeed, the State did not ask the Board to dismiss the Luk Report because of the alleged conflict of interest, but rather it asked the Board to weigh the potential conflict in our assessment of the Luk Report. *See Findings*

E.176. The Board has done so, both during the hearing and here in this decision, and has concluded that it does not impact the validity of the report.

2. *Dr. Luk's Relative Experience*

The State also argues that Dr. Luk lacks the necessary experience to develop a credible analysis of the PFS site. According to the State, Dr. Luk's experience in modeling freestanding casks does not include any sites with a design or conditions similar to those proposed at the PFS site. *See* Findings E.180. In addition, the State argues that Dr. Luk lacks the proper qualifications and experience to conduct a proper SSI analysis. *See* Findings E.181-.182.

We find no merit in the State's claim that Dr. Luk lacks the experience necessary to conduct a successful analysis of the PFS facility. On the contrary, we find Dr. Luk has extensive knowledge and experience in finite-element analysis and in the modeling of nonlinear dynamic seismic behavior. Furthermore, although Dr. Luk may not have been an expert in each and every element of this particular site-specific PFS study, he compiled a team of experts to assist him in those areas in which he lacked expertise. *See* Findings E.185-.186. Thus, the Board finds no reason to doubt the expert credentials of Dr. Luk or of the specialists he assembled on his team.

3. *Comparison of Dr. Luk's Report and the Holtec Report*

The State also argues that although Dr. Luk reached a conclusion similar to that reached by Holtec — namely, that the casks would not tip over — his report does not confirm the methodology used by Holtec. Furthermore, the State notes that like the Holtec analysis results, the results of Dr. Luk's study have not been benchmarked or compared with physical data such as a shake table test. Thus, the State argues that Dr. Luk's report should not be seen as a confirmation of the results of the Holtec analysis. *See* Findings E.187-.190.

For the reasons stated in our previous discussion on the need for a shake table test, the Board finds no reason to require a shake table test to validate Dr. Luk's nonlinear dynamic analysis. *See* above, pp. 350-52. The Board is also persuaded by the Applicant's assertion that Dr. Luk's analysis model, the ABAQUS code, has been benchmarked against a wide variety of classical problems. Dr. Luk also verified the analytical results of his study against available test data in the area of damping results against drop test data. *See* Findings E.194.

Moreover, the Board recognizes that Dr. Luk's report employs an entirely independent method from Holtec to analyze the dynamic behavior of the pad and the casks during earthquake conditions. Rather than undercutting Holtec's results, we believe this difference supports it. Having used an entirely different set of

assumptions and methodologies and still arriving at the same result, Dr. Luk's report provides further assurance for Holtec's conclusion that the casks will not tip over. Furthermore, the Board notes that many of the assumptions questioned by the State in Holtec's analysis were not used by Dr. Luk. *See* Findings E.192-.193. For these reasons, the Board finds the State's concerns to be unsupported.

4. State's Concerns with Luk's Model

The State asserts that Dr. Luk's modeling of the foundation soils at the PFS site has six principal defects: (1) Dr. Luk's analysis models the interface between model elements as a frictional interface rather than the clay soils at the PFS facility; (2) Dr. Luk's model does not represent the reliance of the PFS design on cohesion from bonding at the interface layers to transfer horizontal seismic loads downward from the storage pad to soils below; (3) Dr. Luk's model does not account for post-yield behavior of the upper Lake Bonneville clays; (4) Dr. Luk's model should have used soil characteristics developed by Stone & Webster, instead of those by Geomatrix; (5) Dr. Luk's analysis uses a uniform thickness of 2 feet for the cement-treated soil; and (6) Dr. Luk's analysis uses an improper value for the Young's Modulus. *See* Findings E.197-.207, E.215, E.218. Thus, the State argues that the Luk analysis does not accurately model the design proposed by the Applicant and its results are not a good verification of the Holtec analysis. *See* Findings E.206-.207.

Contrary to the State's objections, the Board finds that Dr. Luk's analysis accurately models the design proposed by the Applicant for the PFS facility. In describing the first asserted defect, the State maintained that Dr. Luk's use of an interface coefficient of friction treats the interface layers under the storage pad as granular materials and models the interface nodes as a frictional material such as sand. This, the State asserts, does not at all represent the actual behavior of the clay soils. During the hearing, Dr. Luk responded to the State's claims by explaining that modeling the interfaces above and below the cement-treated soil with a coefficient of friction is a well-established method in finite-element analysis. Such use of a coefficient of friction does not characterize the properties of the materials, but rather that of the interface between the materials. *See* Findings E.208.

Regarding the State's complaint that the Luk model does not account for the cohesion of the soil, the Board finds that Dr. Luk's model in fact does take the cohesion of the soil into account. During the hearing, Dr. Luk explained that in his finite-element soil foundation model, horizontal layers were developed, with specific soil properties to account for the cohesion in the soils. Furthermore, the Board notes that even if the State is correct and the soil was modeled as cohesionless — a notion contrary to the evidence of record — this would only

maximize the soil's potential for sliding and provide a more conservative result. *See Findings E.211-.212.*

With respect to the alleged deficiency of not accounting for post-yield behavior of the upper Lake Bonneville clays, the Board finds dispositive Dr. Luk's testimony during the hearing that his team has examined the post-yield behavior of the upper Lake Bonneville clays and determined that the effects are not significant. *See Findings E.213.*

Regarding the State's concern that Dr. Luk did not use the soil properties developed by Stone & Webster in his analysis, the Board notes that Stone & Webster did not develop dynamic soil properties. Instead, Stone & Webster used the soil properties developed by Geomatrix, which were the same soil properties used by Dr. Luk. More importantly, using the soil properties developed by Geomatrix allowed Dr. Luk to incorporate soil cohesion into his analysis, which addresses one of the State's earlier concerns. *See Findings E.214.*

The State also asserted that the thickness of the cement-treated soil under the storage pad can vary from 1 to 2 feet, but the Luk analysis assumed a uniform thickness of 2 feet. We agree with the Applicant's explanation that the use of a 2-foot thickness provides a more conservative result because a thicker layer leads to more energy associated with ground excitations going to the storage pad and cask, thus causing a higher level of dynamic behavior of the storage pad and cask. *See Findings E.215.*

Finally, the Luk Report uses a 270,000-psi Young's Modulus for the cement-treated soil underneath the pads. *See Findings E.216.* According to the State, Dr. Luk claims to have received this number from Mr. Mahandra Shah, but the State contends that Mr. Shah had no basis for this number. Furthermore, the State argues that this number is arbitrary and incorrect. Instead, the State claims that the Applicant should have used the actual value of the Young's Modulus for the cement-treated soil. *See Findings E.218-.219.*

The Board is sensitive to the State's assertion that Dr. Luk has committed a significant error in his analysis by using a higher Young's Modulus value (270,000 psi instead of 75,000 psi called for by the design) and for that reason this issue was thoroughly examined during the trial. Although the Board finds that indeed it was an input error for Dr. Luk not to use the 75,000-psi design Young's Modulus, as it turns out such an error produces a more conservative result. The higher Young's Modulus value increases the seismic loads transferred from the underlying soils to the storage pad and cask, leading to greater cask displacements. The Board also notes that Dr. Luk has determined after careful examination that his analyses are not critically sensitive to the value of Young's Modulus. *See Findings E.221-.222.* Thus, the Board is persuaded that Dr. Luk's use of a higher value for Young's Modulus did not adversely impact the validity of his analyses.

G. Board Conclusions

We find that, based on the evidentiary record before us, the Applicant has demonstrated by the preponderance of the evidence that the storage casks will not tip over in the event of a 2000-year return period DBE. We are further assured of this notion by Dr. Luk's independent analysis that similarly demonstrates that in the event of a 2000-year return DBE, the storage casks will not tip over. Although the State raises several important concerns with each of these studies, after a careful review of the record we are assured that the parameters and methodologies are sound. For these reasons, we find that the Applicant has presented sufficient evidence to meet its burden of proof to demonstrate that the HI-STORM 100 will not tip over in the event of a 2000-year DBE.

VII. SEISMIC EXEMPTION REQUEST

A. Background

As previously discussed, the Applicant requested from the Staff an exemption from the NRC regulations that establish design criteria for ISFSI sites located west of the Rocky Mountain range. Without the exemption, the PFS facility would need to be designed to withstand seismic ground motions based on the deterministic criteria for nuclear power plants established in Appendix A, 10 C.F.R. Part 100. *See* Findings F.1, F.5. As indicated in the Applicant's exemption request, the Applicant sought to use a PSHA methodology for a 2000-year mean return period as the design basis earthquake.²⁹ In October 2000, the Staff approved the Applicant's request. *See* Findings F.5.

B. Legal Standards Governing the Site-Specific Analysis Necessary To Obtain an ISFSI License

The Commission's regulations governing the seismic analysis and design criteria for an ISFSI are established in 10 C.F.R. Part 72. According to 10 C.F.R. § 72.92, all applicants must evaluate the natural phenomena that may exist or may occur in the proposed facility's region to determine the potential effect the phenomena may have upon the safe operation of the proposed facility. Furthermore, applicants must also design all SSCs important to safety to withstand events such as a potential earthquake. *See* 10 C.F.R. § 72.122.

Commission regulations also require all applicants to address the geological and seismological characteristics of their proposed site, and for those sites —

²⁹ *See* Findings F.5. Initially the Applicant sought an exemption to use a 1000-year mean return period, but that request was later modified to the 2000-year mean return period.

such as the proposed PFS site — that are located west of the Rocky Mountain range, the facility must meet the criteria established in 10 C.F.R. Part 100, Appendix A. Appendix A requires the Applicant to determine the maximum credible earthquake, labeled the Safe Shutdown Earthquake (SSE), that could occur at the site, based upon the location of surrounding faults, and design its facility to withstand such an earthquake. This deterministic approach does not take into account the probability of such an occurrence, but rather requires the Applicant simply to design against the largest credible vibratory ground motions associated with the site. *See* 10 C.F.R. Part 100, App. A.

As previously noted, PFS has requested an exemption from the deterministic approach established in Part 72 to allow it instead to use a probabilistic analysis to determine the appropriate seismic evaluation and design standards. A probabilistic analysis allows the Applicant to account for both the intensity and likelihood of occurrence of the postulated seismic event, while the deterministic approach uses the maximum credible earthquake as its design basis SSE. Commission regulations allow such an exemption if the Commission determines that the exemption is authorized by law and “will not endanger life or property or the common defense and security and [is] otherwise in the public interest.” 10 C.F.R. § 72.7. Pursuant to these criteria, and after an extensive evaluation, the Staff accepted and granted the Applicant’s request for such an exemption.

C. Basis for the Applicant’s Exemption Request

The Applicant’s exemption request relies upon two key elements: (1) a risk-informed approach that is applied to the seismic design; and (2) “risk reduction factors,” which are significant conservatisms embedded in the design codes, standards, and procedures. We address both of these elements below.

1. Use of a Risk-Informed Seismic Design

The first principle of a risk-informed seismic design is the use of a risk-graded approach to the design. The risk-graded approach imposes graded requirements on a safety structure. Under this approach, facilities and structures with more severe failure consequences are required to have low probabilities of failure, while facilities and structures with lesser failure consequences can have larger probabilities of failure. In other words, more important facilities and structures are designed to fail less frequently, while less important facilities and structures are allowed to have a higher failure probability. *See* Findings F.33. The Staff adopted this approach in approving the Applicant’s exemption request, because the Staff determined that the radiological consequences of a failure at an ISFSI would be less than a design basis accident at a nuclear power plant. The Staff’s

determination primarily rests on two key considerations, namely that an accident involving a spent fuel storage cask would have a much smaller fission product inventory than a nuclear power plant and that such an event would also involve lesser dispersal forces than a nuclear power plant. As a result, the Staff determined that the seismic requirements for the licensing of an ISFSI do not need to be as strict as those for licensing a commercial nuclear power plant. *See Findings F.34-.35.*

2. Use of Risk Reduction Factors

The second principle of the risk-informed seismic safety analysis is to apply a “two-handed approach” to assess seismic safety. This “two-handed approach” involves the consideration of both the mean annual probability of exceedance (MAPE)³⁰ of the DBE and the level of conservatism incorporated in the design codes, standards, and procedures (also referred to as “risk reduction factors”).³¹ *See Findings F.36.* Under this “two-handed approach” if there is significant conservatism in the second hand (risk reduction factors), then a lower standard can be permitted to be set by the first hand (MAPE). *See Findings F.37.*

The State has raised concerns regarding the sufficiency of the risk reduction factors in four general areas: (1) the applicability of risk reduction factors in a nuclear power plant to an ISFSI, (2) the lack of fragility curves for the SSCs, (3) the safety margins involved with the freestanding casks, and (4) the safety margins for the CTB. We address each of them in turn below.

a. Risk Reduction Factors — ISFSI Versus a Nuclear Power Plant

The State has two challenges regarding the risk reduction factors. First, the State argues that because the design concept of the PFS facility — namely using soil-cement and allowing free-sliding casks — is different from that of a nuclear power plant, the risk reduction ratios encompassed in the Standard Review Plan for nuclear power plants, which are in the range of 5 to 20, cannot be utilized for freestanding dry storage casks. In other words, the State contends that the Applicant has failed to demonstrate that nuclear power plant risk reduction factors are applicable to an ISFSI, especially one as uniquely designed as the PFS facility. *See Findings F.45-.46.*

³⁰ The MAPE is exactly the inverse of the mean return period (MRP). For example, for a 2000-year MRP earthquake, the MAPE is $1/2000 = 5 \times 10^{-4}$. *See Findings F.39.*

³¹ A risk reduction factor expresses the degree to which the likelihood of failure of a system or a component in a facility is reduced by the conservatism imbedded in the codes, standards, and procedures of the design. For example, a risk reduction factor of 3 would reduce the design basis earthquake MAPE of a facility by the same amount, say from a MAPE of 6×10^{-4} to 2×10^{-4} .

The State also emphasizes that the 2000-year DBE results in a larger reduction in the seismic demand placed upon the proposed facility than that anticipated under the original deterministic method. Because under the two-handed approach a factor of safety is a function of the capacity divided by the demand, the State argues that when the factor of safety is kept constant, as it is here, and the demand is reduced, then ultimately capacity is also reduced. This, the State asserts, will lead to a smaller design margin for the 2000-year earthquake than for the 10,000-year earthquake. *See Findings F.47-48.*

The Board finds relative to those concerns, however, that the Applicant has provided sufficient evidence to support its conclusion that the risk reduction factors in the design, manufacture, installation, and operation of major safety systems in nuclear power plants are applicable to the safety systems in an ISFSI. The risk reduction factors, which primarily rest with the embedded conservatism in the design codes, standards, and procedures, have been shown to be similar both to design procedures and acceptance criteria in ISFSIs and nuclear power plants. *See Findings F.50.* In contrast, the Board finds no support in the record for the State's claims of significant dissimilarity. Accordingly, the Board is persuaded that similar levels of conservatism can be expected for SSCs designed for ISFSIs as for SSCs designed for nuclear power plants. *See Findings F.53.*

b. Fragility Curves for the SSCs

During the hearing, the State asserted that the Applicant did not develop any fragility curves for the SSCs in the proposed ISFSI, which the State insisted would be needed to provide the probability of failure for the SSCs when combined with the seismic hazard curve. *See Findings F.54.* In its proposed findings of fact, however, the State concludes that although fragility curves would provide some comfort, a properly justified DBE does not mandate the determination of fragility curves. *See Findings F.55.* The Board views this statement as a State withdrawal of its request for the Applicant to develop fragility curves and thus finds no reason to consider this issue further at this time.

c. Risk Reduction Factors of Freestanding Casks

The State also claims that the risk reduction factors for the freestanding HI-STORM casks have not been demonstrated by the Applicant due to the following asserted deficiencies: (1) failure to conduct a probabilistic risk assessment to evaluate the design margins or the consequences of casks tipping over; (2) failure to determine the uncertainties in the SSI involving cement-treated soil; and (3) failure to determine the impact that nonlinear soil behavior will have upon the slope of the hazard curve. *See Findings F.56, F.60-.61.*

In its response, the Applicant relies upon the testimony of its expert Dr. Cornell, who supports the Applicant's assertion that the freestanding casks have a risk reduction ratio of at least 5 based on his analysis showing that the casks, which have been designed for a 2000-year earthquake would not tip over even during a 10,000-year earthquake. *See* Findings F.66. Furthermore, the Applicant stresses three additional factors that support its claim it has used a conservative design. First, the Holtec simulations for the 10,000-year earthquake employ bounding assumptions that include (1) a range of values of 0.2 and 0.8 for coefficients of friction, as well as random selection of coefficients of friction; (2) radiation soil damping of 1% to 5%; and (3) a selected stiffness value of the soil springs to provide resonance of the cask-pad system. *See* Findings F.67. The Applicant also points to Dr. Luk's analysis commissioned by the Staff that, using an entirely different methodology in modeling the 10,000-year earthquake, also shows the casks would not tip over. *See* Findings F.64. Finally, the record demonstrates that, even if the casks were to tip over, there would be no radiological release. Collectively, the Applicant maintains that these significant margins more than account for the potential uncertainties alleged by the State. *See* Findings F.65.

From the record of evidence developed by the Applicant and Staff, the Applicant's claim that the freestanding casks have a risk reduction factor of at least 5 is fully supported based on the Holtec and Luk analyses that demonstrate that the casks would not tip over in a 2000-year DBE or a 10,000-year DBE. *See* Findings F.62-.67. A probabilistic assessment was not relied upon by the Applicant to establish this claim, nor would such an assessment be expected to resolve any disputes between the Applicant and the State because any probabilistic assessment would introduce its own sets of uncertainties. The Applicant's argument is also significantly buttressed by the demonstration of additional conservatisms in the Holtec analysis, including the showing that there would not be any radiological releases even if a cask were to tip over. The potential uncertainties alleged by the State, therefore, do not diminish the risk reduction factor claimed by PFS.

d. CTB Foundations and Storage Pads

The State further asserts that applying a risk reduction factor of 5 to 20 or more for typical nuclear power plant SSCs to the foundations for the CTB and storage pads is not appropriate. The potential foundation failure mechanisms are sliding, loss of bearing capacity, and overturning. *See* Tr. at 12,952-53 (Cornell). The State's reasoning is straightforward: there are no engineering calculations to support the Applicant's claim that the CTB foundations and storage pads can withstand a 10,000-year earthquake. *See* Findings F.68.

The Applicant acknowledges that it has not designed the CTB foundations and storage pads to withstand a 10,000-year earthquake, but insists that such measures are not necessary to claim a risk reduction factor of 5. The Applicant

offers an explanation for this position. The Applicant has quantified several major conservatisms with respect to CTB foundations and the storage pads, which would allow the CTB foundations and storage pads to withstand the seismic loads of a 10,000-year earthquake. *See Findings F.70-.72.* Moreover, when realistic considerations are included in the Applicant's calculations, these conservatisms manifest in much higher factors of safety against sliding, loss of bearing capacity, and overturning. For example, the factor of safety of the storage pads against sliding was calculated to be 1.27 in the east-west direction. Taking credit for passive resistance of the soil-cement around the pads would increase this factor of safety to 3.3. Or taking credit for greater soil shear strength under dynamic loading would increase the factor of safety from 1.27 to 1.9. Additionally, there are other conservatisms such as using worst-case static soil shear strength for the entire pad area; the cyclic nature of seismic loadings; and the difference between measured disturbed soil strength and in-situ soil strength. *See Findings F.72.*

As to the factor of safety against bearing failure, using load combinations allowed by Publication ASCE 4-86 written by the American Society of Civil Engineers, would increase the factor of safety for storage pads against soil-bearing-capacity failure (using 100% earthquake loads as horizontal loads) from 1.17 to 2.1. *See Findings F.73.* Taking credit for the dynamic strength of soils would further increase this factor of safety to 3.63. *See Findings F.75.*

The Applicant has also demonstrated that the factor of safety against pad overturning is 5.6 without taking into account any conservatism. *See Findings F.76.*

After reviewing the relevant evidence, the Board is persuaded that a risk reduction factor of at least 5 is available for the CTB foundations and storage pads. In this regard, for each of the three potential foundation failure mechanisms — sliding, loss of bearing capacity, and overturning — the Applicant has quantified and explained the major conservatisms in its assessment of the factors of safety involved. These conservatisms relate to concrete and verifiable principles such as passive resistance of soil-cement around the pads, dynamic strength of soils, cyclic nature of seismic loads, and the difference between measured disturbed soil strength and in-situ soil strength. The Applicant's quantification and explanation of these conservatisms demonstrate that sufficient margins exist to allow the CTB foundations and storage pads to withstand a 10,000-year earthquake, therefore supporting a risk reduction factor of at least 5.

e. Transfer Time Estimates

The Applicant's expert Dr. Cornell testified during the hearing that the risk reduction factors for the CTB have been shown to be a factor of 5 to 20 or more because, as he explained during the proceeding, the CTB and its components are typical of buildings at nuclear power plants that have a risk reduction factor

in that range. The State, however, challenges this assertion, claiming that the Applicant's presumed risk reduction factor of 5 to 20 is based on an incorrect transfer time estimate. According to the State, the Applicant's anticipated transfer time underestimates the time in which the canister potentially will be exposed and SSCs will be in use during transfer operations. *See* Findings F.80-.81.

We do not agree. As previously indicated, we find the Applicant's transfer time estimates reasonable, well explained, and accurate. Furthermore, the Board believes that the State's concern here regarding the transfer time estimates overlooks the primary reason the Applicant used a risk reduction factor of 5 to 20, namely that the CTB is similar to nuclear power plant buildings, which use a risk reduction factor in that range. Thus, the Board is persuaded that the CTB risk reduction factor will be in the range of 5 to 20, which the Board finds to be adequate.

D. NRC Staff's Justification for Granting Exemption

To fully evaluate the Applicant's seismic exemption request, the Staff conducted a technical review of the seismic and faulting hazard investigation proposed by the Applicant. *See* Findings F.82. Based on its review of the Applicant's analysis, the Staff determined that the Applicant's probabilistic seismic hazard analysis (PSHA) was conservative and adequately assessed the risks to the site.

The Staff's determination that the Applicant's PSHA was adequate was based upon several factors. The Staff found support for the PSHA from previous Commission actions that indicated apparent Commission approval for the use of such a method. The Staff was also influenced by its conclusion that the Applicant used an overly conservative seismic hazard assessment, which added an additional margin of safety to the Applicant's design. *See* Findings F.97-.98. An example of this conservative estimate can be found in the Applicant's conservative fault mode estimates used to create its hazard result calculations. *See* Findings F.90. The Staff also found the Applicant's site-to-source distance models used in determining the ground attenuation relationships and its fault-rupture-related maximum earthquake magnitude distributions to be conservative. *See* Findings F.91.

The Staff's decision to accept the exemption request was also based in part on the Applicant's demonstration that it has used an appropriate probability of exceedance for the DBE used in the design proposal. *See* Findings F.101. In that regard, the Staff was reassured by the fact that the radiological hazards associated with an ISFSI are much lower than those associated with a commercial nuclear power plant. *See* Findings F.102. The Staff also found support in previous instances in which seismic design ground motions with an annual probability of exceeding 5×10^{-4} were found to be appropriate. These instances included the Department of Energy's (DOE) issuance of DOE-STD-1020-94, "Natural

Phenomena Hazards Design and Evaluation Criteria for [DOE] Facilities'' and the Commission's 1998 approval of a 5×10^{-5} MAPE for seismic design ground motions at the TMI-2 ISFSI at INEEL. *See* Findings F.106. In examining these two instances, the Staff asserted that they provided significant relative technical and regulatory insight in deciding that a seismic design based on ground motions that have a MAPE of 5×10^{-4} is appropriate for the proposed PFS facility. *See* Findings F.107-.109. We examine both the DOE standard and the INEEL exemption in the following sections.

1. DOE Standard

The State attacks the Staff's reliance on the DOE standard, DOE-STD-1020-94, to support its determination and the Staff's subsequent disapproval of adopting the standard. Contrary to the State's claims, however, the Staff did not adopt the DOE standard, but instead used it as a reference point for its final decision. *See* Findings F.110. As the Staff's experts indicated during the hearing, the DOE standard uses a risk-graded approach in establishing the seismic hazard's mean probability of exceedance and the Staff's evaluation of the Applicant's request also relied upon the consideration of risk. *See* Findings F.111. Furthermore, although the DOE standard has been revised, the Staff, as it indicated during the hearing, is not obligated to follow such revisions. *See* Findings F.112-.113. For this reason, the Board finds that the revision of DOE-STD-1020-94, in DOE-STD-1020-2002, did not affect the Staff's conclusion to grant the seismic request.

2. INEEL Exemption for TMI Facility

The State also attacks the Staff's reliance on the exemption approval of the TMI ISFSI at INEEL as support for the Applicant's request, because, according to the State, the facts and site conditions are vastly different for the two facilities. For example, the State notes that the INEEL site is located on a federal reservation that is much larger than the Goshute Reservation and the nearest resident is located tens of miles from the facility. In contrast, the nearest neighbor is located only a few miles from the Skull Valley site. In addition, the State claims that the anticipated ground motions at the INEEL site are much lower than those anticipated at the PFS facility. For these reasons, the State insists that the INEEL facility cannot serve as support for the Staff's approval of the Applicants's exemption request. *See* Findings F.115-.116.

The Board finds the Staff was justified in using the INEEL ISFSI as support for granting the exemption request. Although, as the State points out, there are a number of differences between the two sites, the Board finds this does not undermine the support the INEEL exemption provides to the Staff's decision.

This finding is based on the observation that while INEEL was designed to a higher ground motion than the 2000-year return period, the Staff's approval of the INEEL exemption was based on the 2000-year return period. *See* Findings F.120. Thus, the Board finds that the INEEL exemption provides an adequate reference point for the Staff's decision to approve the Applicant's exemption request.

3. *The Geomatrix Probabilistic Seismic Analysis*

The State contends that the Staff's assertion that the Applicant's PSHA was conservative in nature is founded on: (1) erroneous premises, (2) questionable speculation about what the relative PSHA outcome should have been, and (3) a one-party analysis that is subject to scientific challenge. *See* Findings F.121. In presenting this challenge, the State notes that the Staff did not conduct its own PSHA. Instead, the Staff reviewed the geological and seismological inputs to the Applicant's PSHA and performed some independent analysis, notably the slip tendency analysis. *See* Findings F.122. According to the State, the Staff's analysis and its PSHA comparisons do not substantiate the Staff's claim that the Applicant's PSHA results are conservative. As an example, the State points to the Staff's assessment of the slip tendency and conclusion that the Applicant's analysis arrived at a conservative result; the State notes, however, that this blanket endorsement fails to recognize that other experts may draw different conclusions. *See* Findings F.122-.123. Furthermore, the State attacks the Staff's claim that the Applicant's PSHA is more conservative than the PSHA for nearby Salt Lake City, because as the State argues, this premise overlooks the fact that the fault sources near Salt Lake City are larger and more seismically active than fault sources near the proposed PFS site. *See* Findings F.125. As a result, the State argues that although the Applicant's PSHA model may be adequate, there is no support for the Staff's conclusion it is conservative. Thus, the State insists that we reject the Staff's decision to grant the Applicant's exemption request. *See* Findings F.129.

During the hearing, the Staff has explained its conclusion that the Geomatrix PSHA appears to be conservative in some detail. First, the Staff's expert insisted that the slip rate on the Wasatch Fault (near Salt Lake City) is roughly a factor of 10 greater than the slip rate on the Stansbury Fault (near the PFS site), even though the data in the Geomatrix report reflected only a factor of 3 difference. Notwithstanding this insistence, the Staff indicates that even a factor of 3 difference represents significant conservatism for the Geomatrix analysis, because a higher slip rate would cause a stronger earthquake. *See* Findings F.131. In addition, the Staff declares that on a crude basis, a valid comparison can be made to assess whether or not a seismic hazard curve is more conservative than another produced by a different PSHA, without a detailed scrutiny of the two different methodologies used in the PSHAs. The Staff also notes that each of the two seismic hazard curves in question was prepared by professional organizations,

the PFS site by Geomatrix, and the Salt Lake City site by the U.S. Geological Survey. *See* Findings F.132.

The Board agrees with the Staff's conclusion that the Geomatrix PSHA is conservative. The issue here does not need to be decided with extreme precision. The Staff's explanations that the slip rate for the Wasatch Fault near Salt Lake City is likely to be 3 to 10 times larger than that of the Stansbury Fault near the PFS site is supported by expert testimony with appropriate analysis and available data. Perhaps more importantly, the Board is persuaded that a reasonable comparison can be made between two seismic hazard curves performed by competent professional organizations to assess which one is likely to produce a larger earthquake and without the need for detailed scrutiny of every detail in the two different models.

4. Comparison of the Applicant's Design Proposal with Utah's Standards for Highway Bridges

During the hearing, the State also raised concerns because certain Utah buildings and highway bridges are designed for a 2500-year earthquake, which is more stringent than the 2000-year mean return period approved by the Staff for the PFS facility. *See* Findings F.133. This comparison fails to account, however, for the "two-handed approach" used by the Applicant in designing the proposed facility, which results in the design procedures and criteria for highway bridges designed for a 2500-year earthquake being much less conservative than those specified for nuclear power plant SSCs. *See* Findings F.134-.135. Ultimately, because the power plant SSCs contain much higher risk reduction factors, these structures are much stronger and able to withstand much larger ground motions than a structure such as a highway bridge that has a more frequent mean return period. *See* Findings F.136. Although the Board finds that the State was justified in raising this concern, we conclude, based on our exhaustive questioning during the hearing, that the State's concerns have been adequately addressed.

E. Board Conclusions

The Board finds that the Staff's approval of the seismic exemption request was justified. Despite the Board's initial discomfort with the *perception* that the requested seismic exemption would utilize a 2000-year mean return period, less stringent than the 2500-year earthquake standard for certain Utah buildings and highway bridges, we are persuaded that in *reality* the significant safety margins embedded in the "two handed approach" provide reasonable assurance that the 2000-year mean return period is not only adequate, but is in practice more

stringent than the Utah 2500-year standard. Thus, the Utah standard provides no basis for disapproval of the seismic exemption request.

VIII. COMPLIANCE WITH THE RADIATION DOSE LIMITS

The Board finds that the Commission standards governing offsite dose consequence are quite clear. The Commission has established an offsite radiological dose limit of 25 millirem (mrem) to the whole body during normal operations and a total effective dose equivalent of 5 rem for a design basis accident. *See* 10 C.F.R. §§ 72.104(a), 72.106(b). *See also* Findings G.2-.4.

During the course of the proceeding the State suggested that a DBE must not result in dose consequences that exceed the standard of 25 mrem established in 10 C.F.R. § 72.104(a). *See* Findings G.1. The Board finds this suggestion to be without merit. The Commission's regulations clearly establish that in the event of a design basis accident, such as a cask tip-over event or a DBE, the dose consequences must not exceed a total effective dose of 5 rem as established in 10 C.F.R. § 72.106(b). The Board may not hold the Applicant to a more stringent dose limit than what the regulations require.

A. Dose Consequences Analysis Conducted by the Applicant

To examine the normal operational dose rates at the proposed facility, Holtec performed a study in which it determined the direct radiation dose rate at the controlled area boundaries based on the amount of radiation emanating from the sides and tops of 4000 casks. The results of the study demonstrate a maximum dose rate of 5.85 mrem per year.³²

Holtec also analyzed a hypothetical tip-over event to demonstrate the dose consequences of such an event. According to Holtec's results, a cask tip-over would not release any radioactivity to the surrounding environment. Holtec also determined that a cask tip-over would cause some local deformation to the cask, but that it would not affect the cask's shielding performance. *See* Findings G.6-.8.

In addition, Holtec evaluated the radiological dose consequences of a hypothetical multiple-cask tip-over event. The results of this analysis also demonstrated some localized deformation to each of the casks, but there was no significant aggregate increase of radiological doses at the facility boundary. This analysis also examined the effect of all the casks tipping over at once and determined that there would be minimal effect on the overall dose consequence rate. *See*

³²*See* Findings G.5. This calculation assumed a 2000-hour/year (h/yr) occupancy rate at the controlled border and that all 4000 casks contained fuel with a burnup of 40,000 MWD/MTU and a cooling time of 10 years. *See id.*

Findings G.9-11. Thus, the Applicant argues that the proposed design meets the requirements established in 10 C.F.R. § 72.106(b).

1. Time Spent at the Boundary

The Applicant's analysis for radiation dose limits used a 2000-hour/year (h/yr) occupancy time to calculate normal operating dose levels.³³ The Applicant based its calculation on the Commission's regulations, which state that the dose limits are established for any real individual that is located along the boundary of the facility. Thus, the Applicant contends that the dose-limit calculations must take site specifications into account — namely, that there is no one living or likely to live near the facility and therefore the average site worker is the real person targeted by the regulation. *See* Findings G.13.

Contrary to the Applicant's position, the State argues that the radiation dose limits should be based upon 8760 h/yr. The State's calculations assume that an individual is situated at the facility boundary for 24 hours a day, 365 days a year. According to the State, this calculation is consistent with the language in 10 C.F.R. § 72.106(b) that refers to any individual located near or beyond the facility's boundary. Furthermore, the State contends that its position finds support in the fact that PFS has no ability to keep people from its border because it does not own the property. *See* Findings G.14-16.

The Board finds that the Applicant's use of 2000 hours is adequate. The State's reliance on 10 C.F.R. § 72.106(b) as support for its calculation is incorrect, because, as previously discussed, section 72.106(b) applies to accident dose rates — not the dose rates for everyday operations. In addition, although the Applicant has no control over the land at its borders, given the current condition of that land and the belief that few individuals will desire such land in the future, the Board finds insufficient support for this argument. Thus, the Board concludes that the Applicant has established adequate support for its use of 2000 h/yr as the occupancy time for its radiological dose calculations.

2. Tip-Over Analysis

Although none of the studies demonstrate that the casks will tip over, the Applicant and the Staff nonetheless have performed radiological dose calculations assuming that such an event will occur. These calculations demonstrate that, even in the unlikely event that the casks do tip over, any resulting radiological release will be well within the Commission's allowable limits. *See* Findings G.19-38.

³³ This 2000-h/yr level was based upon a worker at the site boundary for 40 hours per week for 50 weeks per year. *See* Findings G.13.

a. Duration of the Event

During the hearing, the Applicant and the Staff testified that they both assumed that an accident event such as a cask tip-over would not last more than 30 days. The State argues that there is no evidence in the record to support such an assumption. Further, the State argues that the Applicant does not have a contingency plan for uprighting casks once they tip over. In this regard, the State contends that even if a contingency plan were in place, the Applicant could not rely upon such a plan when calculating the radiation dose consequences for a facility accident. *See Findings G.19-.20.* According to the State, the standards in 10 C.F.R. § 72.106(b) are for facility design, and to allow an Applicant to insert a contingency measure into its design criteria would violate the Commission's principle of defense-in-depth. *See Findings G.22-.23.*

Even assuming that the State is correct and an accident could not be fixed in 30 days, the 5-rem dose limit would not be exceeded, given the estimated dose rate, even if it took the Applicant as long as 36 years to correct the situation. Furthermore, the Board finds the State's concern that the Applicant cannot take credit for a contingency plan to rectify an accident scenario is without merit. *See Findings G.24.* A reasonable assumption in an accident scenario is that the Applicant will take whatever steps are necessary to mitigate the situation — such as by building a protective berm or by evacuating the surroundings — as soon as possible. Thus, the Board finds the Applicant's 30-day estimate to be adequate.

b. Multiple-Cask Tip-Over Versus Single-Cask Tip-Over

The State argues that in the event of a multicask tip-over, the orientation of the casks — namely the number of casks facing in the outward direction — will have a significant effect on the radiological dose rates. *See Findings G.25.* Both the State and Staff's analyses of multicask tip-over assumed that one full row of casks tipped over with the cask bottoms faced in the outward direction. *See Findings G.26-.27.* The State contends that assuming this configuration allows the analyst to create a conservative but reasonable estimate of the potential dose levels one might experience in the event of a multicask tip-over. The State requests that the Board require the Applicant to redo its multicask tip-over analysis using this more conservative configuration. *See Findings G.28.*

The State's request is without merit. In the event of a multicask tip-over event, the orientation of the tipped-over casks will likely be random, as assumed by the Applicant's analysis. *See Findings G.29.* Even if such an event were to result in all of the cask bottoms facing in the outward direction, the radiological dose levels would not exceed the levels established by 10 C.F.R. § 72.106(b). *See Findings G.30.* Thus, the Board finds the Applicant's analysis to be adequate.

c. Angular Velocity

The State experts also attack the Holtec tip-over analysis because they believe that Holtec incorrectly assumed that the initial angular velocity of a falling cask would be zero. Although the State contests Holtec's angular velocity, the State experts failed to provide an angular velocity of their own. *See Findings G.31-.32.* Furthermore, we believe that, contrary to the State's claim, the Holtec analysis provides an adequate explanation to support the use of a zero angular velocity. For these reasons, the Board finds the Applicant's use of an initial velocity of zero in its tip-over analysis to be correct. *See Findings G.33-.34.*

d. Deceleration

In his prefiled direct testimony, the State's expert Dr. Resnikoff indicated a concern that the top of the HI-STORM cask may decelerate at a rate in excess of 45g. This was based on the understanding that the Commission has placed a 45g limit on the deceleration of the top of the cask in the HI-STORM SAR. During the hearing, however, the testimony of the Staff and Applicant witnesses demonstrated that although the licensing limit is 45g, the spent fuel assemblies have been constructed to withstand accelerations of at least 63g. *See Findings G.35-.36.* Moreover, the Applicant's analysis demonstrates convincingly that under no circumstances will an accident result in accelerations that exceed 45g. For this reason, the Licensing Board finds Dr. Resnikoff's concern to be unfounded. *See Findings G.37-.38.*

3. Dose Calculations

Dr. Resnikoff's prefiled direct testimony also contained two radiation dose calculations that the State asserts refute the dose calculations of the Holtec analysis. Dr. Resnikoff's two calculations were an estimation of the gamma dose released from the bottom of eighty casks that had been tipped over and an estimation of the neutron doses from a cask based on the amount of water evaporation from the concrete shielding. *See Findings G.40.* During the hearing, however, Dr. Resnikoff corrected his calculations in numerous places, due in part to his own analysis and due also to the Applicant's cross examination. *See Findings G.43-.44.*

Due to the discovered errors to Dr. Resnikoff's own testimony in which he admitted that it is unlikely that the accidental dose rate at the facility would ever reach the 5-rem limit, the Board finds his attack on the Applicant's dose rate calculations to be unfounded.

This concludes the narrative portion (Parts I through VIII) of our decision. A table of contents for Part IX, which goes into these matters in more detail, begins on the next page.

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IX. DETAILED ANALYSIS OF RECORD AND FINDINGS OF FACT

A. Site Design and Layout

1. Design and Location

A.1 PFS proposes to construct and operate a dry cask storage ISFSI in which up to 4000 steel and concrete casks, each containing 10 metric tons of spent nuclear fuel, would be placed on reinforced concrete storage pads at its proposed site. Under the PFS proposal, up to eight loaded storage casks would be placed on each pad, which in turn would be arranged in a 25 × 20 array (i.e., up to 500 pads)

occupying approximately 99 acres. Each pad would be constructed of reinforced concrete, and would be 30 feet wide, 67 feet long, and 3 feet thick. Consolidated Safety Evaluation Report for the Proposed Private Fuel Storage Facility (Mar. 2002) at 1-1, 1-2, and 5-8 (Staff Exh. C) [hereinafter SER]; Staff Exh. X.

A.2 In accordance with 10 C.F.R. § 72.42, the PFS facility would be initially licensed for 20 years. Before the end of this 20-year term, PFS could submit an application to renew the license. If granted, all spent fuel will be transferred offsite and the facility will be ready for decommissioning by the end of the second term. SER at 1-1.

A.3 The proposed PFS site is located in the northwest corner of the Reservation of the Skull Valley Band of Goshute Indians, and will cover 820 acres of the Reservation's 18,000 acres. The Reservation is geographically located in Tooele County, Utah, 27 miles west-southwest of Tooele City, Utah, about 50 miles southwest of Salt Lake City, Utah, and 14 miles north of the entrance to the Dugway Proving Ground in Tooele County, Utah. SER at 1-1, 2-3. No large towns are located within 10 miles of the proposed site. The Skull Valley Band of Goshute Indians' Village, which has about 30 residents, is 3.5 miles east-southeast of the site. SER at 1-1. The nearest residence is located about 2 miles from the site. Approximately 36 people live within 5 miles of the site. No transient or institutional populations are present within 5 miles of the site, and no public facilities are expected to be located in the vicinity. SER at 2-4.

A.4 Interstate Highway 80 and the Union Pacific Railroad main line are approximately 24 miles north of the site. Shipping casks approved under 10 C.F.R. Part 71 will be used to transport the SNF to the facility. The shipping casks will either be off-loaded at an intermodal transfer point near Timpie, Utah, and loaded onto a heavy-haul tractor/trailer for transporting to the facility, or transported via a new railroad line connecting the facility directly to the Union Pacific main line. The facility will be accessed by a new road from the Skull Valley Road as shown in Figure 1.1-1 of the Applicant's SAR. SER at 1-1.

A.5 The facility is designed to store up to 40,000 metric tons of uranium (MTU) in the form of spent fuel from commercial nuclear power plants (NPPs) in sealed metal canisters. The spent fuel assemblies are placed in sealed canisters, which are then placed inside a steel and concrete storage cask. The ISFSI, consisting of approximately 4000 storage casks, is passive and does not rely on active cooling systems. *Id.*

A.6 The facility's restricted area is approximately 99 acres surrounded by a chain-link security fence and an outer chain-link nuisance fence. An isolation zone and intrusion detection system are located between the two fences. The cask storage area that surrounds the concrete cask storage pads that support the storage casks is surfaced with compacted gravel that slopes slightly to allow for runoff of storm water. Each concrete pad supports up to eight storage casks in a 2 × 4 array. The CTB, where canisters are transferred from the shipping cask to

the storage cask, is located within the restricted area. An overhead bridge crane and a semi-gantry crane are located within the CTB to facilitate shipping-cask loading/unloading operations and canister transfer operations. SER at 1-1 to 1-2.

A.7 The dry cask storage system that has been identified for use at the facility is the HI-STORM 100 Cask System, designed by Holtec. The cask system is a canister-based storage system that stores spent fuel in a vertical orientation. It consists of three discrete components: the MPC, the HI-TRAC transfer cask, and the HI-STORM 100 storage overpack. The MPC is the confinement system for the stored fuel. The HI-TRAC transfer cask provides radiation shielding and structural protection of the MPC during transfer operations. The storage overpack provides radiation shielding and structural protection of the MPC during storage. The cask system stores up to twenty-four pressurized water reactor fuel assemblies or sixty-eight boiling water reactor fuel assemblies. The HI-STORM 100 Cask System is passive and does not rely on any active cooling systems to remove spent fuel decay heat. SER at 1-2.

A.8 The spent fuel is loaded into the MPCs at the originating NPP. Before transport, the MPC's lid is welded in place and the canister is drained, vacuum dried, filled with an inert gas, sealed, and leak tested. Shipping casks that are approved under 10 C.F.R. Part 71 (e.g., the HI-STAR 100 transportation cask) are used to transport the MPCs from the originating power plants to the facility. At the facility, the shipping cask is lifted off the transport vehicle and placed in a shielded area of the CTB, called a transfer cell. The MPC is transferred from the shipping cask to the transfer cask, then from the transfer cask into the storage cask. The storage cask, loaded with the MPC, is then closed, and moved to the storage area using a cask transporter and placed on a concrete pad in a vertical orientation. *Id.*

A.9 The HI-STORM 100 storage cask is approximately 20 feet tall (239.5 inches) and about 11 feet in diameter (132.5 inches); when loaded with a spent fuel canister, it will weigh approximately 180 tons. The steel and concrete cylindrical walls of the cask form a heavy steel weldment, consisting of an inner and outer steel shell within which the shielding concrete is installed; these walls in the radial direction are approximately 30 inches thick. The cask has four air inlets at the bottom and four air outlets at the top, to allow air to circulate naturally through the annular cavity to cool the MPC within the storage cask. *See* Testimony of Krishna P. Singh and Alan I. Soler on Unified Contention Utah L/QQ [hereinafter referred to as Singh/Soler], Post Tr. 5750, at 7.

A.10 The HI-STORM 100 Cask System has been approved by the NRC for use under the general license provisions of 10 C.F.R. Part 72, Subpart K. *See* SER at 1-2. The HI-STORM 100 Cask System is approved under Certificate of Compliance No. 1014, effective May 31, 2000 (Docket No. 72-1014) (Staff Exh. FF). The Staff's evaluation of the cask system for general use is documented in

the NRC's SER report for the HI-STORM 100 Cask System, issued with the CoC. SER at 1-2.

A.11 Notwithstanding the NRC's issuance of a general CoC for the HI-STORM 100, PFS evaluated the cask system against the parameters and conditions specific to the PFS facility, in order to establish the acceptability of that system for site-specific use at the PFS facility. Based on the Applicant's evaluation and its own evaluation, the Staff also found that the HI-STORM 100 Cask System acceptable for use at the PFS facility under the site-specific license provisions of 10 C.F.R. Part 72. SER at 1-2.

A.12 The Applicant has identified certain organizations as responsible for providing the licensed spent fuel storage and transfer systems and engineering, design, licensing, and operation of the facility — certain officials or employees of which testified in this proceeding. Holtec is responsible for the design of the HI-STORM 100. Stone & Webster is responsible for the design of the facility. The Applicant has overall responsibility for planning and design of the facility, using Stone & Webster as a contractor. The Applicant is also responsible for the operation of the facility and for providing quality assurance (QA) services. SER at 1-3.

2. *The Geologic Setting of the Proposed Facility*

A.13 The proposed site is located on a typical valley floor of the local Basin and Range topography. Skull Valley is a north-trending valley that extends from the Onaqui Mountains to the southwest shore of the Great Salt Lake. The Stansbury Mountains lie to the east of the site and separate the site from Tooele City, Utah, about 27 miles to the northeast. The Cedar Mountains are approximately 14 miles to the west and separate the facility from portions of the Utah Test and Training Range within the Great Salt Lake Desert. Skull Valley, Utah, has little population and limited agriculture, although a cattle ranch is located on the north border of the facility. SER at 2-3, 2-22.

A.14 As summarized in the Applicant's SAR, the proposed site is located in the northeastern margin of the Basin and Range Province, a wide zone of active extension and distributed normal faulting that extends from the Wasatch Front in central Utah to the Sierra Nevada Mountains in western Nevada and eastern California. Topography within the Basin and Range Province reflects Miocene to recent, east-west extensional faulting, in which tilted and exhumed footwall blocks form subparallel north-south striking ranges separating elongated and internally drained basins. Ranges are up to 700 kilometers long with elevations up to 6500 feet above the basin floors. Much of the surface faulting took place at the base of the ranges along normal faults that dip moderately (approximately 60 degrees) beneath the adjacent basins (herein defined as range-front faults), although complex faulting within the basins is also common. SER at 2-28.

A.15 The proposed site in Skull Valley lies in one of the typical basins of the province, bounded on the east by the Stansbury Mountains and the Stansbury Fault and on the west and south by the Cedar Mountains and the East Cedar Mountain Fault. The basin is underlain by late Quaternary lacustrine deposits laid down from repeated flooding of the valley during transgressions of intermontane lakes, most notably Lake Bonneville, which flooded Skull Valley several times during the Pleistocene and Holocene. These deposits form the basis for paleoseismic evaluations of the Skull Valley site. Topography of the proposed site is relatively smooth, reflecting the origin of the valley floor as the bottom of Lake Bonneville. The site gently slopes to the north with a slope of less than 0.1 degree. Detailed topographic maps of the region and the site were provided in the SAR. This smooth valley floor contains small washes up to 4 feet deep and soil ridges up to 4 feet high. SER at 2-29.

A.16 The geomorphology of Skull Valley in the vicinity of the site is typical of a semiarid to arid desert setting. The adjacent mountain ranges are affected by mass-wasting processes and stream erosion that deliver sediment loads to a complex of alluvial fans (aprons) situated at the bases of the ranges. Runoff is conveyed down the ranges and over the alluvial fans through a series of small channels to the valley floor. Stream and spring flows are absorbed into the fan and the valley floor near the fan-floor interface, resulting in minimal surface runoff reaching the central valley near the site. There is no evidence of flash-flooding near the site nor are there deposits indicative of geologically recent mudflows or landslides occurring within the last 2 million years (Ma). *Id.*

A.17 The valley floor near the site comprises beach ridges and shoreline deposits interrupted by bedrock outcrops, such as Hickman Knolls rising about 400 feet above the valley bottom. The valley bottom relief comprises a series of braided, northerly flowing dry washes. The washes are disrupted and convey runoff for only short distances before merging into other washes or open space. This network of shallow washes extends offsite to the north where it confluences with the central valley drainage system and from there flows to the Great Salt Lake. The only perennial surface water is located approximately 10 miles north of the site. The central valley in the vicinity of the facility is unaffected by fluvial processes. *Id.*

A.18 In the southern and eastern parts of the proposed site, numerous north-trending linear sand ridges interrupt the otherwise smooth valley floor. The ridges, which are typically 8 feet high and 100 feet wide, were originally mapped as possible fault traces. In the SAR, the Applicant reviewed the available surficial information and concluded that these features constitute sandy beach ridges deposited by southward longshore transport within the Stansbury shoreline coastal zone of Lake Bonneville. The Applicant provided technical information about the nature and origin of the ridges which substantiated its conclusion that these ridges have a depositional origin. SER at 2-29.

A.19 In a few locations, bedrock composed of Paleozoic carbonate rocks crop out of the smooth valley floor. The largest of these is a small group of hills 1.3 miles south of the proposed site known as Hickman Knolls. Rocks of this outcrop are medium to dark gray dolomite breccia. The origin and stratigraphic correlation of the Hickman Knolls carbonate rocks within the Paleozoic section is not well known. The preferred interpretation put forth by Geomatrix Consultants, Inc. (Geomatrix) is that they are rooted bedrock outcrops. The alternative interpretation based on independent modeling of gravity data by the Staff is that they are landslide deposits, resting unconformably on the Tertiary sediments in the valley.³⁴ The differences in these two interpretations lead to differences in the estimated seismic hazard. In the Geomatrix preferred interpretation, rooted bedrock requires a significant and seismogenic fault just west of Hickman Knolls. In the alternative interpretation, no such fault is necessary. Therefore, the Geomatrix-preferred interpretation leads to a slightly more conservative seismic hazard. SER at 2-29 to 2-30.

A.20 The SAR discusses the geological history of the site and surrounding region. The discussion includes background information about the tectonic setting of the region in the Precambrian and Paleozoic that led to the deposition of the bedrock stratigraphy presently exposed in the Stansbury and Cedar Mountains. In brief, the structural framework of bedrock across the region reflects overprinting of several major periods of North American tectonic activity. These include contractional deformation structures such as thin- and thick-skinned thrusts and folds associated with the Devonian Antler, Jurassic to Cretaceous Sevier, and Cretaceous-Tertiary Laramide orogenies, and extensional normal and detachment faults associated with the Eocene to the current Basin and Range extension. SER at 2-30.

A.21 As noted above, the proposed site lies near the center of a typical Basin and Range valley, situated between roughly north-south and northwest-southeast elongated ranges of exhumed bedrock. Exhumation of the ranges was accomplished by extensional faulting along range-front normal faults. Faulting tilted the ridges to the east. The adjacent basins subsided concomitant with exhumation while they accumulated sediment shed from the eroding ranges. In Skull Valley, as in much of central and western Utah, the valleys are also flooded by transgressions of the intramontane saline lakes. Tertiary and Quaternary deposits in and around the site document numerous transgressions associated with Lake Bonneville and pre-Lake Bonneville lacustrine cycles. Most important to the evaluations of seismic and faulting hazards was identification and characterization

³⁴ See generally “Seismic Ground Motion and Faulting Hazard at Private Fuel Storage Facility in the Skull Valley Indian Reservation, Tooele County, Utah — Final Report,” by John A. Stamatakos, Rui Chen, Martin W. McCann, Jr., and Asadul H. Chowdhury, Center for Nuclear Waste and Regulatory Analysis (Sept. 1999) (Staff Exh. Q) [hereinafter CNWRA Report].

of a detailed Quaternary stratigraphy that provided critical constraints on faulting activity and local and regional active faults. SER at 2-30 to 2-31.

A.22 Valley fill consists of interstratified colluvium, alluvium, lacustrine, and fluvial deposits with minor ash and some eolian material. The coarser deposits are generally near the perimeter of the valley, grading into well-sorted sand and gravel and interlayered with lacustrine silt and clay toward the center of the valley. Thick beds of clay exist in some areas, with sand and gravel along the alluvial fans. The Salt Lake Group of the Tertiary age comprises most of the valley fill with a thickness ranging from 2000 to over 8000 feet. SER at 2-22. The Applicant has classified the subsurface material at the proposed site as a relatively compressible top layer, approximately 25 to 30 feet thick, that is underlain by much denser and stiffer material. The underlying layer is classified as dense sand and silt. SER at 2-23.

A.23 Valley-fill sediments in Skull Valley consist of Tertiary age siltstones, claystones, and tuffaceous sediments overlain by Quaternary lacustrine deposits. Late Miocene to Pliocene deposits of the Salt Lake Formation were exposed in Trench T1 and in Boring C-5. Microprobe analyses of glass shards from vitric tuffs (ashfall deposits) within the sediments were used to correlate the tuffs with volcanic rocks of known age. The analyses indicate ages for the stratigraphic units between 16 and 6 Ma consistent with the known age of the Salt Lake Formation. During the Quaternary (approximately the last 2 Ma), especially the last 700,000 years (700 ka), sedimentation in Skull Valley was dominated by fluctuations associated with lacustrine cycles in the Lake Bonneville Basin. The SAR provides a detailed analysis of these deposits from trenches, test pits, and borings, including two radiocarbon ages on ostracodes and charophytes. SER at 2-31.

A.24 The stratigraphy was also critical to interpretations of the reflection seismic profiles. Two prominent paleosols were developed during interpluvial periods near the Tertiary-Quaternary boundary (approximately 2 Ma) and between the Lake Bonneville and Little Valley cycles (130–28 Ka). These buried soils are characterized by relatively well-developed pedogenic carbonate, both in the soil matrix and as coatings on pebbles. As such, these paleosols form strong reflectors that are readily apparent on the seismic reflection profiles. These horizons were also correlated with cores from the borings drilled directly beneath the seismic profile lines. These constraints on the Quaternary stratigraphy and the high-quality seismic reflection profiles provided in the Geomatrix report are sufficient to document the Quaternary faulting record of the site and to provide a stratigraphic framework for reliable paleoseismic analyses of active faults in and around Skull Valley. SER at 2-31.

A.25 The Applicant has investigated the structural geologic conditions affecting its proposed site, with considerable attention given to the faults and structures identified therein. Classical structural models for the Basin and Range

envision a simple horst and graben framework in which range-front faults are planar and extend to the base of the transition between the brittle and ductile crust, 9 to 12.5 miles below the surface. More recent work has shown that many normal faults are not planar but curved or listric, and they sole into detachments that may or may not coincide within the brittle-ductile transition in the crust. In Skull Valley, the detachment model places the Stansbury Fault as the master or controlling fault of a half graben. The other side of the half graben would include the antithetic East Cedar Mountain Fault and a series of antithetic and synthetic faults within the basin, all of which would sole into the Stansbury Fault 1 to 12.5 miles deep in the crust. *Id.*

A.26 Geomatrix developed a model with two regional cross sections that depict the overall structural framework of Skull Valley and the surrounding ranges. These cross sections were constructed from a compilation and analysis of existing geological map data, reprocessed and new seismic profiles across the valley, and interpretation of proprietary gravity data. The cross sections depict a series of pre-Tertiary folds and thrusts related to the Sevier and older contraction deformations that have been cut by a series of Tertiary and Quaternary normal faults related to Basin and Range extension. The normal faults are considered moderately dipping (approximately 60 degrees) planar features following the horst and graben model. SER at 2-31 to 2-32.

A.27 As discussed in the seismic study of the PFS facility conducted by the Center for Nuclear Waste and Regulatory Analysis (CNWRA), the Staff considers that this horst and graben model is conservative for predicting a maximum earthquake potential for these faults. *See* SER at 2-32; CNWRA Report. Faults that extend all the way to the base of the seismogenic crust define a larger area for earthquake rupture and thus greater maximum magnitude earthquakes than those that terminate into a detachment above the brittle-ductile transition. SER at 2-32.

A.28 The cross sections show three first-order, west-dipping normal faults and one east-dipping fault (the East Cedar Mountain Fault). The west-dipping faults are the Stansbury and two previously unknown faults in the basin informally named the East and West faults. These new faults were interpreted based mainly on analyses of the gravity and seismic reflection data and by analogy to other faults in the Basin and Range. Discovery of these new faults and related structures was found to have important implications for both the seismic and fault displacement hazard assessments. *Id.*

A.29 Finally, within the valley fill, the Applicant's SAR documented several additional secondary faults designated as fault zones A to F. Each fault zone has a number of secondary splays that are designated with numeral subscripts (e.g., A1 to A7, B1 and B2, and so forth). These fault zones are all considered secondary faults related to deformation of the hanging wall above the larger East and West faults. They are too small to be independent seismic sources but large enough to be considered important in the fault displacement analysis. The largest of the

secondary faults is the F fault, which appears to be a splay of the East fault. SER at 2-33.

B. Characterization of Subsurface Soils

B.1 “The Commission’s requirements governing the characterization of subsurface soils for an ISFSI are set forth in 10 C.F.R. Part 72. In general, 10 C.F.R. § 72.90 requires an evaluation of site characteristics that may directly affect the safety or environmental impact of the proposed facility.” NRC Staff Testimony of Goodluck I. Ofoegbu Concerning Unified Contention Utah L/QQ, Part C [hereinafter Ofoegbu] Post Tr. 11,001, at 3. Specific requirements for the characterization of the subsurface soils are found in 10 C.F.R. § 72.102. *See id.*

B.2 Section 72.102(c) of 10 C.F.R. states “[s]ites other than bedrock sites must be evaluated for their liquefaction potential or other soil instability due to vibratory ground motion.” Additionally, 10 C.F.R. § 72.102(d) states “[s]ite-specific investigations and laboratory analyses must show that soil conditions are adequate for the proposed foundation loading.”

1. Subsurface Soils at the Proposed Facility

B.3 With respect to its subsurface field investigations, PFS utilized multiple techniques in characterizing the subsurface soils at the proposed site and assessing their adequacy for the proposed foundation loadings. These techniques included, *inter alia*, soil borings (including visual field classification of drill cuttings and split-spoon samples and the collection of undisturbed soil samples), standard penetration tests (SPTs), dilatometer tests (DMTs), in situ cone penetrometer tests (CPTs), seismic CPTs (which provided measurements of pressure and shear wave velocities in addition to penetration resistance data), downhole geophysical measurements, and the excavation of test pits and trenches. *See* Joint Testimony of Paul J. Trudeau and Anwar E.Z. Wissa on Section C of Unified Contention L/QQ [hereinafter Trudeau/Wissa] Post Tr. 10,834, at 5-8; SER at 2-55. The locations of the various soil borings, CPTs and DMTs, and test pits at the PFS site are shown in Figures 2.6-2, 2.6-18, and 2.6-19 of the SAR. Trudeau/Wissa Post Tr. 10,834, at 6; PFS Exh. 235. The results of these various investigations are presented in Section 2.6 and Appendix 2A of the SAR and visually manifested in the form of geologic maps and site stratigraphy or “foundation” profiles that are also provided in the SAR. *See* Trudeau/Wissa Post Tr. 10,834, at 5-6.

B.4 The seventeen foundation profiles provided by PFS in Figures 2.6-5 and 2.6-20 to 2.6-22 of the SAR (two diagonal, six east-west, and six north-south lines in the pad emplacement area, and two east-west lines and one north-south line in the CTB area) depict the subsurface soil composition in the vicinity of all

safety-related structures at the proposed site. *See* Trudeau/Wissa Post Tr. 10,834, at 6. These profiles demonstrate the nature, location, and thickness of the various soil layers underlying the proposed PFS site. *See id.* at 6-8.

B.5 Based on the information obtained from its geotechnical investigations, the Applicant was able to characterize the subsurface soil profile — for geotechnical engineering purposes — as consisting of two layers. *See* Ofoegbu Post Tr. 11,001, at 6. Layer 1, a relatively compressible top layer that is approximately 25 to 30 feet thick, consists of a mixture of clayey silt, silt, and sandy silt with occasional silty clay and silty sand. *See id.*; SER at 2-55 to 2-56. As reflected in the seventeen foundation profiles (*see* PFS Exhs. 233, 233A), Layer 1 can be further subdivided into four sublayers (in top-down order): Layer 1A, classified as eolian silt, is typically about 3 to 5 feet thick; Layer 1B, a silty clay/clayey silt mixture that varies in thickness from about 5 to 10 feet;³⁵ Layer 1C, a mixture of clayey silt, silt, and sandy silt, with thickness of about 7.5 to 12 feet; and Layer 1D, a silty clay/clayey silt mixture with maximum thickness of about 5 feet.

2. Factors of Safety for the Applicant's Design

B.6 The primary purpose of soil characterization is to gather sufficient information on the characteristics, properties, and variability of the soils to establish their capacity to resist foundation loading with an acceptable factor of safety. State of Utah Testimony of Dr. Steven F. Bartlett on Unified Contention L/QQ (Soil Characterizations) [hereinafter Bartlett] Post Tr. 11,822, at 4. In general, factors of safety are expressed as the capacity of the system to resist failure divided by the demand placed on the system by the seismic event and other foundation loads. *Id.* at 3. The capacity of the foundation is primarily a function of the soil's shear strength and the type, flexibility, and embedment of the foundation. The demand on the system is primarily a function of the intensity (i.e., amplitude) of earthquake strong ground motion and the mass and frequency of vibration of the foundation and the overlying structure. *Id.*

B.7 The State insists that for extreme environmental events, such as earthquakes, a factor of safety of at least 1.1 is considered inviolable. Tr. at 11,845-48 (Bartlett). During the hearing, the State pointed out that a factor of safety of 1.1, or 10%, is widely used in the engineering profession (Tr. at 10,802 (Ebbeson); Tr. at 6163-64 (Trudeau)); it is the acceptance criterion in NUREG-0800, § 3.8.5, Section II, Subpart 5, Structural Acceptance Criteria for Seismic Category I

³⁵ In the Applicant's prefiled testimony on Part C issues, Mr. Trudeau referred to Layer 1B as "Layer 2." Trudeau/Wissa Post Tr. 10,834, at 8. The parties acknowledged this difference in nomenclature during the hearing, and Mr. Trudeau explained that his reference to "Layer 2" was in fact a reference to the Layer 1B or upper Lake Bonneville soils (located approximately 3 to 10 feet below the ground surface). *See* Tr. at 11,732, 11,815-16, 11,834-35 (Trudeau).

Structures, at 3.8.5-7 (State Exh. 93), and has been adopted by PFS as a minimum design requirement in its seismic stability calculations for the storage pads and CTB. Stability Analysis of Canister Transfer Building (PFS Exh. VVV) at 21-24 [hereinafter CTB Analysis]; Stability Analyses of Cask Storage Pads (PFS Exh. UUU) at 22-26 [hereafter Pad Analysis]; Tr. at 6163, 6169 (Trudeau).

B.8 The State challenges the Applicant's demonstration that the dynamic forces and the capacity of the soils have been properly described and used in the Applicant's calculation of a 1.1 factor of safety against sliding, bearing capacity, and overturning of the pads and the CTB. Tr. at 11,845 (Bartlett). According to the State, the Applicant is relying primarily on the shear strength of the soils to resist earthquake forces. *See* Tr. at 11,849-50 (Bartlett). In its seismic calculations, the Applicant computes factors of safety against sliding of 1.27 for the pads and 1.26 for the CTB, and 1.17 against bearing capacity failure of the pads for its design basis case. Bartlett Post Tr. 11,822, at 5-6; Tr. at 11,843 (Bartlett). The State argues that, based on the PFS calculated design values, there is a 6% to 15% margin in the PFS assumed capacity of the soils used in its design calculations before it would reach unacceptable performance. Bartlett Post Tr. 11,822, at 5-6. For this reason, the State insists that the soundness of the Applicant's sampling, characterization, analysis, and testing program of site soils is critical to the Applicant's demonstration that the site soils are adequate for the proposed foundation loadings and to show an adequate margin of safety against potential failure during an earthquake. *See* State Findings ¶ 11.

B.9 Although the State contends that a factor of safety of at least 1.1 against the various soils failure modes in an earthquake is "inviolable," the NRC Staff testified that it is not necessary to meet a factor of safety of 1.1 against soils failure to satisfy NRC regulatory requirements in 10 C.F.R. Part 72. Tr. at 6594-96 (Ofoegbu). As explained by the Staff, all that Part 72 requires is that the SSCs important to safety be shown to perform their safety functions when subjected to seismic loadings. *Id.* The foundation stability analyses performed by PFS demonstrate that this condition will be met, whether or not the factor of safety guidelines is satisfied. *Id.*

B.10 The Board finds that the Applicant's foundation stability analyses demonstrate that there are sufficient margins against the onset of soil failure. The minimum factors of safety calculated by PFS against sliding and bearing capacity failure of the pads are 1.27 and 1.17 (or 27% and 17%), respectively. Rebuttal Testimony of Paul J. Trudeau to Testimony of State of Utah Witness Dr. Stephen F. Bartlett on Section C of Unified Contention Utah L/QQ (Soils Characterization) [hereinafter Trudeau Soils Reb.] Post Tr. 11,954, at 2. These factors of safety are well above the Commission's recommended 1.1 factor of safety. Further, the Applicant's foundation stability analyses were performed utilizing conservative assumptions. If those assumptions were replaced with more realistic ones, we believe the analyses would show even larger margins of safety. *See id.* at 2-5.

3. Importance of the Shear Strength of the Upper Lake Bonneville Clays

B.11 The parties agree that the soils in the upper Lake Bonneville clay layer are the soils of interest for establishing the minimum value of soil strength; however, the parties disagree as to the extent to which an “accurate” computation of the strength of those soils is necessary.

B.12 The State insists that an accurate and adequate characterization of the upper Lake Bonneville clays is essential to the PFS demonstration that the pads and CTB will be supported on a stable foundation during a seismic event. Consequently, the State argues that PFS must show that both the seismic performance and the shear-strength characteristics of these soils throughout the pad emplacement area and footprint of the CTB are well defined and understood. *See State Findings ¶ 13.*

B.13 PFS focused its soils investigations — borings, samplings, and laboratory tests — on the upper Lake Bonneville clay layer. Due to the Applicant’s conservative approach in establishing the minimum strength and other characteristics of the facility’s site soils, the Board finds that even if there were some inaccuracies in the determination of the strength of the upper Lake Bonneville clays, the conservatisms built into the Applicant’s methodology for determining the soils properties and the factors of safety against soil failure are more than sufficient to assure that the soils conditions are adequate to meet the anticipated foundation loadings. *See Trudeau Soils Reb. Post Tr. 11,954, at 2-5.*

4. Specific State Concerns with the Applicant’s Testing of the Subsurface Soils

B.14 The State’s position is that there are fatal flaws in the PFS testing program because, *inter alia*, PFS has not adequately sampled and tested the upper Lake Bonneville clays or established their stress-strain behavior under the range of cyclic strains imposed by the DBE. *Bartlett Post Tr. 11,822, at 5.* At bottom, the State claims that by not adequately defining the lateral and vertical variability of the upper Lake Bonneville clays through site-specific investigations and laboratory analyses, PFS has not shown that those soils will have the shear strength to resist earthquake loadings that PFS is relying upon in its seismic stability calculations. *See State Findings ¶ 15.* The Staff and PFS do not share the State’s concerns.

a. Density of Soil Borings

B.15 The State claims that in many respects the Applicant’s sampling of the pad emplacement area is grossly deficient. *See id.* ¶ 23. One of the State’s primary concerns is that the sampling program does not conform to the density of borehole

spacings recommended in Regulatory Guide 1.132, Appendix C. Bartlett Post Tr. 11,822, at 5-7. PFS admitted that it used Regulatory Guide 1.132 to plan its field and laboratory investigations for the CTB. Trudeau Soils Reb. Post Tr. 11,954, at 6. Unlike borehole spacing used in the pad emplacement area, there is no disagreement that PFS has met the density of boreholes recommended in Regulatory Guide 1.132, Appendix C, for the CTB.

B.16 Appendix C of Regulatory Guide 1.132 provides a table of spacing and depth of subsurface explorations for various types of safety-related foundations. For linear structures, such as a row of storage pads, Regulatory Guide 1.132 recommends a spacing of one boring per every 100 linear feet for favorable, uniform geologic conditions, where continuity of subsurface strata is found. Even though this Regulatory Guide is specific to NPPs, the State argues that it should serve as appropriate guidance at the PFS site unless PFS has devised a more conservative sampling plan. In addition, the State contends that its position is reinforced by the fact that PFS makes analogies to nuclear power plant guidance in arguing for the grant of its seismic exemption. *See* State Findings ¶24.

B.17 According to the State, PFS drilled nine boreholes (A1, B1, C1, A2, B2, C2, A3, B3, and C3) in or near the pad emplacement area for the purpose of retrieving samples for laboratory testing and analysis. Bartlett Post Tr. 11,822, at 7. The State calculates that borings taken together with the CPT soundings result in a spacing of about one boring or sounding every 221 feet in the pad area. *Id.* at 6. Mr. Trudeau claims that seven borings, in addition to the nine cited in Dr. Bartlett's testimony, were drilled in or near the pad emplacement area (i.e., boreholes A4, B4, C4, D1, D2, D3, and D4). Trudeau Soils Reb. Post Tr. 11,954, at 7-8. Reviewing SAR Fig. 2.6-19, the State notes borings A4, B4, and C4 are south of the rail spur and are about 200 feet from the edge of the southern-most row of pads. Borings D1, D2, and D3 (outside the eastern boundary of the perimeter fence) and D4 (adjacent to the CTB) are about 375 feet or more from the edge of the eastern-most row of pads. Regulatory Guide 1.132 recommends borings be spaced one every 100 linear feet; therefore, the State argues that the Board should not consider those borings to meet the intent of Regulatory Guide 1.132. *See* State Findings ¶25.

B.18 The State argues that PFS used an approximate borehole and cone penetrometer spacing of about 221 feet for the pad area. *Id.* ¶26.

B.19 NRC Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants," is not a binding regulatory requirement (and not even a guidance document) for ISFSIs, but only a guidance document issued by the NRC Staff with respect to soils investigations for the foundations of nuclear power plants. *See Curators of University of Missouri*, CLI-95-1, 41 NRC 71, 97-98 (1995). The applicable regulatory guidance document for Part 72 facilities, which is NUREG-1567, does not provide any guidelines on the number or placement of

borings for foundation analyses. *See* “Standard Review Plan for Spent Fuel Dry Storage Facilities,” NUREG-1567 (Mar. 2000).

B.20 Nuclear power generation facilities have larger and more heavily loaded foundations than those of the proposed structures at the PFS facility. Trudeau Soils Reb. Post Tr. 11,954, at 5. They also have several categories of interconnected safety-related systems and components, such as buried piping and electrical power and control systems, which are sensitive to movements of the ground and the enclosing structures. By contrast, ISFSIs have no such interconnected systems. Trudeau/Wissa Post Tr. 10,834, at 13-14; Trudeau Soils Reb. Post Tr. 11,954, at 5.

B.21 For the above-cited reasons, the guidance in Regulatory Guide 1.132 is not directly applicable to ISFSIs, such as the PFS facility. Trudeau Soils Reb. Post Tr. 11,954, at 5. In fact, State expert, Dr. Bartlett, acknowledged that Regulatory Guide 1.132 is guidance and not strictly applicable to ISFSIs. Surrebuttal of Dr. Steven Barlett to PFS Witness Paul Trudeau’s Rebuttal Testimony on Section C of Unified Contention Utah L/QQ [hereinafter Bartlett Soils Surrebuttal] Post Tr. 11,982, at 3.

B.22 Regulatory Guide 1.132 also recognizes that the spacing and depth of borings or other site-characterization activities depend on the complexity of the site-specific subsurface conditions and the particular information needed for the engineering design of structure foundations. Ofoegbu Post Tr. 11,001, at 5-6. Further, Regulatory Guide 1.132 states:

Because the details of the actual site investigations program will be highly site dependent, the procedures described herein should be used only as guidance and should be tempered with professional judgment. Alternative and special investigative procedures that have been derived in a professional manner will be considered equally applicable for conducting foundation investigations.

“Site Investigations for Foundations of Nuclear Power Plants,” Regulatory Guide 1.132 (Mar. 1979) (PFS Exh. 234) [hereinafter Reg. Guide 1.132].

B.23 PFS elected to follow the guidance in Regulatory Guidance 1.132 with respect to the borings in the CTB because that building is somewhat analogous to a nuclear power plant structure. For the storage pads, however, PFS exercised professional judgment and developed a subsurface investigation program that combined the drilling of boreholes with other activities to the extent warranted by site conditions and the size, loading, and isolation of the storage pads. Trudeau Soils Reb. Post Tr. 11,954, at 6.

B.24 The Applicant based its professional judgment upon extensive investigations conducted at the proposed site. The initial geotechnical investigations at the PFS site were performed in late 1996. The results of those initial investigations

were reflected in the initial version (Rev. 0) of the SAR for the PFS facility, which was filed in June 1997. Trudeau/Wissa Post Tr. 10,834, at 4-5.

B.25 PFS performed an initial set of borings in 1996 in the pad emplacement area, following a uniform grid-like pattern, with the borings spaced approximately 600 feet apart and covering the entire area. Trudeau/Wissa Post Tr. 10,834, at 4-6. Such a grid was subject to supplementation with additional borings, if anomalous or irregular conditions were encountered; however, no such conditions were identified. Trudeau Soils Reb. Post Tr. 11,954, at 6.

B.26 This initial set of borings served to establish that the soil properties were reasonably uniform across the pad emplacement area of the PFS site. *Id.*

B.27 As the initial borings were made, SPTs were performed that provided estimates of soil strength and compressibility and allowed visual inspection of samples and index property testing of the samples in the laboratory. The “blow count” values required to drive the standard split-spoon sampler into the soil at various depths were consistent across the pad emplacement area, confirming the Applicant’s belief that the subsoil characteristics are uniform and consistent across the pad emplacement area. *Id.* at 6-7. Based on these initial results, PFS confirmed that it was sufficient to drill boreholes in a uniform grid across the entire pad emplacement area, so that all sections of the area were covered. *Id.* at 6.

B.28 After the initial borings, PFS performed additional soil investigations, including borings in the CTB area and a series of CPT soundings to better assess soil strength and compressibility. CPTs are conducted using a device with an instrumented conical tip that is pushed into the soil and that provides an essentially continuous record of the soil strength by tracking the force required to advance the cone through the soil. Tr. at 11,727-29 (Trudeau). The device also has an instrumented sleeve that advances as the cone tip moves downward and measures the force required to overcome the friction acting on the sleeve and move the sleeve into the ground. *Id.*

B.29 In 1999, PFS drilled and sampled twelve additional borings in the CTB area and performed thirty-nine CPTs (sixteen of which included measurements of pressure and shear wave velocities in addition to the penetration resistance data), and eighteen dilatometer soundings. Trudeau/Wissa Post Tr. 10,834, at 5.

B.30 Subsequent CPTs yielded essentially the same value of tip resistance for comparable depths at various locations across the pad emplacement area, indicating again that the stratigraphy across the site is uniform. Trudeau Soils Reb. Post Tr. 11,954, at 7.

B.31 The results of the geotechnical investigations conducted by PFS are presented in section 2.6 and Appendix 2A of the SAR, as revised through April 2001 (Rev. 22). That section, which is 219 pages long plus attachments and appendices, presents a comprehensive description of the various investigations that have been conducted. It includes geologic maps, profiles of the site stratigraphy,

and discussions of structural geology, geologic history, and engineering geology. Trudeau/Wissa Post Tr. 10,834, at 5-6.

B.32 Figure 2.6-5 of the SAR includes fourteen sheets of “foundation profiles” that depict the composition of the PFS facility subsoil layers at various locations in the pad emplacement area, and Figures 2.6-20 through 2.6-22 of the SAR present foundation profiles under the CTB. These profiles cover all safety-related structures and encompass all borings made by PFS in the vicinity of those structures. Trudeau/Wissa Post Tr. 10,834, at 6; PFS Exhs. 233, 233A.

B.33 The locations of the borings made to study subsurface conditions at the PFS site are summarized in three location plans (Figs. 2.6-2, 2.6-18, and 2.6-19 of the SAR), which permit correlating the locations of the borings with those of the CPTs and the geological samplings performed by Geomatrix. Trudeau/Wissa Post Tr. 10,834, at 6; PFS Exh. 235.

B.34 The composition of the soils at the PFS site has been well established through the investigations performed by PFS. Tr. at 11,835 (Bartlett). It is undisputed that the soils below 30 feet or so are dense and have significant strength and very low compressibility, so they are of no concern from the geotechnical standpoint. Tr. at 11,832-33 (Bartlett). This underlying layer is identified in the Staff’s SER as “Layer 2.” Ofoegbu Post Tr. 11,001, at 5-8.

B.35 All parties agree that the upper Lake Bonneville Deposits are, relatively speaking, the least strong and the most compressible soils in the profile. *See, e.g.*, Tr. at 11,749 (Trudeau); Tr. at 11,788-90 (Ofoegbu); Tr. at 11,834-35 (Bartlett). Beneath the upper Lake Bonneville Deposits is a 10-foot layer referred to as lower Lake Bonneville Deposits or “Layer 1C,” which is siltier and less clayey and strong than the upper Lake Bonneville Deposits. *See* Tr. at 11,748 (Trudeau); Tr. at 11,836 (Bartlett). Underneath Layer 1C is a 3- to 5-foot layer of silty clay and clayey silt, similar to but stronger than the Layer 1B material. Tr. at 11,748-49 (Trudeau).

B.36 A determination was made by the Applicant after the initial tests that the soil properties at the PFS site are reasonably uniform in the horizontal direction (that is, across the various site locations). Trudeau/Wissa Post Tr. 10,834, at 6; Tr. at 11,772 (Trudeau). Layer 1B is particularly uniform across the site. Tr. at 11,816 (Ofoegbu); Tr. at 11,884-85 (Bartlett).

B.37 The horizontal consistency of the materials at the site was further demonstrated by the CPT data, which show that the upper soil layers have fairly uniform properties across the pad emplacement area and beneath the CTB. Trudeau/Wissa Post Tr. 10,834, at 7.

B.38 A trench was dug by Geomatrix near the center of the pad emplacement area. Data obtained from that trench confirmed that the soils in approximately the upper 30 feet of the subsoil are fairly uniform and consistent in the horizontal direction across the site. The site investigations conducted by Geomatrix for PFS

are described in the Geomatrix report “Fault Evaluation Study & Seismic Hazard Assessment, February 1999.” Trudeau/Wissa Post Tr. 10,834, at 7.

B.39 Drawings known as “geological plates” were prepared by Geomatrix based on its site investigations. Data from the geological plates correlate well with the data on subsurface conditions presented in the foundation profiles developed by PFS. Comparison of the Geomatrix plates with the foundation profiles in SAR Figure 2.6-5 demonstrates that the nature, location, and thickness of the various layers of the profile are essentially the same, thus corroborating the foundation profile data. *Id.*

B.40 The PFS facility boring program determined that the pad emplacement area subsurface conditions are uniform, so that they conform to the general guidance in Regulatory Guide 1.132, which states:

Subsurface conditions may be considered favorable or uniform if the geologic and stratigraphic features to be defined can be correlated from one boring or sounding location to the next with relatively smooth variations in the thicknesses or properties of the geologic units. An occasional anomaly or a limited number of unexpected lateral variations may occur. Uniform conditions permit the maximum spacing of borings for adequate definition of the subsurface conditions at the site.

Reg. Guide 1.132 at 1.132-3 (footnote omitted). Because of the uniform site conditions, there is no need for a denser set of borings. Trudeau/Wissa Post Tr. 10,834, at 14. There is no reason to believe that a denser set of borings would have yielded any different results from those that PFS obtained. *Id.*

B.41 It is therefore appropriate to characterize the PFS site as “uniform” and thus, if the guidance in Regulatory Guide 1.132 is to be followed, a maximum spacing of borings is sufficient for the adequate characterization of the subsurface conditions. *Id.* at 14.

B.42 The soils investigations performed at the PFS facility are thus sufficient to properly characterize the site from the geotechnical standpoint and demonstrate that the soil conditions at the PFS site are adequate for the proposed foundation loadings.

b. Continuous Soil Sampling

B.43 The State also claims that PFS has not continuously sampled the upper Lake Bonneville clays with depth. *See* State Findings ¶28.

B.44 Again the State starts with Regulatory Guide 1.132, which recommends continuous sampling in a single boring or when that is not possible, then samples should be taken from adjacent closely spaced borings in the immediate vicinity to represent the material in the omitted depth intervals. *See* State Findings ¶29.

B.45 Although PFS relies upon CPT data in lieu of collecting samples continuously throughout the upper Lake Bonneville clays to confirm that no weak layers are present, the State contends that CPT is an in-situ test that indirectly measures soil property; it is not a technique for obtaining undisturbed samples for laboratory testing. Tr. at 11,868-69 (Bartlett). CPTs measure the resistance to penetration required to advance the cone-shaped tip of the instrument through the soils; these measurements are recorded as tip resistance values and are related to the stiffness and density of the soil. Tr. at 11,728 (Trudeau). The State argues, however, that PFS did not conduct any statistical analysis of the CPT data to determine the variability of the upper Lake Bonneville clays. Nor did PFS analyze the range or standard deviation of the tip resistance across the site. State Findings ¶ 32.

B.46 At the PFS site, the CPT measured the relative stiffness of the soils. The State argues that these data would need to be correlated back to obtain engineering soil properties, such as shear strength. Tr. at 11,947-48 (Bartlett). The State's experts believe that the visual representation of the CPT data on PFS Exhibit 233A is a depiction of the relative stiffness of the tip resistance of the cone penetrometer, not of the shear strength of that layer. *See id.*

B.47 According to the State, in the pad emplacement area, the boreholes and CPTs are not adjacent to each other; they are spaced tens, if not hundreds, of feet apart. Tr. at 11,863-66 (Bartlett).

B.48 The State insists that the 3- to 13-foot-thick upper Lake Bonneville clay is the critical layer that may affect the engineering properties that PFS is relying upon. It claims that the intent of Regulatory Guide 1.132 is to determine whether there are relatively thin zones of weak or unstable soils in the upper Lake Bonneville clays. The State believes that sampling at 5-foot intervals in a 3- to 13-foot layer does not constitute continuous sampling. In addition, the CPTs were performed after the laboratory samples had been taken. Therefore, the State argues that the CPT data could not have been used to select the weakest zone for the laboratory shear strength test program. *See* State Findings ¶ 36. Further, the State contends that PFS has not demonstrated that it has closely spaced staggered borings in the pad area in which PFS has continuously sampled the depth of the upper Lake Bonneville clays. *See* Tr. at 11,863-66 (Bartlett).

B.49 For the same reasons presented in our previous discussion, the guidance in Regulatory Guide 1.132 with respect to the taking of continuous soil samples is inapplicable to an ISFSI. Even though the recommendations in the guide are not applicable to the PFS facility, the sampling conducted by PFS in the pad emplacement area through the use of CPTs, which are continuous through the upper 30 feet of the soil profile, was consistent with the guide's recommendations. (The soils below the upper 30 feet are much stronger and less compressible than those above; consequently, continuous sampling of the deeper soils was not required.) Trudeau Soils Reb. Post Tr. 11,954, at 7-9.

B.50 The State asserts that the sampling program conducted by PFS does not meet the guidance in Regulatory Guide 1.132 because the continuous measurements taken by the cone penetrometer are not “sampling” since no soil samples are recovered for laboratory testing. Tr. at 11,868 (Bartlett). There is, however, no basis for making such a distinction. The purpose of the recommendation in Regulatory Guide 1.132 that continuous sampling be conducted is to identify “[r]elatively thin zones of weak or unstable soils [that] may be contained within more competent materials and may affect the engineering characteristics or behavior of the soil or rock.” Reg. Guide 1.132 at 1.132-5. The soils characterizations conducted by PFS, both through the drilling of boreholes and the performance of CPTs, establish that no such zones of weak or unstable soils exist at the pad emplacement area or under the CTB. Trudeau Soils Reb. Post Tr. 11,954, at 8-9.

B.51 Such layers would have been detected through changes in the cone tip resistance measured during the CPTs, which included readings at 0.2-foot intervals within the Layer-1B soils at thirty-seven locations across the pad emplacement area. *Id.* at 9; Tr. at 11,773 (Trudeau). Moreover, continuous, undisturbed sampling of Layer-1B soils in boreholes drilled within the adjacent CTB area did not reveal any zones of weak or unstable soils. *See* Trudeau Soils Reb. Post Tr. 11,954, at 9.

B.52 Therefore, the objectives of Regulatory Guide 1.132 with respect to continuous soil sampling have been achieved. Trudeau Soils Reb. Post Tr. 11,954, at 7-9; Ofoegbu Post Tr. 11,001, at 9.

c. Undersampling

B.53 Shear strength is easily established through laboratory testing. Tr. at 11,840 (Bartlett). The State does not object to the manner in which PFS conducted its laboratory tests for determining the soil shear-strength parameters. Tr. at 11,840-41 (Bartlett). However, the State asserts that the Applicant’s determination of the minimum shear strength of the soil is inadequate due to undersampling, because PFS estimated the minimum horizontal shear strength of the soils in the pad emplacement area by performing laboratory tests on three specimens taken from a single soil sample. *See* State Findings ¶41.

B.54 According to the results of the Applicant’s testing, the soil sample used to measure the minimum horizontal strength of the soils in the pad emplacement area was obtained from the weakest portion of the weakest layer (Layer 1B) of the soil profile. This sample also exhibits the highest void ratio of all the samples tested in the pad emplacement area (signifying lowest density and hence lowest strength), and it was taken from the quadrant in the pad emplacement area that had been determined to have the lowest soil strength. Trudeau Soils Reb. Post Tr. 11,954, at 9.

B.55 PFS contractor ConeTec took continuous measurements of cone penetrometer tip resistance at thirty-seven locations in the pad emplacement area of the PFS site. The results of those measures are presented graphically in the foundation profiles prepared by PFS, such as PFS Exh. 233A. ConeTec also provided tables of numerical values of tip resistance versus depth, which recorded the actual measurements of tip resistance and allow a numerical correlation to be drawn between the measured tip resistance and the undrained shear strength of the soil at the various locations in the soil profile. Tr. at 11,772-73, 11,955-62 (Trudeau); Tr. at 11,789-91, 11,817-18 (Ofogebu). The value of undrained shear strength that can be derived from the results of the CPTs for the lowest tabulated value of tip resistance corresponds almost exactly to the value of shear strength measured in the laboratory by PFS for the sample it selected for that purpose. PFS Exh. 238; Tr. at 11,960 (Trudeau). Therefore, the CPT results confirm that the value of minimum shear soil strength determined by PFS in laboratory tests is indeed the minimum value of undrained shear strength found in the pad emplacement area.

B.56 Because of the uniformity of the soils in the horizontal direction, the manner in which the test sample used for determining the minimum value of undrained shear strength was selected, and the confirmation provided by the CPT measurements, it is reasonable to conclude that the value of undrained horizontal shear strength used by PFS represents that of the weakest soils found at the pad emplacement area at the PFS site. Tr. at 11,772 (Trudeau).

B.57 According to the State, the sample for the one borehole taken in the pad emplacement area resulted in a shear resistance, for a vertical stress of 2 kips per square foot (ksf), of about 2.1 ksf. Tr. at 11,937 (Bartlett). From one of the samples taken from the CTB area, the shear resistance for a vertical stress of 2 ksf was about 1.75 ksf. Tr. at 11,938 (Bartlett). The State compares the CTB and pad data, and claims that this comparison should strongly suggest to the Board that the 2.1 ksf used for the design of the pad emplacement area is not the lower-bound undrained shear strength of the upper Lake Bonneville clays at the PFS site. *See* State Findings ¶42.

B.58 According to the State, the Applicant's demonstration to overcome the State's claim of gross undersampling in the pad area is based on the following sequence: the direct shear test sample came from one borehole in the northeast quadrant of the site; of all the soils specimens tested in the pad area, the northeast quadrant had the highest void ratio; a high void ratio results in low soil density; and low soil density is evidence of a weak soil. *See id.* ¶44. Furthermore, the State insists that there is no apparent reason PFS could not have performed additional direct shear testing on other undisturbed samples from some or all of the other five borings in the pad area. *See id.*

B.59 Dr. Bartlett, the State's expert, argues against using CPT data alone to predict shear strength. Bartlett Post Tr. 11,822, at 9; Tr. at 11,874-81 (Bartlett).

B.60 According to Dr. Bartlett, to accurately predict undrained shear strength from CPT data, a specific N_k factor in the following equation from EPRI, Equation 4-61 (State Exh. 100), must be developed for the site-specific soils. Equation 4-61, $q_c = N_k s_u + \sigma_{vo}$ gives the theoretical relationship for the cone tip resistance in clay, where q_c is the cone tip resistance; σ_{vo} is the total overburden stress; and N_k is the cone bearing factor, which is empirically determined. Published ranges for N_k from various locations for clayey soils vary from 4.5 to 75. State Exh. 100 at 4-55, 4-47.

B.61 The State argues that Mr. Trudeau relied on an N_k factor developed by ConeTec to predict undrained shear strength from the CPT data. *See* State Findings ¶47. This factor was developed from triaxial compression tests which measure shear in a subvertical direction; however, the mode of failure for sliding at the PFS site is horizontal, i.e., direct shear. Thus, the State believes that the ConeTec N_k factor is inappropriate for sliding calculations and likely overestimates the available shear resistance provided by the clayey soils. *See* State Findings ¶47 (*citing* Tr. at 11,955-62, 11,972 (Trudeau)).

B.62 To counter the Applicant's position, Dr. Bartlett developed some hand-drawn plots of the CPT data published in the ConeTec report to show there is horizontal and vertical variability in the upper Lake Bonneville clays. Tr. at 11,891-92 (Bartlett); State Exh. 99. Dr. Bartlett testified that he had been unable to obtain the electronic CPT data from PFS so that he could refine his plots. Tr. at 11,898-99 (Bartlett). Dr. Bartlett, relying on his past experience in testing Lake Bonneville sediments and his composite plots of CPT data, testified that there could potentially be a difference of a factor of 2 in the tip resistance and undrained shear-strength variability of the upper Lake Bonneville clays across the pad emplacement area. Bartlett Post Tr. 11,822, at 9; Tr. at 11,874-81 (Bartlett).

B.63 Drawing upon Dr. Bartlett's conclusions (as established in his prefiled testimony), the State argues that if one were to assume that one undrained shear-strength value (2.1 ksf) that PFS has obtained for the pad area, which is an average value, and taking into account the variability in the CPT logs, then the shear-strength values in the pad area could range from 1.4 ksf to 2.8 ksf. *See* State Findings ¶49 (*citing* Bartlett Post Tr. 11,822, at 7). PFS has a 1.27 factor of safety against sliding for the pad based on 2.1 ksf. An undrained shear strength of 1.82 ksf or less decreases the factors of safety below 1.1. State Findings ¶49.

B.64 Dr. Bartlett asserts that there can be considerable horizontal variability in the shear strength exhibited by the upper Lake Bonneville soils across the pad emplacement area and that there may be some location at which the shear strength may be considerably below the 2100 pounds per square foot (2.1 ksf) obtained by PFS in its laboratory tests. *See* Bartlett Post Tr. 11,822, at 9. The evidence provided by Dr. Bartlett in support of his position, however, is some tracings he made with markers of the cone penetration tip resistance plots, taken off enlarged photocopies of the data plotted in the foundation profiles in SAR Figure

2.6-5. State Exh. 99; Tr. at 11,893-99 (Bartlett). We find these drawings to be insufficient evidence to support Dr. Bartlett's claim. *See* Trudeau Soils Reb. Post Tr. 11,954, at 10-11. Furthermore, resorting to manual plots like Dr. Bartlett's is unnecessary because a report provided by ConeTec includes tabulations of the actual values of cone penetration tip resistance measured in the tests. *See* PFS Exh. 238. In fact, the foundation profiles show that the measured cone penetrometer tip resistance varies as one moves downward (even within a given soil layer) and is remarkably uniform for a given depth from one location to another. Trudeau Soils Reb. Post Tr. 11,954, at 10-11.

B.65 Even assuming that such variability existed, there is no basis for asserting that the value used by PFS is not the minimum shear strength of the soils in the pad emplacement area. If soils of lower strength were to exist in the pad emplacement area, the conservatisms incorporated into the PFS analyses and design (discussed below) would more than compensate for the difference in that hypothetical lower strength and that utilized by PFS in its analyses.

d. Additional Tests (Cyclic Triaxial and Triaxial Extension Tests)

B.66 The State also asserted that (1) PFS should have included strain-controlled cyclic triaxial tests in its laboratory shear-strength testing program, and (2) PFS has not adequately analyzed the stress-strain behavior of the native foundation soils under a range of cyclic strains imposed by the design earthquake. *See* Bartlett Post Tr. 11,822, at 10-12. Of particular concern to the State is that PFS "ensure that there is no significant degradation of shear strength at shear strain levels caused by the design basis earthquake" (*id.* at 11) and that it "consider the magnitude of the cyclic strains imposed by the earthquake and the effects that these cyclic strains have on the soil's shear strength properties" (*id.* at 12). Based on our review of the evidence, as discussed below, we find that PFS has satisfactorily addressed the State's concerns.

B.67 According to the State, earthquake loadings are cyclic in nature with several reversals in the direction of loading during a large earthquake. The State claims that PFS has used the peak undrained shear strength determined from a monotonic triaxial compression and direct shear tests (i.e., one-directional loading without cycling) to represent the soil's shear resistance for the design of the pads and CTB foundations. Bartlett Post Tr. 11,822, at 10.

B.68 Dr. Bartlett expressed concern that PFS had not tested the strength behavior of the upper Lake Bonneville clays at a range of high strain levels. This is important because if their shear strength degrades due to earthquake cycling, then there is an additional unconservatism introduced into the PFS sliding calculations. Tr. at 11,992-93 (Bartlett). He suggests that to remedy this defect, PFS could conduct *strain-controlled* cyclic triaxial tests to ensure that

there is no significant loss or degradation of shear strength due to cycling. Bartlett Post Tr. 11,822, at 10-12.

B.69 While PFS did not conduct strain-controlled cyclic triaxial tests, it performed resonant column tests, which are a form of strain-controlled cyclic triaxial tests. Indeed, they are the only form of strain-controlled testing that is recommended in Appendix B, “Laboratory Test Methods for Soil and Rock,” to NRC Regulatory Guide 1.138, “Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants” for use in developing curves of shear moduli and damping versus shear strain. Trudeau/Wissa Post Tr. 10,834, at 18. The resonant column test results can be readily extrapolated to establish the behavior of site soils at higher strains than those covered by the tests, so that all the strains potentially of interest are covered. *Id.* Therefore, strain-controlled cyclic triaxial tests to measure shear moduli and damping at higher levels of strain than those measured in the resonant column tests are not required. *Id.* at 19; Tr. at 11,736-39 (Trudeau).

B.70 The site response analyses performed by Geomatrix established that the layer of soil exhibiting greatest effective shear strain is Layer 1B. For the soils in that layer, the effective shear strains under design basis seismic loadings are within the range of strains measured directly in the resonant column tests. Trudeau/Wissa Post Tr. 10,834, at 19; Tr. at 11,736 (Trudeau). For that reason, additional strain-controlled cyclic triaxial tests are unnecessary.

B.71 In addition, PFS conducted stress-controlled cyclic triaxial tests to determine the soil’s collapse potential. The results of the tests did not show any degradation of the shear strength of the samples throughout 500 cycles of loading at extremely high cyclic stress ratios. The resulting cyclic strains were very small, indicating an essentially elastic response throughout the tests and demonstrating that there is no strength degradation for these soils due to even higher levels of cyclic stress than those experienced during a DBE. Thus, strain-controlled cyclic triaxial tests are unnecessary. Trudeau Soils Reb. Post Tr. 11,954, at 11.

B.72 Although the State attempts to argue to the contrary, their expert Dr. Bartlett agreed that if one can be assured that there is no marked decrease in shear strength at high levels of strain, the concern about characterizing the dynamic properties of the soil at high strain levels is of no consequence. Tr. at 11,992-93 (Bartlett). He characterized the testing that PFS conducted with respect to this issue at a “C-minus” level, meaning that knowledge in this area could be improved, but the failure to conduct the strain-controlled triaxial tests was not a fundamental flaw in the PFS program. *Id.*

B.73 According to the State, PFS has primarily used triaxial compression tests to calculate the soil’s resistance to bearing capacity failure and has given no consideration to performing triaxial extension tests to determine the degree of anisotropy of the foundation soils. The State contends that if significant anisotropy is present, then the use of triaxial compression tests overestimates

the average shear resistance along the potential failure plane. Bartlett Post Tr. 11,822, at 11-12. The State believes that this issue has the greatest significance in analyzing the bearing capacity of the storage pads, due to their relatively narrow width (30 feet) and the small margin (i.e., 5%) against seismic bearing capacity failure estimated by the Applicant. Bartlett Post Tr. 11,822, at 11-12.

B.74 As previously discussed, the vertical shear strength obtained by PFS in its triaxial compression tests for the pad emplacement area is 2.2 ksf, and the horizontal shear strength as obtained in the direct shear tests is 2.1 ksf. Hence, the degree of anisotropy exhibited by the PFS site soils is slight, if any. Tr. at 11,973 (Trudeau); Tr. at 12,021 (Ofoegbu).

B.75 The soil failure mechanism is a composite of failures along horizontal and vertical surfaces and is adequately represented by either the horizontal or vertical shear strengths determined by laboratory test results and field measurements. Tr. at 12,017-21 (Ofoegbu). Therefore, the effects of anisotropy are insignificant.

B.76 Dr. Bartlett asserts that performing triaxial extension tests is necessary to properly assess the bearing capacity of the soils beneath the storage pads. Bartlett Post Tr. 11,822, at 11-12. However, such tests typically are not performed to assess the bearing capacity of foundations, nor are they mentioned in Appendix B of Regulatory Guide 1.138. Trudeau/Wissa Post Tr. 10,834, at 19-20. Moreover, the minimum factor of safety against bearing capacity failure of the storage pads was computed by PFS using many conservative assumptions, including among others declining to use, as is customary, the average shear strength of the soil through a depth of 30 feet below the base of the pads to determine the bearing capacity. Ofoegbu Post Tr. 11,001, at 7. If this and other conservatisms in the analysis were removed, the calculated minimum factor of safety against bearing capacity failure of the storage pads would be well in excess of the required standard. Therefore, the concerns about soil anisotropy are inconsequential and the asserted need for triaxial extension tests does not exist.

C. Use of Soil-Cement and Construction

1. Background and Proposed Uses

a. Design Description

C.1 Soil-cement is a material produced by blending, compacting, and curing a mixture of soil, portland cement, other possible admixtures, and water to form a hardened material with specific engineering properties. Trudeau/Wissa Post Tr. 10,834, at 21. Soil-cement typically has far greater strength than that of the soil that is its main constituent, and thus is used to increase soil strength. *Id.*

C.2 Some soil-cement mixtures are referred to as “cement-treated soils.” Referring to a particular mixture as a “soil-cement” or as a “cement-treated soil” is a function of the durability of the mixture of soil, portland cement, and/or

other admixtures that has been formulated. Mixtures with greater degrees of stabilization and/or durability are generally referred to as soil-cement; mixtures with lesser such qualities are called cement-treated soil. Soil-cement is typically expected to be able to pass durability tests that measure the ability of the stabilized soil to retain its properties after long periods of exposure to the elements. *Id.* at 22. Cement-treated soil has less strength than soil-cement and is not expected to pass durability tests.

C.3 PFS intends to use soil-cement and cement-treated soil in three different ways. In the area directly underneath the concrete pads upon which the storage casks rest, cement-treated soil is to be used as a cohesive material that will be strong enough to resist the sliding forces generated by the DBE. The cement-treated soil will provide bonding with the bottom of the concrete pad above it and with the clay soils beneath, so as to transfer the horizontal earthquake forces downward from the pad and into the underlying clay soils. Soil-cement is to be used in the area around and between the cask storage pads. There, the function of the soil-cement is to support the weight of the transporter vehicle that is used to deliver storage casks to the pad area. Soil-cement was chosen for this application so that the soil materials would not need to be wasted and replaced with structural fill. Finally, soil-cement is to be placed around the CTB foundation mat, extending outward from the mat a distance equal to the associated mat dimension, to provide additional passive resistance against sliding forces in the event of a DBE. *Id.* at 23-24.

C.4 Soil-cement is often used for soil stabilization purposes, that is, to improve the compressive strength of the soil so that it becomes more rigid and less compressible, and to increase its resistance to sliding by virtue of its cohesive properties. Tr. at 10,843-44 (Wissa). At the PFS facility, the design relies on the compressive strength of the soil-cement to provide passive resistance to sliding of the CTB, and it relies on the cohesive strength of the cement-treated soil underneath the pads to essentially bond the pads to the underlying stiff clays. Tr. at 10,841-42, 10,845 (Trudeau). While the soil-cement “frame” surrounding the storage pads provides passive resistance against sliding of the pads, PFS conservatively does not take credit for such resistance. Tr. at 11,965-67 (Trudeau).

C.5 The soil-cement and cement-treated soil at the PFS facility have several design requirements. First, the cement-treated soil underlying the pads should have a minimum unconfined compressive strength of 40 pounds per square inch (psi). The cement-treated soil is also required to have a thickness no greater than 2 feet and a modulus of elasticity or Young’s Modulus (that is, a vertical stress-to-strain ratio) less than or equal to 75,000 psi. Second, the soil-cement to be placed around and between the cask storage pads is to have a thickness of 28 inches (3-foot height of the pads, minus the top 8 inches, which will be filled with compacted aggregate). The soil-cement adjacent to the pads should have a

minimum unconfined compressive strength of at least 250 psi, in order to meet the durability (wet/dry and freeze/thaw cycle) requirements, since it will be exposed to the detrimental effects of frost. Finally, the soil-cement to be placed around the CTB will have a thickness of 5 feet (plus 8 inches to be filled with aggregate). It also is expected to have a minimum unconfined compressive strength of at least 250 psi, in order to meet the durability requirements (wet/dry and freeze/thaw), since its upper half will be within the frost zone, and to provide the required passive resistance to sliding. Trudeau/Wissa Post Tr. 10,834, at 24-25.

C.6 All parties agree that these design requirements can be met by the use of appropriate soil-cement mixtures. *Id.* at 31; Tr. at 11,018-19, 11,021 (Ofogebu); Tr. at 11,088-89 (Mitchell). Indeed, the State soil-cement expert testified that he knew of nothing that would preclude PFS from meeting its design objectives for the soil-cement program. Tr. at 11,211-12 (Mitchell).

b. General State Concerns

C.7 The State raises several problems with the Applicant's proposed use of soil-cement to bolster the foundations of the storage pads and the CTB. According to the State, the Applicant's soil-cement program is part of the demonstration that the Applicant must make in order to satisfy the requirements of 10 C.F.R. § 72.102. Furthermore, the State contends that the Applicant bears the ultimate burden of demonstrating that the soil conditions at the site are adequate with the addition of soil-cement to sustain the proposed foundation loadings. In this regard, the State argues that there are a number of uncertainties in the Applicant's current testing programs and proposed future testing programs to prevent the Board from finding that the Applicant has sustained its burden. In addition, the State asserts that the NRC inspection programs are not designed to detect latent defects or to be a "construction watchdog," and that the Applicant and Staff cannot rely upon these programs as assurance that the soil-cement will meet its intended goals. *See* State Findings ¶¶ 125-130.

C.8 Moreover, the State claims that several of the tests already completed by the Applicant demonstrate that the Applicant's proposed precedent-setting use of cement-treated soil will not adequately sustain the proposed foundation loadings. The State argues that the Applicant's sliding stability calculations are not based upon site-specific investigations and laboratory analysis and thus are unreliable. In addition, the State claims that the Applicant has not adequately demonstrated that the shear strength of the cement-treated soil will meet the necessary 1.1 factor of safety required by the NRC Staff. The State also contends that the Applicant has not demonstrated that the proposed facility design will meet the requirements of 10 C.F.R. §§ 72.102(d), 72.90, 72.102(c), and 72.122(b). Finally, the State claims that even if the Applicant can demonstrate that its design concept is adequate, there is evidence to indicate that significant degradation due to

cracking, debonding along interface layers, and moisture infiltration will erode its ability to meet the proposed foundation loadings. *See* State Findings ¶¶ 130-134.

2. *Specific State Challenges*

a. *Potential Problems with the Construction Process*

C.9 According to the State, one uncertainty during the construction stage is the effect construction and exposure of the subsurface layer will have on the upper Lake Bonneville clays. *See id.* ¶92. The State believes that once the surficial material is removed, the clays may be disturbed by construction activities or become degraded by weather conditions causing the clays to dry out (hot, dry conditions) or gain moisture (wet conditions). *See id.*

C.10 Another uncertainty, raised by the State, concerns how much of the upper Lake Bonneville clays will be removed along with the eolian silts during excavation of the site. The State contends that the record contains insufficient evidence to establish that the eolian silts have a uniform depth across the site and that the depth is 3 feet. Therefore, the State argues that the Applicant cannot rely on varying the thicknesses of cement-treated soils if the eolian silts are at depths greater than 3 feet because of Holtec's constraint that the cement-treated soil may only be 1 to 2 feet thick. *See id.* ¶93. If the upper Lake Bonneville clays are excavated or disturbed, PFS intends to replace them with compacted clay fill. Tr. at 10,898-900 (Trudeau). According to the State's experts, however, there is currently no analysis on whether the remolded upper Lake Bonneville clays, consisting of compacted clay fill, will have the same shear strength as the undisturbed upper Lake Bonneville clays that form the basis of the PFS pad sliding analysis. State of Utah Testimony of Dr. Steven F. Bartlett and Dr. James K. Mitchell on Unified Contention Utah L/QQ (Soil-Cement) [hereinafter Mitchell/Bartlett] Post Tr. 11,033, at 11-12. The State contends that this has significance to the PFS pad sliding calculations, because remolded or compacted clay will have a decrease in shear strength from the design values PFS is relying upon for the native soils. *Id.* at 12.

C.11 As described by the Applicant's expert during the hearing, the soil-cement and the cement-treated soil to be used at the PFS facility will be constructed by removing the topmost layer of soil at the PFS site, which is a layer of eolian silt, and mixing it with cement in the appropriate proportions, as construction proceeds across the site. Trudeau/Wissa Post Tr. 10,834, at 23. Soil-cement manufacture will likely involve mixing the soil and the cement at a processing plant onsite to ensure high quality. Tr. at 10,890-91 (Wissa); Tr. at 10,906 (Trudeau).

C.12 The design requires that there be a minimum of 1 foot and a maximum of 2 feet of cement-treated soil under each storage pad. There may be an area in the southeastern corner of the pad emplacement area where the eolian silt

extends deep enough that, after its removal, it may be necessary to fill in below one or more of the pads to limit the cement-treated soil thickness to 2 feet. Tr. at 10,898 (Trudeau); Rebuttal Testimony of Paul J. Trudeau and Anwar E. Z. Wissa to Direct Testimony of State of Utah Witnesses Dr. Steven F. Bartlett and James K. Mitchell on Section C of Unified Contention Utah L/QQ [hereinafter Trudeau/Wissa Reb.] Post Tr. 11,232, at 7. In any location where this happens, PFS expects to place compacted native soils.

C.13 The State's construction concerns, such as remolding of the upper Lake Bonneville clays, are easily addressed by use of appropriate techniques for the installation of soil-cement and cement-treated soil. Trudeau/Wissa Post Tr. 10,834, at 36-37. The main area of concern with respect to remolding of the native soils is with respect to the cask storage pads, for which the cohesive strength of the clay under the cement-treated soil is required to provide sliding resistance. However, there is construction equipment that can be located on either side of the pads at the placement locations and reach out to make a cut to the final subgrade surface, if necessary. All other construction equipment can be kept off of the exposed subgrade. Through these means, the subgrade can be sufficiently protected during the soil-cement installation. *Id.* The State's expert, Dr. Mitchell, agreed that the measures proposed by PFS can effectively protect the soils from any adverse effects from disturbance due to construction activities. Tr. at 11,162 (Mitchell). He also agreed that the construction techniques proposed by PFS to avoid remolding of the clay soils are within the state of the art. Dep. of James K. Mitchell (Mar. 15, 2002) (PFS Exh. 228) [hereinafter Mitchell Dep.] at 114-15.

C.14 As we explained above, the State also claims that construction activities or removal of the overlying soils may cause the underlying soils to lose strength, casting doubt on the utility of the undrained shear-strength values obtained by the Applicant in its sampling program. For this reason, the State urges us to find that the samples of the upper Lake Bonneville clays that the Applicant has used for testing may not be representative of actual field conditions. We find no basis to do so. We would expect that any major construction project that ensues over a protracted period will encounter field conditions that differ from the conditions experienced during a preconstruction testing program. The Applicant has not discounted that potential; indeed, it has committed to utilize construction practices with field quality control requirements that take this potential into account. *See* Trudeau/Wissa Post Tr. 10,834, at 34-37; PFS Exh. JJJ at 2.6-118 to -119. The Applicant has also indicated that it intends to demonstrate at the start of construction that the techniques it allows the contractor to use will not have an adverse impact on the strength of the soils. There are a number of construction techniques available to prevent damage to the native soils beneath the pads, and the Applicant intends to use appropriate measures to prevent such damage. Trudeau/Wissa Post Tr. 10,834, at 36-37. With respect to potential damage due to exposure to the elements, this will be minimized through the use

of proper construction procedures, scheduling, and measures such as the removal of excess moisture from the soil. *See id.* at 36.

b. Design Problems Affecting the Native Soil and the Cement Pad

(i) CRACKING

C.15 The State has raised particular concerns about cracks in the soil-cement and cement-treated soil, which could lead to a loss of tensile strength in those materials. *See* State Findings ¶ 117. According to the State, the loss of tensile capacity is important, because it will decrease some of the structural competency of the soil-cement layer. Tr. at 11,112-13 (Mitchell). The State argues that because there are no cases to draw upon that use soil-cement of the depths that PFS intends to use, it is difficult to predict the size and extent of such cracks. Tr. at 11,111 (Mitchell).

C.16 The State raised several factors that could cause the concrete slab to crack. First, the State contends that concrete slabs can crack for unknown reasons (e.g., garage floors, bridges). Tr. at 11,130 (Mitchell). According to the State, the concrete slab may also crack from a cask tip-over or seismic event. Tr. at 11,130-32 (Mitchell); Tr. at 11,133 (Bartlett). Finally, the State argues that the pad could be degraded by windblown sulfates and salts that attack and corrode the steel reinforcing bar via shrinkage cracks in the concrete and cause the concrete to spall and crack. Tr. at 11,134-36 (Bartlett)

C.17 There is an 8-inch layer of aggregate on top of the soil-cement around the pads. SAR Fig. 4.2-7 (State Exh. 212). In the north-south direction, there will essentially be a 30-foot-wide gravel trench, and if there is no rapid drainage of water from the aggregate, the State argues that it will create a bathtub effect. The State believes that shrinkage cracks between the soil-cement and the storage pads or debonding of the laminar planes will result in the ingress of standing water as well as snow melt. Tr. at 11,137-40 (Mitchell); Tr. at 11,140-44 (Bartlett). This increased moisture, in turn, could lead to the weakening of the upper Lake Bonneville clays. Tr. at 11,147-48 (Mitchell). According to the State, of greater operational significance is whether weakened soil-cement from water infiltration will be capable of supporting the cask transporter used to move the 175-ton storage casks. *See* State Findings ¶ 120.

C.18 At the outset of its argument, the State notes that the main consequence of crack formation is the potential infiltration of moisture into the soil beneath the soil-cement that surrounds the pads and the CTB. Tr. at 11,147-48 (Mitchell). However, as discussed below (*see* Section (ii), Moisture), water infiltration — if occurring — is not expected to have a significant adverse impact on the performance in an earthquake of the soil-cement or cement-treated soil, and the

underlying soils, or on the behavior of safety-related structures at the PFS facility under seismic loadings.

C.19 The State is also concerned about the potential reduction in the tensile strength of the soil-cement due to crack formation (Mitchell/Bartlett Post Tr. 11,033, at 8-9; Tr. 11,208-09 (Bartlett)); however, any such loss would occur only in the cracked area, and would not constitute a total loss of tensile strength unless the crack went through the entire cross section of the soil-cement. Tr. at 11,300-01 (Trudeau). This is unlikely to occur. Tr. at 11,110-11 (Mitchell). In any event, the Applicant does not rely on the tensile strength of the soil-cement, so the effect, if any, of such cracking is inconsequential. *See* Trudeau/Wissa Post Tr. 10,834, at 41; Tr. at 11,296-97 (Trudeau).

(ii) MOISTURE

C.20 The State claims that water will infiltrate the soil-cement or cement-treated soil layers and will potentially degrade those materials. Tr. at 11,147-49 (Mitchell). Potential pathways for water infiltration include cracks in the concrete slab, shrinkage cracks between the soil-cement and the structure (pads or CTB), and standing water in the rows between the pads. Tr. at 11,137-38 (Mitchell).

C.21 The Board finds that the Applicant has demonstrated that water infiltration will not be a problem at the PFS site, because the storage casks on top of the pads will provide a source of heat that will be transmitted downward through the concrete pad and the cement-treated soil. Therefore, the area beneath the pads on which casks rest will be warmer than surrounding areas, causing moisture to migrate away from the cement-treated layer beneath the pads to the surrounding areas due to heat gradient effects. Trudeau/Wissa Post Tr. 10,834, at 33; Tr. at 11,012 (Ofoegbu). In addition, there is no mechanism for moisture to migrate toward the upper layer of the soil, given the great depth to the groundwater table at the site and the semiarid conditions in Skull Valley. Trudeau/Wissa Post Tr. 10,834, at 37; Ofoegbu Post Tr. 11,001, at 15-16.

C.22 Moreover, the mechanisms postulated by the State witness under which such infiltration could happen are unlikely (e.g., continuous top-to-bottom cracking of the 3-foot-thick reinforced concrete, *see* Tr. at 11,134-37 (Bartlett); dropping of a cask on the pad, causing a crack that is not subsequently repaired, *see* Tr. at 11,130-34 (Mitchell); water accumulating in the permeable “bathtub” created by the 8 inches of aggregate that will be placed on top of the soil-cement and then filtering down through shrinkage cracks, *see* Tr. at 11,137-39 (Mitchell); snowfall accumulating on top of the aggregate, *see* Tr. at 11,141-42 (Bartlett); and separation between the CTB and the soil-cement layer adjacent to it due to differential settlement, *see* Tr. at 11,153-57 (Bartlett)). For example, the Applicant will install berms around the pad emplacement area to direct any surface water away from the pad emplacement area; within the pad emplacement area, the site

is generally sloped from south to north and from the center of the site to the edges where there are concrete-lined drainage ditches to transport the surface water to the detention pond at the north. Tr. at 11,233-34 (Trudeau). Accordingly, there is no potential for significant presence of standing water in the pad emplacement area following snow melt, runoff, thunderstorms, or any other mechanism. Tr. at 11,234 (Trudeau).

C.23 Furthermore, any water that enters through a crack in the soil-cement will be unlikely to penetrate all the way down to the underlying soils, because the soil-cement will be constructed in thin lifts, all of which will cure at different times. While each of the lifts may have its own shrinkage cracks, it is very unlikely that the cracks on each lift will line up exactly with the cracks on other lifts. Tr. at 11,234-35 (Trudeau). In addition, the adhesive material used to provide bonding between successive lifts will serve as a barrier against crack propagation. Tr. at 11,197-98 (Mitchell). And, in the area of the soil-cement frame around the pads, there is a continuous layer of cement-treated soil that extends out beyond the pads that would prevent the downward passage of water. Tr. at 11,236-37 (Trudeau).

C.24 If water does enter the soils beneath the soil-cement through cracks, it just as easily can evaporate through them during dry periods. Tr. at 11,196 (Mitchell). Total precipitation at the PFS site is on the average 9 inches a year. Tr. at 11,139 (Bartlett). The site thus has a semiarid climate, which would facilitate the evaporation of any accumulated water. Tr. at 11,236 (Trudeau).

C.25 In addition to the unlikelihood of water infiltration through the mechanisms postulated by the State, tests performed on the soils at the PFS site demonstrate that the strength of the soils is only minimally affected by an increase in water content. *See* SAR at 2.6-42 to 2.6-44b (PFS Exh. 230); Ofoegbu Post Tr. 11,001, at 15-16.

C.26 Finally, any moisture accumulation and attendant potential reduction in the shear strength of the soil would only be a localized phenomenon, which would not have a significant effect on the strength or bearing capacity of the soils underlying the storage pads or the CTB. Ofoegbu Post Tr. 11,001, at 15-16; Tr. at 11,152-53 (Mitchell); Tr. at 11,157-58 (Bartlett).

(iii) PAD-TO-PAD INTERACTIONS

C.27 The State believes that because the soil-cement and cement-treated soil will not be constructed with steel or other reinforcement, they will be very weak in tension. Mitchell/Bartlett Post Tr. 11,033, at 7-8. Further, the State argues that because the casks, pads, soil-cement, and soils have very different masses, these masses will have different frequencies of vibration and behave differently during the cyclic forces from an earthquake. Tr. at 11,206-07 (Bartlett). The State maintains that the inertial effect (i.e., the fundamental frequencies at which these

different masses want to vibrate) introduces not only compression but tension into the system and creates out-of-phase motion of the various masses. *Id.*

C.28 According to the State, the Applicant assumes that during an earthquake, the system — pad, soil-cement, cement-treated soil, and soil — will act as an integrated mat keeping each individual pad in place and in phase with the other adjacent pads and will transfer all of the dynamic load down to the underlying native soils. Mitchell/Bartlett Post Tr. 11,033, at 8. Conversely, the State claims that the heavily reinforced relatively massive pad and the weak soil-cement in between the pads will act out of phase, and the soil-cement, which is stiffer than the underlying native clays, will act as a strut and pick up the dynamic load and transfer it laterally. Tr. at 11,206-07 (Bartlett).

C.29 Further, the State notes the storage pad has been analyzed to determine its structural suitability for dynamic loading conditions but no similar calculation exists for the underlying cement-treated soil or soil-cement. Mitchell/Bartlett Post Tr. 11,033, at 7-8.

C.30 As we explained in detail above, the State's major concern appears to be that the Applicant has assumed that the different masses of the entire system would move in-phase. According to the record, however, the Applicant has designed the proposed facility to prevent the pads from sliding at all in the event of an earthquake. *See, e.g.*, Testimony of Paul J. Trudeau on Section D of Unified Contention Utah L/QQ [hereinafter Trudeau Section D] Post Tr. 6135, at 5, 9. Thus, the analysis that the State criticizes does not represent the Applicant's anticipated performance of the pads and their foundations during an earthquake.

C.31 During the hearing, the Applicant's expert Paul Trudeau explained that there will be no out-of-phase motion of the pads relative to the underlying soil, so the "push and pull action" posited by the State will not take place. However, to test the State's hypothesis, Holtec performed an analysis in which it modeled two adjacent pads, 5 feet apart, one pad fully loaded with eight casks, the other having only a single cask, and included a representation of the soil-cement between the pads. Rebuttal Testimony of Alan I. Soler on Section D of Unified Contention Utah L/QQ [hereinafter Soler Reb.] Post Tr. 10,557, at 2. The configuration in these simulations was set so that the potential for pad-to-pad forces was maximized. No forces were allowed to be absorbed by the soil-cement; no forces were allowed to be transmitted downward to the cement-treated soil and to the soils beneath; no damping was included in the model; a maximum value of Young's Modulus for the soil-cement was assumed; the pads were not allowed to slide; and no credit was taken for the potential crushing of the soil-cement by the forces going from one pad to the other. Tr. at 10,657, 10,720-24 (Soler).

C.32 Holtec performed two computer simulations for this model: one in which the soil-cement between the pads is assumed to retain its integrity and therefore be able to transmit both tension and compression forces; and another simulation in which the soil-cement is assumed to be cracked and thus able to

transmit only compression forces. Soler Reb. Post Tr. 10,557, at 2. Notwithstanding the very conservative assumptions made in running these simulations, the maximum calculated force in the soil beneath the pads was less than that required to initiate pad sliding. Additional Cask Analyses for the PFSF (PFS Exh. 225) [hereinafter Additional Cask Analyses]; Tr. at 10,723 (Soler). Also, while both simulations predicted some interactions between the pads or between the pads and the soil-cement, the forces resulting from those interactions, when added to the seismic loadings, resulted in total cask motions of the same order — inches — as had been obtained in prior simulations that had not expressly accounted for pad-to-pad interaction forces. Soler Reb. Post Tr. 10,557, at 3-4.

3. *Testing*

a. *Adequacy*

C.33 The appropriate soil-cement formulation for each of the aforementioned applications will be established through a laboratory testing program. Trudeau/Wissa Post Tr. 10,834, at 25. PFS is conducting this program in accordance with a document entitled “Engineering Services Scope of Work for Laboratory Testing of Soil-Cement Mixes,” ESSOW 05996.02-G010 (2001) (PFS Exh. GGG) [hereinafter ESSOW]. Trudeau/Wissa Post Tr. 10,834, at 25-26. The laboratory testing program is being conducted by a PFS contractor, Applied Geotechnical Engineering Consultants, Inc. (AGEC), in accordance with the ESSOW. Trudeau/Wissa Post Tr. 10,834, at 30. This includes full compliance by AGECEC with the QA Category I requirements of the ESSOW. SAR at 2.6-109 (PFS Exh. JJJ).

C.34 As set forth in the ESSOW, the laboratory testing program being implemented by PFS to develop soil-cement mixtures that meet applicable design requirements is in accordance with well-established regulatory guidance and industry standards. Trudeau/Wissa Post Tr. 10,834, at 31. In particular, the ESSOW cites Regulatory Guide 1.138 as a source of guidance with respect to laboratory test methods for soils, in addition to numerous other standards issued by the American Society for Testing and Materials (ASTM) and the Portland Cement Association. Trudeau/Wissa Post Tr. 10,834, at 29. In addition, PFS has committed to follow the standards, procedures, and recommendations contained in the industry standard publication “State-of-the-Art Report on Soil Cement,” American Concrete Institute Report ACI 230.1R-90 (1998) (PFS Exh. HHH) [hereinafter ACI Committee 230 Report] with respect to mix proportioning, testing, construction, and quality control for soil-cement. Trudeau/Wissa Post Tr. 10,834, at 29.

C.35 PFS witness Dr. Wissa, who is one of the developers of the ACI Committee 230 Report, testified that the design, placement, testing, and performance

of soil-cement are well-established technologies, and that this fact provides reasonable assurance that the program proposed by PFS can be executed successfully. *Id.* at 32. These standards and procedures were developed to reduce the likelihood and mitigate the effects of the type of soil-cement cracking and degradation cited by the State. Ofoegbu Post Tr. 11,001, at 18-19.

C.36 The ESSOW sets forth a series of tests to be conducted in several phases. Trudeau/Wissa Post Tr. 10,834, at 26. These tests include, *inter alia*, soil index property tests, moisture-density tests, and durability tests. *Id.* PFS intends to conduct additional tests beyond those identified in the ESSOW. *Id.* For instance, it has committed to performing direct shear tests to demonstrate that adequate bond strength exists at the interfaces between the in situ clay and cement-treated soil and between the cement-treated soil and the bottom of the cask storage pads. *Id.* at 26.

C.37 The index property tests are used to ascertain basic properties of the site soils, including, *inter alia*, water content, the Atterberg limits (i.e., liquid and plastic limits), and particle size and gradation. *Id.* The water contents of the soils are determined in accordance with ASTM D2216, whereas the Atterberg limits of the soils are measured in accordance with ASTM 4318. *Id.* Sieve analyses (ASTM D422 and D1140) and hydrometer analyses (ASTM D422) are used to determine the gradation of particle sizes and the percentages of various clay-sized particles, respectively, in the soil samples. *Id.* AGEC has provided preliminary test results for the index property tests, and Dr. Wissa indicated that these tests, although preliminary, “appear to be reliable and adequate to describe the on-site surficial soils that will be stabilized with cement.” *Id.* at 30.

C.38 Moisture-density tests, which are conducted in accordance with ASTM D558, establish for each soil-cement mixture the relationship between the moisture content of the mixture and the resulting density when the mixture is compacted. In particular, these tests establish the optimum moisture content and maximum density for molding laboratory test specimens for further testing. *Id.* at 27. AGEC has provided preliminary results for these tests. *Id.* at 30.

C.39 Once PFS has identified those soil-cement mixes with the optimal combination of properties, it will perform durability tests in accordance with ASTM D559 and D560 to determine the durability of soil-cement specimens subjected to repeated cycles of exposure to the elements during extreme conditions. *Id.* at 27-28. These tests include “wet-dry” and “freeze-thaw” tests to determine moisture/volume changes and soil-cement losses due to (1) repeated exposures to inundation and drying and (2) alternate cycles of freezing and thawing. *Id.* PFS witness Trudeau testified that “successful completion of the durability tests establishes that the soil-cement mixture tested is adequate to provide a durable

soil-cement mix, one that will not lose compressive strength over time due to the effects of weather and normal wear and tear.” *Id.*³⁶

C.40 PFS indicated that AGECE has performed a set of durability tests, but that a review of these tests determined that they failed to demonstrate the durability of the tested samples. *Id.* at 30. PFS witness Trudeau opined that this failure was likely due to insufficient compaction of the test specimens prior to performance of the tests. *Id.* He further testified that the test program is currently on hold, pending determination of the causes for the failure of the durability tests that were performed by AGECE. *Id.*

C.41 The next step in the proposed soil-cement testing program is the performance of compressive strength tests in accordance with ASTM D1633 and D558. *Id.* at 28. Specifically, for those soil-cement mix formulations shown to meet the durability tests, compressive strength tests will be performed on cured test specimens to determine whether the formulations meet the design requirements for compressive strength. *Id.* If the compressive strength of a given soil-cement sample is determined to be adequate, then the soil-cement mixture will be deemed appropriate for use at the PFS site. *Id.*

C.42 Finally, as noted above, the cement-treated soil will be subject to direct shear tests to confirm that the bond (1) at the interfaces between the concrete bottom of the cask storage pad and the cement-treated soil, (2) at the interfaces between lifts of cement-treated soil, and (3) at the interfaces between cement-treated soil and the in-situ clayey soil exceed the strength of the clay soils at the site. *Id.* at 29. According to PFS, such confirmation will demonstrate that the cement-treated soil provides sufficient resistance against seismic sliding forces. *Id.*

C.43 Following completion of the testing phase, PFS will develop procedures for the placement and treatment of the soil-cement/cement-treated soil, lift surfaces, and foundation contact in accordance with the recommendations of the ACI Committee 230 Report. *Id.* at 31; SAR at 2.6-118 (PFS Exh. JJJ). Specific construction techniques and field quality control requirements will also be identified in the construction specifications developed by PFS during this phase of the project. SAR at 2.6-118 (PFS Exh. JJJ).

C.44 To ensure that sufficient bonding is achieved, PFS plans to utilize the techniques described in the ACI Committee 230 Report and the DeGroot, G., 1976, “Bonding Study on Layered Soil Cement,” REC-ERC-76-16, U.S. Bureau of Reclamation, Denver, CO, September 1976. Trudeau/Wissa Post Tr.

³⁶The cement-treated soil to be placed under the cask storage pads will not be subjected to durability tests, because it is to be located beneath the 3-foot-thick concrete pads and is therefore not exposed to the elements. Trudeau/Wissa Post Tr. 10,834, at 28. Also, the cement-treated soil would not be susceptible to freezing and thawing cycles due to its location below the depth of frost penetration at the PFS site. *Id.*

10,834, at 31. These techniques include, *inter alia*, (1) minimizing the time between placement of successive layers or “lifts” of soil-cement, which will have a compacted thickness of approximately 6 inches; (2) moisture conditioning to facilitate the proper curing of the soil-cement; (3) producing a roughened surface on the soil-cement prior to the placement of additional lifts or concrete foundations; and (4) using a dry cement or cement slurry to enhance the bonding of concrete or new soil-cement layers to underlying layers that have already set. SAR at 2.6-118 (PFS Exh. JJJ).

C.45 During the hearing, the Applicant’s witness, Dr. Wissa, testified that the Applicant’s soil-cement laboratory testing program is adequate, if properly implemented. Trudeau/Wissa Post Tr. 10,834, at 30. The State notes that, when asked to elaborate, Dr. Wissa further testified that if he were to conduct the PFS soil-cement testing program, he would basically need to start all over so that he could vouch for the quality of his work. Tr. at 10,980 (Wissa). He would use the AGECE test results as a check on his results. Tr. at 10,978-79 (Trudeau). The State points out that at the end of the hearing, Dr. Wissa noted that he was talking with the Applicant about taking over the soil-cement testing program, but at that time it was unknown who would be conducting the testing program. *See* State Findings ¶ 81.

C.46 The State points out that the quality and success of the PFS demonstration that it can prove and successfully implement its soil-cement design concept depends in significant part on the credentials and experience of the person or entity chosen to conduct and supervise the testing program. *See* State Findings ¶ 82.

C.47 All parties agree that PFS has developed a suitable program for testing the properties of the soil-cement, which is embodied in the ESSOW. Trudeau/Wissa Post Tr. 10,834, at 25-26; Tr. at 11,089-93 (Mitchell). The program will be effective in establishing whether the properties of the soil-cement specified in the design have been achieved. Tr. at 11,266 (Mitchell).

C.48 The parties also agree that the program is based on appropriate industry standards, including the ACI Committee Report, and that it includes the proper tests and suitable test methodology. Trudeau/Wissa Post Tr. 10,834, at 29; Ofoegbu Post Tr. 11,001, at 14-15; Tr. at 11,060-61 (Mitchell).

C.49 Finally, the parties agree that the program to which PFS has committed in the SAR (SAR at 2.6-118, 2.6-119 (PFS Exh. JJJ)) is reasonable and should lead to proper soil-cement and cement-treated soil installation. Trudeau/Wissa Post Tr. 10,834, at 31-32; Ofoegbu Post Tr. 11,001, at 12-13; Tr. at 11,088-89 (Mitchell). The program — including the construction procedures it calls for — is based on well-accepted, standard practices set forth in manuals issued by organizations such as the U.S. Army Corps of Engineers and the Portland Cement Association. Tr. at 10,973-74 (Trudeau/Wissa).

C.50 There is also a fair degree of flexibility in establishing the acceptance criteria for the soil-cement and cement-treated soil, as well as the tolerances that the specified material content must meet. Tr. at 10,945-47 (Wissa); Tr. at 11,179-81 (Mitchell). If, however, a soil-cement installation failed to meet design requirements, it is most likely that the Applicant would rework or replace the soil-cement rather than attempt to demonstrate its acceptability through analyses. Tr. at 10,938-40 (Trudeau); Tr. at 10,965-67 (Wissa).

C.51 PFS witnesses also testified that appropriate measures will be taken during construction to ensure that the required quality of installation and the requisite properties of the soil-cement are achieved and any nonconformances are corrected. The work would be subject to oversight of both the contractor and the owner, would be subject to NRC approval, and would be required to conform with NRC requirements. Tr. at 10,968-69 (Wissa); Tr. at 10,992-93 (Trudeau).

b. Proof of Design and Timing

C.52 A major point of disagreement between the Applicant and the Staff, on the one hand, and the State, on the other, is that the State believes that the test program to confirm that the soil-cement will have the requisite properties should be completed before licensing of the facility, whereas the other parties do not think this is either required by NRC regulations or necessary. *Compare Mitchell/Bartlett Post Tr. 11,033, at 5 with Trudeau/Wissa Post Tr. 10,834, at 33-34 and Tr. at 11,017 (Ofoegbu).*

C.53 During their testimony, State experts pointed out the potentially adverse economic consequences that could befall PFS if, after licensing, it was determined that the use of soil-cement in the manner proposed by PFS was for some reason unworkable. Tr. at 11,096-100; 11,104-07 (Mitchell). In response, the Applicant argued that when questioned, the State was unable to point to a regulatory rule, regulation, or regulatory guidance that requires the soil-cement testing program to proceed in advance of licensing, and the Staff witness testified that, once the design requirements are established and a commitment is made to perform an appropriate testing program to demonstrate compliance with them, an applicant is free to defer testing to the post-licensing phase. Tr. at 11,017-18 (Ofoegbu).

C.54 The State's position, contrary to that of the Staff, is that the Applicant's future soil-cement program is part of the demonstration PFS must make to prove its design concept and to satisfy 10 C.F.R. § 72.102. That demonstration, says the State, must be satisfied before PFS can receive a license. *See State Findings ¶ 125.*

C.55 In this proceeding, the Applicant bears the ultimate burden of proof. In order to carry that burden, PFS must show by site-specific investigations and laboratory analyses that its soil conditions, including soil-cement, are adequate

for the proposed foundation loadings. 10 C.F.R. § 72.102(d). *See* State Findings ¶ 126.

C.56 According to the State, the items that PFS has yet to demonstrate in its soil-cement program include the following: (1) adequate classification of surficial soils, (2) selection of soils for further testing including durability (wet-dry, freeze-thaw), (3) testing to determine the correct percentage of cement to add to soils as well as moduli testing to achieve Young's Modulus of less than 75,000 psi, and (4) testing to determine bonding and adhesion between interface layers. Furthermore, the State argues that there are uncertainties about implementing the Applicant's laboratory testing program, whether confirmatory tests can be successfully carried out in the field, and whether construction techniques or activities will degrade the strength of the upper Lake Bonneville clays. *See id.* ¶ 127.

C.57 The State argues that neither the Applicant nor the Staff can rely on the NRC's inspection program to ensure that placement of cement-treated soil under 500 pads at PFS will meet the Applicant's target performance goals. The State argues that the NRC's inspection program is not geared to detect latent defects or to be a watchdog at every step of construction. *See id.* ¶ 130.

C.58 According to the State, the Applicant has not met its burden to show in its sliding analyses, PFS Exhibit UU, that the shear strength of both the upper Lake Bonneville clays and the cement-treated soil will meet a minimum factor of safety of 1.1. *See id.* ¶ 132.

C.59 The State also argues that neither the Applicant nor the Staff has demonstrated that the Applicant can meet the requirements of 10 C.F.R. § 72.102(d). Also, the State contends that PFS has not met the requirements of 10 C.F.R. §§ 72.90, 72.102(c), or 72.122(b). *See* State Findings ¶ 133.

C.60 The testimony at the hearing shows that the design requirements for the soil-cement and the cement-treated soil have been adequately established. Additionally, the PFS witnesses testified that PFS has committed to developing a soil-cement mix design using standard industry practices, and has further committed to performing a soil-cement testing program in accordance with appropriate industry standards. Thus, PFS has specified the tests it intends to perform and the acceptance criteria that will be applied to the test results. As stated in the SAR, PFS is also committed to performing field testing during construction to demonstrate that it has, indeed, achieved in the field the bond strengths that are required. Trudeau/Wissa Post Tr. 10,834, at 34-35. Such tests will include obtaining core samples through the pad and the underlying layers of interest, taking them to the laboratory, performing shear tests at the interfaces, and demonstrating that the shear strength along those interfaces exceeds that of the underlying clay. The Applicant believes that this will confirm that a good bond has been achieved and that the shear strength available along those interfaces

exceeds the shear strength used in the sliding stability analyses. Tr. at 10,963, 10,971, 10,981-82 (Wissa).

C.61 Although he was not involved in developing the test program, PFS witness Dr. Wissa reviewed the soil-cement laboratory testing program developed by PFS and the standards and methodologies it contains. Trudeau/Wissa Post Tr. 10,834, at 30. He testified that if properly implemented, the program will lead to the identification of suitable soil-cement and cement-treated soil mixes and construction specifications that will meet the specified design requirements and give adequate performance for the life of the proposed facility. *Id.* Similarly, Staff witness Dr. Ofoegbu testified that there is information in the literature that indicates that the soil-property changes that result from cement-stabilization can be considered long-lasting. Ofoegbu Post Tr. 11,001, at 14.

C.62 The Staff has also reviewed the design submitted by PFS, including the associated calculations and specified material properties, to determine compliance with the applicable regulatory requirements. *See* Tr. at 11,016 (Ofoegbu). The Staff determined that the analyses submitted by PFS demonstrated that the design would be safe, and that based on information available in the technical literature, the material properties used by PFS in its design are achievable. *See* Tr. at 11,021 (Ofoegbu). The Staff's analysis is documented in the SER. Tr. at 11,022 (Ofoegbu). In this regard, the Staff concluded that PFS has "proven its design," even without having completed the soil-cement testing program. Tr. at 11,021 (Ofoegbu).

4. Precedent

C.63 The parties do not agree on whether the Applicant's use of soil-cement to resist sliding during an earthquake is a unique application of soil-cement. The State maintains that it is a unique and untested application to add cement to soil to provide additional seismic sliding resistance and stability to shallowly embedded foundations from strong ground motions. Mitchell/Bartlett Post Tr. 11,033, at 5-6; Tr. at 11,051 (Mitchell).

C.64 The State argues that the weight of the evidence and the direct experience and involvement in many of the projects PFS is relying upon to prove its case weigh strongly in the State's favor. The State also insists that the Applicant cannot rely on the properties of the material as defining precedent. *See* State Findings ¶ 114.

C.65 The Applicant and the Staff point out that soil-cement has been used for soil stabilization in numerous instances, both in the United States and abroad. Trudeau/Wissa Post Tr. 10,834, at 33; Trudeau/Wissa Reb. Post Tr. 11,232, at 1-3; Ofoegbu Post Tr. 11,001, at 14. For example, soil-cement has been used to provide foundation strength for an office building in Tampa, Florida, a dam spillway foundation mat in Fort Worth, Texas, a number of coal handling

and storage facilities throughout the United States, a nuclear power station in Koeberg, South Africa, and a variety of other applications including highways. ACI Committee 230 Report §§ 2.5, 2.6; SAR at 2.6-113, 2.6-114 (PFS Exh. JJJ); Tr. at 10,971-72 (Trudeau). In that respect, the Applicant argues that since all uses of soil-cement rely on the same mechanical properties, all prior uses of soil-cement can be said to constitute precedents for its use at the PFS facility. Tr. at 11,262-63 (Mitchell). The number of applications for soil-cement and the confidence in its use by the technical community continues to grow over time. Tr. at 11,190-91 (Mitchell).

C.66 In particular, soil-cement was used extensively to resist lateral forces and form permanent foundations for the five highway tunnels for I-90 and I-93 that converge at the Fort Point Channel crossing of Boston's Central Artery/Tunnel Project. This is essentially the same use of soil-cement that is being proposed for the PFS facility. Trudeau/Wissa Reb. Post Tr. 11,232, at 1-2; Tr. at 10,846-47 (Wissa).

C.67 In this instance, we do not need to decide whether there is precedent for the PFS proposed use of the soil-cement, because, as explained by the Staff's experts during the hearing, there is no regulatory requirement that the suitability of soil-cement for its intended use be demonstrated by case history precedent. Ofoegbu Post Tr. 11,001, at 12-13. Instead, what is of significance to the Board is whether the Applicant's proposed design satisfies the regulatory requirements. This includes an assessment of whether a material with a specified property would be adequate for the proposed foundation loading, and whether the specified property is achievable for that material based on available information.

5. *Young's Modulus*

C.68 The State insists that one of the most difficult tasks confronting the Applicant is to find a mix using PFS surficial site soils that will attain a Young's Modulus (i.e., a vertical stress-to-strain ratio) of less than 75,000 psi for 40-psi compressive strength cement-treated soil. See State Findings ¶98. This is, however, not as a difficult task as the State contends. All parties agree that seeking to limit the Young's Modulus to less than 75,000 psi for cement-treated soil having an unconfined compressive strength of 40 psi is achievable, because having a relatively low modulus is consistent with the relatively low strength required. Tr. at 10,914-15 (Wissa); Tr. at 11,023-24 (Ofoegbu); Tr. at 11,159-60 (Mitchell). This is also supported by data reported in the literature. Tr. at 11,023-26 (Ofoegbu).

C.69 Dr. Ofoegbu provided citations to references that demonstrate that a Young's Modulus of no more than 75,000 psi is achievable at a compressive strength of 40 psi. Tr. at 11,025-26 (Ofoegbu). The State attempts to dismiss this testimony by asserting that the tests referenced by Dr. Ofoegbu are based on

site-specific soils (State Findings ¶99), but a careful review of the record does not support this proposition. Dr. Ofoegbu did not indicate any such limitations when describing the literature, and in fact referred to a paper that provided charts of ranges of values of Young's Moduli for use in soils analysis. Tr. at 11,026 (Ofoegbu).

C.70 Another issue raised in the State's proposed findings is that the soil-cement and the cement-treated soil continue to cure with time. *See* State Findings ¶100. The State argues that in order to achieve a Young's Modulus of no more than 75,000 psi, one may need to start with a modulus perhaps as low as 40,000 psi. Tr. at 11,222 (Mitchell). During the hearing, the State's expert on the subject, Dr. Mitchell, testified that he could not specify a starting value of modulus to aim for without test data, and that his only point was that it would not be prudent to start at the 75,000-psi value. Tr. at 11,222 (Mitchell). Our record demonstrates that the greatest increase in Young's Modulus occurs during the first 28 days of curing. Tr. at 11,226-27 (Mitchell); Tr. at 11,251-52 (Wissa). For that reason, the Young's Modulus value used in Holtec's cask drop and tip-over analysis is benchmarked at a curing age of 28 days. Tr. at 11,253 (Trudeau). In other words, the 75,000-psi maximum Young's Modulus value is determined as of the 28-day curing point. *Id.* Dr. Mitchell was not aware of what benchmark PFS intended to apply, but confirmed that 28-day strength was a commonly used value. Tr. at 11,227-28 (Mitchell). Because he was unaware of the benchmark used by PFS, Dr. Mitchell incorrectly assumed that the 75,000-psi limit applied throughout the life of the facility. *See, e.g.*, Tr. at 11,216-17 (Mitchell). While the strength of the cement-treated soil increases slowly with time after 28 days as it continues to cure, this process is immaterial because the important data point for which the cask drop and tip-over analyses are performed is after 28 days of curing.

C.71 The State also insists that the Young's Modulus should be measured under dynamic, not static, loads. *See* State Findings ¶101-102. State witness Dr. Ostadan, however, noted that the Holtec design intent could be satisfied by formulating a test program that established that the modulus of elasticity of the cement-treated soil did not exceed 75,000 psi at the strain level occurring in the vicinity of cask impact (i.e., 1.93% in the soil directly beneath the cement-treated soil) based on Holtec's analysis. Tr. at 7426-27 (Ostadan). Thus, we find the distinction between dynamic and static loadings immaterial; the important issue is that the proper strain level be achieved in the test. The PFS approach in determining the Young's Modulus is to use soil strain level as the reference parameter for its Young's Modulus testing. Moreover, the Sandia National Laboratories paper that provided experimental data forming the bases for the cask-drop analyses uses static moduli of elasticity for the soils underlying the pad, and it indicated substantial agreement between analytical results and experimental results, demonstrating that large-strain moduli are appropriate for such analyses. Tr. at 10,927-28 (Trudeau); Tr. at 10,988 (Wissa).

C.72 For the reasons established above, we find that the State’s concerns are unfounded and the Applicant has demonstrated it will be able to attain a Young’s Modulus of less than 75,000 psi for 40-psi compressive-strength cement-treated soil.

D. Seismic Design and Foundation Stability

1. Overview of the Pad Storage System

a. Proposed Design Concept for the Pad Storage System

D.1 At the PFS facility, the SNF will be stored in large storage casks resting on concrete pads. The storage cask system to be used by PFS is the HI-STORM 100.

D.2 As described in section 4.2.1.5.2 of the SAR, the HI-STORM 100 storage casks will be placed on a regular array of concrete pads arranged to provide a lateral (edge to edge) spacing of 35 feet between adjacent pads in the east-west direction and 5-foot longitudinal spacing in the north-south direction. Each pad will be sized to accommodate a 2 × 4 array of casks with a 15-foot pitch (the distance between the casks’ center points) in the width (or east-west) direction and 16 feet in the length (north-south) direction. As described in section 4.2.3.1 of the SAR, the cask storage pads will be independent structural units constructed of reinforced concrete, each pad being 30 feet wide, 67 feet long, and 3 feet thick. Each pad will be capable of supporting eight loaded storage casks. At maximum capacity, the facility would contain 500 such pads, each supporting eight loaded storage casks. Singh/Soler Post Tr. 5750, at 8; Joint Testimony of Robert Youngs and Wen Tseng on Unified Contention Utah L/QQ [hereinafter Youngs/Tseng] Post Tr. 5529, at 9-10. A graphical representation of the cask storage arrangement is shown on PFS Exhibit 84 and Staff Exhibit X (Figure 1.2-1 of the SAR).

b. Overview of State’s General Concerns

D.3 The State contends that the entire design and seismic performance of the cask-pad system at the PFS site relies on one design calculation: Holtec’s nonlinear cask stability analysis to determine the seismic loading to the pads and foundations. State Findings ¶146. According to the State, seismic forces estimated in this one design calculation propagate throughout other seismic and engineering calculations that the Applicant is relying upon to demonstrate the performance of its ISFSI during an earthquake. Tr. at 7344-45 (Ostadan). Thus the State argues that Holtec nonlinear analyses are also being used as the basis to: (1) predict cask movement atop the pads; (2) predict seismic loads transferred to the soil-cement, cement-treated soil, and soils; (3) perform the structural design

of the storage pads; (4) predict pad sliding; and (5) analyze the effects of SSI on the response of the pads and the casks. *See* State Findings ¶ 146.

D.4 The State argues that the Applicant's design is unconventional and unprecedented. State Findings ¶ 148. According to the State, the unproven features at the PFS site include: (1) unanchored cylindrical casks, (2) acceptance of cask sliding on the pad as a basic design philosophy and taking full credit from cask sliding to reduce the seismic load to the storage pads and their foundations, (3) shallowly embedded storage pads founded on a compressible clay with the potential for several inches of settlement, and (4) untested and precedent-setting use of cement-treated soil and soil-cement as a structural foundation element to resist lateral earthquake forces and to add strength and stiffness to soils. Tr. at 7724-28, 7350-53, 10,286-87 (Ostadan/Bartlett). On top of this, the State insists that there is relatively little margin for error in design. State Findings ¶ 148. For example, if the Applicant has underpredicted dynamic loads by only 20% or overpredicted capacity by 20%, then the State points out that it becomes questionable whether the PFS design will perform during an earthquake. Tr. at 7342-43 (Ostadan).

D.5 In addition to no performance data, the State claims the Applicant has provided no test data it can rely upon to evaluate the performance of the casks. The State notes that the storage casks intended for the PFS site have not been tested either experimentally or during an actual earthquake to determine their performance under earthquake conditions. State Findings ¶ 150. Holtec entered the dry cask business only in the mid-1990s. Tr. at 5915-16 (Singh). According to the State, about twelve HI-STORM 100 casks are in use and about fifteen others have been delivered to nuclear reactor sites. *See* State Findings ¶ 150.

D.6 The State believes that it was possible for the Applicant to have acquired experimental test data on the performance of the HI-STORM 100 casks. According to the State, the Applicant could have conducted shake table tests on a scale-model cask or may acquire such data by conducting shake table tests on a full-sized cask next spring in the United States. The State points out, however, that the Applicant has chosen not to do so. *Id.* ¶ 156.

D.7 The State points out that an assertion of "engineering judgment" without any explanation or reasons for the judgment, is insufficient to support the conclusions of the expert engineering witness. State Findings ¶ 157 (citing *Texas Utilities Electric Co.* (Comanche Peak Steam Electric Station, Units 1 and 2), LBP-84-10, 19 NRC 509, 518 (1984)). Further, the State argues that where an expert witness states ultimate conclusions on a crucial aspect of the issue being tried, and where that conclusion rests upon a performed analysis, the witness must make available sufficient information pertaining to the details of the analysis to permit the correctness of the conclusion to be evaluated. State Findings ¶ 157 (citing *Virginia Electric and Power Co.* (North Anna Nuclear Power Station, Units 1 and 2), ALAB-555, 10 NRC 23, 27 (1979)).

D.8 The State also argues that Holtec’s design calculation is based entirely on a nonlinear computer program. State Findings ¶158. The State insists that nonlinear analyses are well known for being sensitive to the selection of input parameters and have been referred to as obtaining solutions from a ‘‘black box.’’ Tr. at 7335-36, 7551-52 (Ostadan). According to the State, small changes in an input parameter, such as contact stiffness or damping, could dramatically change the result of nonlinear analyses. Tr. at 7336, 7352 (Ostadan); State Testimony of Dr. Mohsin R. Khan and Dr. Farhang Ostadan on Unified Contention Utah L/QQ, Part D (Cask Stability) [hereinafter Khan/Ostadan] Post Tr. 7123, at 11-12. Finally, the State notes that PFS has no performance data or experience data to calibrate its design calculation. State Findings ¶158.

2. Specific State Concerns with the Applicant’s Pad Stability Analysis

a. Concern with the Applicant’s Methodology

D.9 The State maintains that the many disparate pieces of the Applicant’s seismic design have evolved, often in response to cost-cutting measures, and have not been fully thought out and integrated into a cohesive and rigorous design. *Id.* ¶171. According to the State, emblematic of this is the lack of independent verification or checks and balances of the input parameters to the various design calculations. *Id.* In addition, the State highlights the fact that many of the input parameters for the design calculations are derived from Holtec — a company with a large financial stake in the outcome of the proposed project. *Id.*

D.10 Furthermore, the State argues that the Applicant’s design has evolved from contemplation of anchored casks, excavation, and replacement of foundation soils with structural fill, to unanchored casks and removal of the eolian silts to save costs. *Id.* ¶172; Tr. at 10,293-94 (Bartlett). According to the State, soil-cement was first introduced to stabilize the eolian silts in place and to provide a stable platform for the cask transporter, and only when there was a significant increase in ground motions, did PFS introduce using cement-treated soil as a mechanism to resist seismic loading. State Findings ¶172.

D.11 Moreover, the State continues, rather than bypass the weaker and more compressible zone of the upper Lake Bonneville clays either by treating the clays or embedding the pads into deeper, stiffer, and stronger soil, the Applicant has chosen to place cement-treated soil on top of the relatively soft clays in an application that is precedent setting and whose design concept and requirements are yet to be tested. *See id.* ¶173. According to the State, the Applicant’s seismic design of the cask–pad system is to transfer the seismic loads from the casks and pads down through the cement-treated soils to the upper Lake Bonneville clays. *Id.*

D.12 The State notes that the foundation design of the CTB also changed in response to an estimated 35% increase in ground motions at the PFS site. Tr. at 7313-14 (Bartlett); State of Utah Testimony of Dr. Steven F. Bartlett and Dr. Farhang Ostadan on Unified Contention Utah L/QQ (Dynamic Analysis) [hereinafter Bartlett/Ostadan] Post Tr. 7268, at 4; CTB Analysis at 5-6. Now, the State continues, existing soils around the footprint of the CTB will be excavated to a depth of about 5 feet, mixed with cement and placed a distance of about 240 feet to 280 feet out from the basemat of the building. Testimony of Bruce E. Ebbeson on Section D of Unified Contention L/QQ [hereinafter Ebbeson] Post Tr. 6357, at 5; Tr. at 7313 (Bartlett). A reinforced concrete key will also be constructed around the perimeter of the foundation mat. Ebbeson Post Tr. 6357, at 5.

D.13 The State also points out that the soils at the PFS site have limited capacity to carry loads and thus the Applicant turned to the use of soil-cement surrounding the foundation of the CTB as a means to provide passive resistance to sliding during an earthquake. Tr. at 7313-16 (Bartlett/Ostadan). The State argues that in order for the soft clays to attract the load, there must be some lateral movement of the building to mobilize the peak shear strength of the soil-cement. Tr. at 7316 (Ostadan). If the passive resistance of soil-cement is not used, the State believes the calculated factor of safety against sliding will be less than 1. Tr. at 10,798 (Ebbeson); Bartlett/Ostadan Post Tr. 7268, at 4-5.

D.14 Finally, the State contends that there are complexities in evaluating a foundation design, especially under seismic conditions. State Findings ¶ 177. Unlike fabricated material such as concrete and steel where the boundary conditions in the design are reasonably well defined, the State argues that is not the case with soils. Tr. at 10,300 (Bartlett). Soils are naturally deposited materials that are heterogeneous and isotropic, and are quick to reach a yield and exhibit nonlinear complex behavior. *Id.* Because of the way in which soils have been laid down by nature, the State asserts that there are huge uncertainties in soil properties that affect their strength and compressibility, both with time and during an earthquake. Tr. at 10,301 (Bartlett). According to the State, the usual practice in geotechnical engineering is to rely on simple models that are based on basic civil engineering concepts. *Id.* Because of these uncertainties and the judgment involved, the State argues it is only when there is sufficient precedence and actual experience that geotechnical engineers have confidence in their models. Accordingly, the State believes there should be a hesitancy to model the nonlinear behavior of a soil beneath a foundation system based on an untested design or reliance on a nonlinear analysis, such as the one performed by Holtec. Tr. at 10,301-02 (Bartlett).

b. Cask Sliding as a Design Concept

D.15 According to the State, PFS relies on cask sliding as a mechanism to reduce seismic loads. Bartlett/Ostadan Post Tr. 7268, at 5. For example, based on his review of the forces that Holtec has provided, Dr. Ostadan insists that at different times during the duration of shaking there is separation in the contact points between the cask and the pad. Tr. at 10,435-36 (Ostadan). The State also points out that nowhere in Holtec’s analysis has it presented the forces for the casks analytically anchored to the pad — in the analyses the casks have always been allowed to slide smoothly on the pads. Tr. at 10,291 (Ostadan). As such, the State believes the forces transmitted to the pad and the underlying soils will be significantly greater if the casks are not allowed to slide. Tr. at 10,292 (Bartlett).

D.16 The State argues that sliding of SSCs in earthquake-resistant design is not common and is rarely used. Tr. at 7345 (Ostadan). The State believes that with no experimental or reliable performance data, it is a bold gesture for PFS (and the NRC Staff) to rely solely on the Holtec nonlinear analysis to predict cask performance and to take full credit for reduction of seismic forces to the foundations resulting from sliding of the casks atop the pads. *See* State Finding ¶ 186.

D.17 Contrary to the State’s argument, the PFS storage cask design does not “control” sliding, but merely allows it to occur. Tr. at 7335-39 (Ostadan). And the fact that sliding may occur in a “uniform and controlled manner” is not a design requirement but, rather, the result predicted by the cask stability analyses conducted by Holtec. Tr. at 7341-42 (Ostadan).

D.18 It is true that, if pad sliding occurs, such sliding has the beneficial effect of reducing the seismic loading to which the cask is subjected. *See, e.g.*, Tr. at 7348-49, 7354 (Ostadan); Tr. at 6633-35 (Pomerening); Tr. at 6155-56 (Trudeau). However, to the extent that such effect occurs, it is again a consequence of the design and not a design feature or mechanism. In any event, any facility that features unanchored casks (such as those at the Hatch and San Onofre plants) resting on a concrete foundation will be subject to potential sliding of the foundation, and will thereby experience a beneficial reduction in the seismic loadings on the casks. Hence, this feature of the PFS facility is also not unique. Tr. at 7306-07 (Ostadan).

c. Flexibility of the Storage Pads

D.19 Foundation damping (also known as radiation damping) is the property of structures to reflect back or radiate into the soil a portion of the energy imparted upon the structures by the seismic excitation. Tr. at 7457-59 (Ostadan). If a structure is rigid, it will be efficient in radiating energy back into the soil. As the flexibility of the structure increases, its ability to radiate energy back into the

soil decreases. Tr. at 7455-57 (Ostadan). This reduction in radiation damping is a matter of degree, and is a function of the amount of flexibility exhibited by the structure. Tr. at 7459-60 (Ostadan).

D.20 The State believes that the question for the Board to address regarding pad flexibility is whether the pad is flexible enough for the cask-drop and tip-over constraint and rigid enough to produce significant radiation damping and provide a smooth (i.e., undeformed) surface for cask sliding. State Findings ¶ 196.

D.21 According to the State, an initial premise underlying Holtec's design calculations is that the pad will act as a rigid body. *Id.* ¶ 189. In that regard, the State notes that the original Holtec Multi-Cask Seismic Response at the PFS ISFSI (at 3-4), dated May 19, 1997 states "the characteristics of the pad are based on the assumption that the 30-foot by 64-foot section responds to seismic excitation as a rigid body; this assumption has been based on recommendation of the project architect and engineering group responsible for the ISFSI design of the PFS facility." State Findings ¶ 189 (*citing* Tr. at 6186-87 (Trudeau)). The State argues that this assumption was not based on the recommendation of either Mr. Trudeau or Dr. Tseng. According to the State, this starting premise has led to Holtec's assumption that there will be no deformations in the pad and that the casks will slide smoothly over the pads. State Findings ¶ 189. The State also insists that the assumption of pad rigidity has also guided Holtec's selection of soil springs and damping values. Tr. at 7451 (Ostadan).

D.22 According to the State, Holtec has calculated damping that is associated with a rigid pad and the International Civil Engineering Consultants, Inc. (ICEC)³⁷ has used those respective soil springs and damping values in its design calculation. Bartlett/Ostadan Post Tr. 7268, at 14. The State argues that the Applicant has not shown the pads are rigid, yet it still takes full credit for radiation damping. Tr. at 7459 (Ostadan). The State insists that if the pads are in fact rigid, there would be significant SSI effects with the soils playing a major role in dissipating energy through radiation damping. *Id.* at 7455-57.

D.23 The State contends that ICEC was never asked to determine the appropriate damping under rigid or flexible conditions. Tr. at 7467 (Ostadan). Instead, according to the State, ICEC was given the dynamic forces that came out of Holtec's nonlinear time history analysis. *Id.* The State believes that the relative flexibility or rigidity of the pad could have been easily ascertained by using the industry standard computer program for soil structure interaction, SASSI, and conducting a half-day analysis, first by assuming the pad was rigid and then assuming it has the properties of concrete. *Id.* at 7466, 7471. According to the State, by calculating the amount of damping for these two scenarios, the Applicant would have quantified the appropriate amount of damping for the PFS site. *Id.*

³⁷ PFS Expert Dr. Wen Tseng is President of ICEC.

This issue is important because if smaller damping values are used, seismic loads would be higher than those calculated by Holtec. *Id.* at 7470-71.

D.24 The State argues that the contact condition in Holtec's analytical calculation for cask tip-over and drop also requires that the pad and underlying cement-treated soil be somewhat flexible to be able to absorb energy from cask impact. Tr. at 7449 (Ostadan). Here, the State insists that PFS is asking that the cement-treated soil be strong enough to carry the horizontal loads and meet the pad sliding requirements but soft enough to satisfy Holtec's cask-drop tip-over conditions. Tr. at 7422-23, 7450-54 (Ostadan).

D.25 During the trial, the State's expert, Dr. Ostadan asserted that what is important is not necessarily the amplitude of displacement, as argued by the Applicant's experts, but rather the movement of the different points on the pad with respect to each other. Tr. at 7460, 7465 (Ostadan). Dr. Ostadan believes that the larger the relative movement over the pad, the less damping, and less damping will result in an increase in the calculated seismic loadings. Tr. at 7460, 7469-70 (Ostadan). The State argues further when evaluating pad stiffness that one needs to look at the entire pad and determine whether it is moving intact together and engaging with the soil (highest damping) or flip flopping (less damping). Where the maximum deformation is repeating in nearby adjacent points, the pad is flexible. Dr. Ostadan, the State's expert in SSI, testified that looking at maximum relative displacement was a very cumbersome way to ascertain pad flexibility when two runs on SASSI would readily produce the answer. Tr. at 7471 (Ostadan).

D.26 As we previously noted, Dr. Ostadan expressed concern over the Applicant's analysis because it did not account for a potential rippling effect of the pad, which could decrease the radiation damping available. Tr. at 7464-65, 7468-71 (Ostadan). However, a plot of vertical displacements on the pad as a function of location on the pad shows that the displacement along the pad is virtually zero for most of the length of the pad and there is one single, gradual, small vertical displacement of the pad at the point of application of the seismic loading, which slowly decreases as one moves away from the point of application of the seismic force. PFS Exh. 227; Rebuttal Testimony of Wen S. Tseng on Section D of Unified Contention Utah L/QQ [hereinafter Tseng Reb.] Post Tr. 10,727, at 2-3. These results show the absence of "ripples" of the type of concern to Dr. Ostadan, and demonstrate the rigid behavior of the pad under dynamic seismic loadings. *Id.*

D.27 PFS performed an evaluation of the effects of pad flexibility on the properties of the foundation, based on the methodology described in a recognized technical paper (Iguchi and Luco (1981)) and demonstrated that the effect of flexibility on the foundation damping properties of the pad is insignificant in the frequency range of importance to the cask response. Youngs/Tseng Post Tr. 5529, at 21-22; Tseng Reb. Post Tr. 10,727, at 2. This result is supported

by the computer analyses conducted by Sandia Laboratories for the NRC Staff, which incorporated pad flexibility and yielded very small cask displacements under seismic loadings. Tr. at 6788-89 (Luk). Holtec also performed, for another facility, parametric studies that compared the stability of the casks, assuming a rigid versus a flexible pad, and determined that the differences in the two cases were negligible. Singh/Soler Post Tr. 5750, at 38-39.

D.28 The maximum displacements shown in Table D-1(d) of the ICEC Calculation are on the order of $\frac{3}{8}$ of an inch. Youngs/Tseng Post Tr. 5529, at 24; PFS Exh. 85, at 234. These are “very small” displacements. Dep. of Farhang Ostadan (Mar. 8, 2002) (State Exh. 112) at 105. Moreover, Dr. Tseng testified that the maximum displacements in that table include rigid displacements, that is, vertical motions of the entire pad as a rigid body. Youngs/Tseng Post Tr. 5529, at 24. When the rigid displacements are removed, the maximum deviation of local displacements from rigid body motion for the pad is on the order of approximately $\frac{1}{8}$ of an inch. *Id.*; Tr. at 10,754-55 (Tseng). Such a small local displacement would produce only secondary effects on the global dynamic response of the pad-cask system, and would not affect the stability of the casks. Youngs/Tseng Post Tr. 5529, at 24; Tr. at 5662 (Tseng); Singh/Soler Post Tr. 5750, at 46-47.

D.29 Regarding the State’s claim that the Applicant’s seismic design entails “conflicting requirements,” the Board notes that the State’s own experts’ testimony opined that these “conflicting” requirements can be resolved by the use of appropriate materials, and testing can show whether or not these requirements have been satisfied. *See* Tr. at 7451-52, 10,399-401 (Ostadan).

D.30 Furthermore, there is no requirement that the pad be rigid to ensure smooth sliding of the cask; in fact, the effects of pad flexibility are only second-order in nature, as Holtec demonstrated in analyses performed for Tennessee Valley Authority’s Sequoyah Nuclear Power Plant. Singh/Soler Post Tr. 5750, at 38-39; Tr. at 6014 (Singh). In any case, Holtec used both an upper bound (0.8) and a lower bound (0.2) coefficient of friction between the cask and the pad to account for local irregularities at the interface between the two bodies; in some analyses, Holtec used a random coefficient of friction from 0 to 1 between the cask and the pad. Singh/Soler Post Tr. 5750, at 41; Tr. at 6018-20 (Soler). These variations in the coefficient of friction would account for the potential effects of pad flexibility on cask sliding. Singh/Soler Post Tr. 5750, at 41. We therefore conclude that the effects of pad flexibility on the dynamic behavior of the casks in a seismic event are negligible.

d. Soil–Structure Interaction Analysis

(i) GEOMATRIX ANALYSIS OF THE SOIL COLUMN

D.31 Geomatrix performed a soil column analysis to obtain the strain compatible soil properties in the free field using a common industry program, SHAKE. Tr. at 7570-72 (Ostadan). Because soil material is highly nonlinear during earthquake shaking, the State contends that it is common industry practice to perform a soil column analysis without any structures or foundations present and input the design motion at the top of the column, thereby obtaining the properties of the soil as impacted by the design motion. Tr. at 7514-15, 7571 (Ostadan). The State insists that, although the SHAKE soil properties are used in SSI analysis, the SHAKE analysis cannot in any way be considered an SSI analysis. *See* Tr. at 7513 (Ostadan).

D.32 According to the State, the SHAKE analysis is done in the free field and does not take into account the natural frequency of the structure or the foundation or other SSI effects. Tr. at 7515, 7570 (Ostadan). On a relatively soft and layered soil site like the PFS site, the State insists that one needs to account for the following: (1) deformation of the soil, (2) the additional amplification of the seismic motion that could be caused by the soil, (3) radiation damping in the soil, and (4) realistic values for the seismic loads and seismic response of the structure. Tr. at 10,312-13 (Ostadan). The State believes that the seismic response of a structure will be influenced by its natural frequency, which for the pad–foundation system is about 5 to 11 hertz (Hz). *Id.* at 10,418-19 (Bartlett/Ostadan).

D.33 There is no regulatory requirement that the design of cask storage pads include a formal SSI analysis. In addition, there is no claim in this proceeding that the design inputs provided by Geomatrix were inadequate. Nor is there a claim that Holtec’s analyses were deficient for failing to expressly quantify soil–structure interaction effects. There is also no claim that the pad is incorrectly designed, except in that long-term pad settlement was not considered in the pad’s design, which we find to be inconsequential and unrelated to soil–structure interaction. For these reasons, the Board finds the Applicant’s SHAKE analysis to be adequate.

(ii) PAD ACCELERATION

D.34 According to the State, Dr. Ostadan has written and reviewed numerous SSI reports. State Findings ¶ 200. His criticism of Holtec’s cask stability report is that it does not discuss or present its results for a reviewer to evaluate and does not quantify any SSI effects. Dr. Ostadan believes that Holtec is focused only on the displacement of the cask and these other questions remain unanswered. Tr. at 7517 (Ostadan).

D.35 Dr. Ostadan contends that Holtec's seismic analysis of the soil properties under the pad is represented by a set of soil springs or soil damping parameters. Tr. at 7565 (Ostadan). The soil properties Holtec used were those from Geomatrix's SHAKE analysis. Tr. at 7567 (Ostadan).

D.36 According to Dr. Ostadan, the seismic loads from the cask are exerted on the pad and additional seismic loads are due to the mass of the pad, itself. Tr. at 7533 (Ostadan). He notes that the forces exerted on the pad coming from the cask were provided to ICEC by Holtec, but Holtec did not provide the inertial load of the pad itself. By not providing the inertial load of the pad itself, Dr. Ostadan believes ICEC and Stone & Webster were forced to make two assumptions. First, ICEC, in the design of the pads, and Stone & Webster, in its pad sliding analysis, had to guess at the inertial load of the pad itself. Second, Stone & Webster also had to guess at the loads coming from the cask. Tr. at 7529-36 (Ostadan).

D.37 The State criticizes this analysis because ICEC was not asked to perform a complete SSI analysis or to analyze damping. Tr. at 7466-67 (Ostadan). ICEC simply applied the dynamic forces obtained from Holtec in the SASSI model to obtain the stresses and moments in the pad for the purpose of structural design, and to estimate the amount of steel reinforcement. Tr. at 7467 (Ostadan). At best, the State claims that ICEC's analysis constitutes about 10% to 20% of what is needed for a complete SSI analysis. State Findings ¶ 204.

D.38 Dr. Ostadan also argues that to understand the inertial load of the pad requires knowledge of the acceleration of the pad. Tr. at 10,338 (Ostadan). Further, according to the State, from Holtec's analysis it is unknown how much shear force is going to be generated based on the pad itself. In that regard, the State contends that the dynamic loads from Holtec do not include acceleration of the pad or shear forces. State Findings ¶ 205.

D.39 Turning to the dynamic forces for pad stability, the State contends that instead of obtaining the acceleration of the pad from Holtec in the cask stability design calculations contained in PFS Exhibit UU, Mr. Trudeau assumed a number — peak ground acceleration (0.7g) — for a design input into the pad sliding analysis. Bartlett/Ostadan Post Tr. 7268, at 18. According to the State, peak ground acceleration (PGA) is the ground motion in the free field and does not account for SSI effects. State Findings ¶ 206. Thus, the State insists that use of PGA for the seismic loads for the pads has nothing to do with the response of the pad. Tr. at 7480-81 (Ostadan). The pad, the soil, and the foundation have their own natural frequency, which ranges from 5 to 11 hertz. Tr. at 7481 (Ostadan). Thus, the State argues that using PGA as the input motion to estimate the seismic loads for the pad is appropriate only for rock sites, which is not the case at the PFS site. Tr. at 7480-81 (Ostadan).

D.40 According to the State, Mr. Trudeau attempts to justify his use of PGA by assuming that there is a tremendous amount of radiation damping — 48% to 52% — and with these high damping values, the design motion in the free

field (0.7g) is a fairly close fit. Trudeau Section D Post Tr. 6135, at 14-16; Tr. at 6199-6200 (Trudeau); Tr. at 7623 (Ostadan). However, the State argues that Dr. Ostadan, an expert in SSI — compared to Mr. Trudeau who has little experience in analyzing SSI³⁸ — found Mr. Trudeau’s assertion of high damping values “unusual” for such a foundation system. Tr. at 7623 (Ostadan). Moreover, according to the State, the “simple” calculation that Mr. Trudeau performed to arrive at about 50% damping was not the method he used in his CTB stability calculations. State Findings ¶207 (*citing* Tr. at 6200-01 (Trudeau)). In that regard, although the State has some concerns about the CTB analysis (e.g., damping and treating the CTB mat as rigid), the State believes that Stone & Webster took a logical approach in obtaining the dynamic response of the CTB mat. Tr. at 7530 (Ostadan).

D.41 Because, in his opinion, the report performed by the Staff’s expert Dr. Vincent Luk,³⁹ is about the only place in the record that comes close to discussing pad accelerations, Dr. Ostadan testified that he resorted to Figures 17 and 20b of the Luk Report as an indicator of pad acceleration. Tr. at 10,339, 10,342-44 (Ostadan). Dr. Ostadan contends that Dr. Luk omitted proportional damping from his model and that his analysis tends to overpredict high-frequency response, which may be responsible for the 3g acceleration in Figure 17, but Figure 20b does have accelerations beyond 10g. *Id.* at 10,342-43. In that regard, Dr. Ostadan claims that even though Dr. Luk omitted proportional damping and Figures 17 and 20b only apply to one node, one still can glean high pad acceleration from those figures. *Id.* at 10,343-44. Moreover, accelerations at low-end frequencies in the range of 5 to 7 hertz are still large and indicate high accelerations of the pad. *Id.* at 10,343.

D.42 For these reasons, the State insists that there is ample evidence to suggest that the acceleration of the pads may be greater than that estimated by PFS. State Findings ¶211.

D.43 Essentially, the question raised by the State is what the correct value of response acceleration for the pad would be and how much of an error would be introduced by using, as PFS did, the PGA (that is, the free-field ground acceleration) as a proxy for the response acceleration of the pad. The short answer is that the horizontal response acceleration computed based on the Holtec analysis would be 0.79g instead of the 0.711g used by PFS in its analyses. Rebuttal Testimony of Paul J. Trudeau on Section D of Unified Contention Utah L/QQ [hereinafter Trudeau Section D Reb.] Post Tr. 11,275, at 1, 3-4. Use of the 0.79g acceleration instead of the PGA employed by PFS would merely result in a slight

³⁸ State Findings ¶207 (*citing* Tr. at 6163 (Trudeau)).

³⁹ For a full description of Dr. Luk’s report, *see* below, Findings E.152-.174.

decrease in the “base case” factor of safety against sliding of the pads from 1.27 to 1.22. Trudeau Section D Reb. Post Tr. 11,275, at 4.

D.44 The Applicant provided ample support for its claim that the horizontal pad response acceleration differs little from the PGA by showing that the radiation damping applicable to the soil–pad–cask system is so high (50% for the “best estimate” soil properties case) that the effects of SSI in terms of amplifying the accelerations imparted on the pad are limited. Therefore, the response acceleration of the pad is essentially equivalent to the free-field ground acceleration. Trudeau Section D Post Tr. 6135, at 14-16; PFS Exh. 231; Tr. at 11,280 (Trudeau).

D.45 Dr. Ostadan indicated that he had not seen a calculation that demonstrated the existence of the 50% value of radiation damping estimated by PFS and expressed concern that such a damping level might be unrealistic. Tr. at 7623 (Ostadan). He agreed, however, that if such a level of damping could be established, his concern about the difference between PGA and the response acceleration of the pads would diminish. Tr. at 7624 (Ostadan). PFS subsequently produced a calculation that substantiated the radiation damping values it used and which was not challenged by the State. *See* PFS Exh. 231; Tr. at 11,279-81 (Trudeau).

D.46 The Applicant provided additional confirmation of the appropriateness of its use of peak ground acceleration in its cask stability analysis by comparing the factor of safety against sliding of the pads it computed for its base case, 1.27, against the factor of safety that would be obtained using the time history of forces developed by Holtec in its SSI analysis of the pad and casks. The use of this time history of forces at the base of the pad and casks yielded a factor of safety against sliding of 1.25, demonstrating that there is only a very slight reduction in the minimum factor of safety against sliding when these loads are used instead of computing the inertial forces of the pad and cement-treated soil based on the peak horizontal ground accelerations. Trudeau Section D Post Tr. 6135, at 14-16.

D.47 The State’s attempt to contrast (1) the horizontal pad acceleration used by the Applicant (0.711*g*) with (2) the response of the mat of the CTB from the SSI analysis performed by PFS for that building (1.047*g*) is unavailing. As noted by the Applicant’s expert, Mr. Trudeau, the CTB is a much taller structure than the pads, hence the SSI effects should be more pronounced for that building than for the pads. Tr. at 6192-93 (Trudeau).

D.48 Similarly, we do not agree with the conclusions Dr. Ostadan drew from his comparison of the Luk Report pad accelerations with the pad accelerations used by Stone & Webster. Bartlett/Ostadan Post Tr. 7268, at 18. During the hearing, Dr. Ostadan acknowledged that at the time he provided the testimony in Answer 37, he had not reviewed the Luk Report in any detail. Tr. at 7781, 7786, 7793, 7798 (Ostadan). Accordingly, he was not aware that the figures from the report on which he relied were obtained by omitting the stiffness proportional damping and were only for a single node, and thus could not be relied upon

to be a correct representation of the pad accelerations. Tr. at 7788 (Ostadan); Tr. at 7794-98, 7801-02 (Ostadan). On redirect, Dr. Ostadan reiterated his view that the Luk Report can be read to suggest that high pad response accelerations exist. Tr. at 10,342-44 (Ostadan). However, Dr. Ostadan could not reconcile his assertion that the Luk Report's high accelerations should be given credit with the inconsistent fact that the same report predicts very little displacement of the cask under such accelerations. Tr. at 10,427-28 (Ostadan). In light of this and the rest of the evidence on this point, we find the State's argument based on the accelerations depicted in the Luk Report to be without merit.

D.49 To summarize, nothing before us indicates the Applicant's use of the PGA to compute the dynamic forces for pad stability is erroneous. In addition, we note that the peak acceleration, whatever its value, will be applied only at a single point in time in the entire time history; therefore, any errors in the computation of that acceleration will be absorbed by the fact that the average factor of safety against sliding is approximately 10 throughout the duration of the earthquake. Trudeau Section D Post Tr. 6135, at 16.

D.50 Moreover, as the undisputed testimony of all parties shows, sliding of the pads, if occurring, tends to reduce loading on the casks and is therefore beneficial from the standpoint of cask stability. Therefore, this concern, even if valid, would have no practical impact on the safety of the facility.

e. Pad-to-Pad Interaction

D.51 Dr. Bartlett's and Dr. Ostadan's prefiled testimony (answer 36) provides a detailed description of the State's concerns with pad-to-pad interaction. Bartlett/Ostadan Post Tr. 7268, at 15-18. They claim that in its sliding stability calculation, Stone & Webster assumed that, for a longitudinal column of storage pads, the soil and cement-treated soil under the pads and soil-cement around the pads would move in unison with the pads. In other words, they contend that Stone & Webster assumed that during an earthquake the different masses of the entire system would be in-phase. *Id.* at 15-16.

D.52 Next, the State witnesses observed that the storage pads and surrounding soil-cement are not structurally tied together, such as with reinforcing rebar and argued that in Dr. Tseng's deposition testimony, he admitted that the pads and soil-cement would not act as an integrated structure. Bartlett/Ostadan Post Tr. 7268, at 15-16.

D.53 The crux of the State's testimony is that during the cycling of earthquake forces, the following will occur: (1) there will be separation between the soil-cement and the storage pads; (2) the soil-cement and pads will not act as an integrated unit; and (3) the difference in modulus between the very stiff soil-cement and the relatively soft upper Lake Bonneville clay will create strain incompatibility and stress concentration in the soil-cement as the gap between the

soil-cement and pads attempts to close. As a consequence the State believes that if the soil-cement does not fail in compression, it will act as a strut introducing significant transfer of inertial force through pad-to-pad interaction. Bartlett/Ostadan Post Tr. 7268, at 15-16.

D.54 According to the State experts, the SSI effects will cause the pads, which are only 5 feet apart from each other, to move differently from the free-field motion of the soils. Tr. at 10,380-81 (Ostadan); Bartlett/Ostadan Post Tr. 7268, at 17. The State believes that this phasing of the motion of the pads will create a push and pull action as the pads move toward and away from each other, creating a force transfer that has not been accounted for in the Applicant's sliding analysis of the pads and stability analysis of the casks. Tr. at 10,380-81 (Ostadan); Bartlett/Ostadan Post Tr. 7268, at 17.

D.55 In one of the many computer runs that Dr. Soler conducted during the course of the hearing, one scenario involved modeling compression of the soil-cement within a two-pad system. Tr. at 10,382 (Ostadan); PFS Exh. 225, at 28. The resulting force transfer from that analysis is reported to be 1900 kips. Tr. at 10,382 (Ostadan). The State argues that this is a large force, which has not been accounted for in the stability analysis of the pads. Tr. at 10,382 (Ostadan). The State has serious concerns about, what it believes is, the already slim margin in the Applicant's pad seismic stability calculation, PFS Exhibit UU, where the base case has only a 27% calculated margin of safety. *See* State Findings ¶217.

D.56 According to the State, the Applicant's attempt to present the pad-to-pad interaction effect is unrealistic because the Applicant insists that the pads will not slide. State Findings ¶218 (*citing* Trudeau Section D Reb. Post Tr. 11,275, at 6-7). The State insists that Mr. Trudeau assumes that there will be no sliding because PFS has calculated a 27% factor of safety against sliding and also because of the interface strength and bonding of the soils-cement-treated, soil-pad-soil-cement system. *Id.* In the State's opinion, however, this does not overcome its concerns, because as Dr. Bartlett testified, pad-to-pad interaction can occur without sliding. Bartlett/Ostadan Post Tr. 7268, at 17. According to the State, the upper Lake Bonneville clay underlying the pads is a relatively deformable body compared to the much stiffer soil-cement plug between the pads. State of Utah Partial Surrebuttal Testimony of Dr. Steven F. Bartlett to Rebuttal Testimony of Paul J. Trudeau on Unified Contention Utah L/QQ (Dynamic Analyses) [hereinafter Bartlett Dynamic Analysis Partial Surrebuttal] Post Tr. 11,306, at 4. Thus, during earthquake cycling there will be SSI effects from the differences in kinematic (stiffness of the soil-cement relative to the deformable clay soil) and inertial (mass differences between the cask-pad system and the soil-cement) properties of the system. *Id.* An example of these effects, according to the State, is that the relatively stiff plug of soil-cement will transmit the earthquake force horizontally from pad to pad whether or not the pad is sliding. *Id.* The Holtec Report, discussed in the preceding paragraph, briefly analyzed a simple two-pad system

in the longitudinal direction and showed a significant transfer of lateral forces even without initial pad sliding. *Id.* Certainly, the State insists pad sliding will cause more severe pad-to-pad interaction effects than calculated by Holtec in PFS Exhibit 225. *Id.* Furthermore, the State points out that the Holtec calculation did not include the effects of multiple pad interactions. State Findings ¶ 218.

D.57 Testimony by Applicant and Staff witnesses showed that the soils beneath the pad foundations are essentially uniform across the pad emplacement area and have sufficient strength to withstand the DBE loadings without experiencing significant deformation (i.e., strain). Mr. Trudeau testified that the effective shear strain in the clayey soil underlying the soil-cement was only 0.13%. Trudeau Section D Post Tr. 6135, at 19; Tr. at 6208-09 (Trudeau). While this strain was computed for the free field, no significant variations in soil strain level would be anticipated if the presence of the pads and the casks was taken into account. Tr. at 6210-12 (Trudeau).

D.58 With respect to soil strength, Dr. Bartlett referred to the upper Lake Bonneville clays as “fairly soft” and “somewhat as a jello.” Tr. at 11,309 (Bartlett). On further examination, however, he acknowledged that the clays have a strength in excess of 2000 psi and are “soft” only when compared with an adjacent soil-cement layer. Tr. at 11,335 (Bartlett). Another description of the strength of these clays was provided by Mr. Trudeau, who stated that the upper Lake Bonneville clays at the PFS site are partially saturated, stiff, and competent. Tr. at 6278 (Trudeau).

D.59 There is also uniformity of properties in the upper Lake Bonneville clay soils across the pad emplacement area. *See, e.g.*, Tr. at 11,726 (Trudeau); Tr. at 11,816-18 (Ofoegbu).

D.60 As we previously noted, to support the Applicant’s position, Holtec conducted an analysis in which it modeled two adjacent pads, 5 feet apart, one pad fully loaded with eight casks, the other having only a single cask, and included a representation of the soil-cement between the pads. Soler Reb. Post Tr. 10,557, at 2. Holtec performed two simulations for this model: one in which the soil-cement between the pads is assumed to retain its integrity and therefore able to transmit both tension and compression forces; and another simulation in which the soil-cement is assumed to be cracked and thus able to transmit only compression forces. Soler Reb. Post Tr. 10,557, at 2.

D.61 The configuration in these cases was set to maximize the potential for pad-to-pad forces. As explained by Dr. Soler: (1) no forces were allowed to be absorbed by the soil-cement; (2) no forces were allowed to be transmitted downward to the cement-treated soil and to the soils beneath; (3) no damping was included in the model; (4) a maximum value of Young’s Modulus for the soil-cement was assumed; and (5) no credit was taken for the potential crushing of the soil-cement by the forces going from one pad to the other. Tr. at 10,657, 10,720-24 (Soler). According to the results of Holtec’s analysis, the maximum

estimated force in the soil beneath the pads was less than the minimum required to initiate pad sliding. Tr. at 10,723 (Soler). Also, while both cases predicted some interactions between the pads or between the pads and the soil-cement, the forces resulting from those interactions, when added to the seismic loadings, resulted in total cask motions of the same order — inches — as had been obtained in prior simulations that had not expressly accounted for pad-to-pad interaction forces. Soler Reb. Post Tr. 10,557, at 3-4.

D.62 Dr. Ostadan made it clear that his concern was not with the effect of pad-to-pad interaction forces on the structural integrity of the pads or the direct effect of these forces on the casks, but only with their potential effect on the foundations. See Tr. at 10,697-700 (Ostadan). Since the results of the Holtec simulation indicate that pad-to-pad interaction forces have essentially no impact on the stability of either the pads or the storage casks, we agree with the Applicant's assessment that pad-to-pad interaction forces have no practical significance.

D.63 State witnesses testified that their concern over pad-to-pad interaction would be magnified if the pads actually were to slide. Tr. at 7520 (Ostadan). The testimony of PFS witnesses, however, is that the design of the cement-treated soil will provide a large margin against the potential sliding of the pads. See, e.g., Trudeau Section D Post Tr. 6135, at 9, 18-19; Trudeau Section D Reb. Post Tr. 11,275, at 6-7.

D.64 The State interpreted the pad-to-pad interaction forces resulting from the two Holtec analyses referenced above as being potentially additive to those included in the PFS sliding stability calculation and resulting in making the forces acting on the pad exceed the available resisting forces and potentially induce pad sliding. Tr. at 10,618-21 (Ostadan). This interpretation is erroneous for two reasons. First, and most significant, the Holtec model is all-inclusive, since it accounts both for the seismic forces acting directly on the pads and for the effects of pad-to-pad interaction. Tr. at 10,618-20 (Soler). In addition, it would be improper to add the maximum seismic forces acting on the pad and the maximum pad-to-pad interaction forces, since they could act at different points in time and, depending on the direction of the pad motion, could be subtractive rather than additive. *Id.*

D.65 Dr. Ostadan also theorized that there could be configurations in which interaction loads from various pads could accumulate on a single pad and result in potential sliding of the pad, but indicated that without additional analysis he could not specifically postulate any. Tr. at 10,685-91 (Ostadan). Without further support, however, we cannot give credit to his theory. At any rate, as we discussed above, sliding of the pads is beneficial to the stability of the casks and has no adverse safety consequences.

D.66 In responding to the State's claim concerning effect of interaction between pad and the 5-foot layer of soil-cement separating the pads, PFS testified

that, by virtue of the interface strengths between the concrete pad and the underlying cement-treated soil and between the cement-treated soil and the underlying silty clay/clayey silt, the pads will be bonded to the underlying clayey soils; therefore, because pads will not slide, there will not be interaction between the pad and the soil-cement frame. Trudeau Section D Reb. Post Tr. 11,275, at 6-7. The pads are sufficiently close in the north-south direction that the pads and 5-foot-wide soil-cement plug between them will move in concert with the underlying soils when they deform due to the earthquake loading; and thus, there will be no pad-to-pad interaction. *Id.*

D.67 In addition, should there be a sliding of the pads leading to a collision with the soil-cement frame across a postulated gap between the two surfaces, the soil-cement will tend to crush under the imparted loading, because there is a significant difference between the compressive strength and modulus of elasticity of the storage pad (3000 psi and 3,120,000 psi), and the compressive strength and the dynamic modulus of the soil-cement (250 psi and 228,000 psi). NRC Staff Testimony of Daniel J. Pomerening and Goodluck I. Ofoegbu Concerning Unified Contention Utah L/QQ, Part D [hereinafter Pomerening/Ofoegbu] Post Tr. 6496, at 21-23. The crushing of the soil-cement will limit the magnitude of the force that can be transmitted from one pad to another. *Id.* at 26. Because of the low magnitude of force that can be transmitted through the soil-cement layer between the storage pads, the influence on the structural integrity of the storage pads and the stability of the casks during a collision between the pad and the soil-cement plug will be minor. *Id.*

D.68 In their direct testimony, PFS experts, Dr. Singh and Dr. Soler provided an answer analogous to the Staff's, indicating that if one postulated the existence of a gap between a pad and the adjacent soil-cement plug, and further postulated that the pads did slide under the design basis seismic event, the closure of the soil-cement-to-pad gap would lead to horizontal impacts not included in the current analysis. The impact, however, would result in an additional energy absorption by the soil-cement, resulting in minimal changes to the forces on the pad and casks. Singh/Soler Post Tr. 5750, at 44-45.

D.69 In order to test the validity of this hypothesis, Holtec performed an analysis in which it examined the potential effect of a gap between a pad and the adjacent soil-cement layer. The analysis evaluated the impact forces that would be imparted on the pad as a result of its collision with the soil-cement across the gap and the effect of those forces on the stability of the casks on the pad. For this analysis, a single pad fully loaded with eight casks was allowed to slide on the underlying soil and collide with a fixed, rigid soil-cement frame surrounding the entire pad with a clearance gap of approximately 0.6 inches to all edges of the moving pad. Soler Reb. Post Tr. 10,557, at 2. The results of the Holtec analysis for this case indicate that, while there will be impacts between the pad and the surrounding soil-cement, the forces produced by those impacts tend to

offset the forces that would be imparted by the gradual application of compression of the pad against the soil-cement, so that the net result is a reduction in the overall forces acting on the pad and the casks, and a reduction by a factor of 2 in the displacement of the casks. Tr. at 10,564-67 (Soler). In short, the collision between the pad and the soil-cement frame has no discernible adverse impact on the stability of the casks. *See* PFS Exh. 225.

D.70 The reason for the limited effect of pad-to-pad interactions is that such interactions do not impart forces of sufficient magnitude on the pads to affect the stability of the casks on the pads. Soler Reb. Post Tr. 10,557, at 4. The speculations by the State witnesses on how those interaction forces may alter the “load path” and cause sliding of individual pads or soil failures do not alter the fact that, as shown by the testimony, pad-to-pad interaction concerns are inconsequential. Again, if the interaction results in sliding of the pads, this effect is beneficial in terms of enhancing the stability of the casks.

f. Pad Settlement

D.71 According to the State, long-term pad settlement was not considered in the Applicant’s structural design of the pads or in Holtec’s cask sliding stability analysis. Tr. at 10,332 (Bartlett). Settlement from differential cask loading could cause dishing or tilting of the pads. Consequently, such an effect would impact Holtec’s cask stability analysis because Holtec assumed a perfectly horizontal planar surface in its cask sliding and stability analyses. Tr. at 10,332-33 (Bartlett).

D.72 The State contends that the PFS estimations of pad settlement have spiraled downward from an initial 5 inches of settlement, to approximately 2 inches to finally, in rebuttal testimony, 0.5 inch. Internal Memo from Macie to Trudeau/Georges, Apr. 2, 1997 (State Exh. 211) [hereinafter Macie Memo]; SAR at 2.6-50 (State Exh. 168); Trudeau Reb. Post Tr. 11,275, at 4.

D.73 According to the State’s experts, in 1997 the Applicant predicted total differential pad settlement of 5 inches in one month under full loads. Macie Memo; Tr. at 10,334 (Bartlett). The State also believes that at one time PFS contemplated preloading the pads (applying a certain amount of fill to try to take the settlement out before the pads are constructed). Tr. at 10,334-35 (Bartlett). There is no known plan for the Applicant to do any preloading. Tr. at 10,335 (Bartlett). While the State admits that the 1997 memo is only a historical document, not a currently applicable one, it nonetheless argues that it does point out the longstanding concerns about the settlement of the pads and potential impact such settlement could have upon structural adequacy of the pads. State Findings ¶234.

D.74 The State agrees that 2 to 3 inches of settlement is a reasonable estimate of total settlement, but it believes a few inches of settlement is a significant number in foundation design. State Findings ¶234. For the case at hand, given Holtec’s assumptions of a perfectly smooth surface for point-to-point contact on

the bottom of the cask, the State argues that what is important is the relative distribution of the settlement and the angle of inclination of the pad, and how they impact sliding and the inertial forces transferred to the pads and foundation. Tr. at 7763-64 (Ostadan).

D.75 During the hearing, Dr. Ostadan indicated that he expects that, over the long range, the middle of the pad will settle more and the edges will settle less, deforming the pad into a concave shape. According to Dr. Ostadan, this deformation may reduce the area of contact between those casks placed on the center of the pad and the surface of the pad, and may influence the rate of cask sliding during a seismic event. Tr. at 7363-65 (Ostadan).

D.76 Pad settlement is due to three mechanisms: immediate settlement similar to elastic settlement as the pad is loaded; consolidation settlement; and long-term, creep-type settlement. Tr. at 7495-96 (Bartlett). Immediate settlement is over in a matter of days; consolidation settlement occurs over a term of months, or at most a few years; and creep settlement takes place over the full design life of the facility. Tr. at 7495-96, 7644-46 (Bartlett).

D.77 The estimated total long-term settlement of the pads was computed in Stone & Webster Calculations 05996.02-G(B)-03, Rev. 3, “Estimated Static Settlement of Storage Pads,” and 05996.02-G(B)-21, Rev. 0, “Supplement to Estimated Static Settlement of Cask Storage Pads” (May 21, 2001). As explained in those calculations, the settlement of the pad is predicted based on conservative assumptions that result in an upper-bound estimate of approximately 1.75 inches for the total long-term settlement of the pads. Trudeau Section D Reb. Post Tr. 11,275, at 4; SAR at 2.6-50 (State Exh. 168).

D.78 Mr. Trudeau testified that, based on the conservatisms incorporated in the pad static settlement analyses, the actual long-term static settlement of the pads that can be reasonably expected to occur would be much less than the 1.75 inches that is predicted in the Stone & Webster calculations — which is only one fourth to one third of this estimated value, or approximately 0.5 inch. Trudeau Section D Reb. Post Tr. 11,275, at 4.

D.79 In his testimony, Dr. Bartlett indicated that he did not contest the 1.75-inch total settlement reflected in the most recent PFS calculation. *See* Tr. at 11,347-48 (Bartlett). Dr. Ostadan, on the other hand, testified that there would be an additional impact on the settlement experienced by any one pad from the loading of other pads. Tr. at 7765-73 (Ostadan). Such an impact, however, would appear to be at best a second-order effect, considering the distance between pads and the fact that Dr. Ostadan assumes that the pad deflection will be greatest at the center of the pads and least at the edges, where any impact of the settling of adjacent pads would be experienced. *Id.*

D.80 We note that, according to State Exhibit 168, the 1.75 inches of maximum, long-term pad settlement is computed assuming that the entire upper layer of subsoil has the same compressibility characteristics as those of the upper

Bonneville Lake deposits, which as discussed above are the weakest and most compressible soils at the PFS site. Therefore, we conclude that, as indicated in State Exhibit 168, the 1.75-inch estimate “conservatively overestimates the expected settlements.” In light of this clear overestimation, we regard the 0.5-inch estimate provided by Mr. Trudeau, from which the known conservatisms have been removed, as reasonable. Such settlement levels would raise no significant stability concerns. Tr. at 11,125 (Mitchell).

D.81 The Applicant and the Staff witnesses also testified that, because of the great stiffness contrast between the concrete pad and the underlying clayey soils, the long-term settlement of the pads at the PFS facility will be essentially uniform across the pad. Thus, its effect on the dynamic response of the pads and the casks supported on the pads should be negligible. Trudeau Section D Reb. Post Tr. 11,275, at 6.

D.82 Dr. Bartlett disputed the assessment that the long-term settlements of the pad would be essentially uniform. Bartlett Dynamic Analysis Partial Surrebuttal Post Tr. 11,306, at 3. However, as Dr. Bartlett himself explained, determining the distribution of the estimated maximum settlement of a foundation is difficult and involves choosing between (1) assuming it occurs at the center of the pads to maximize “the dishing effect,” (2) assuming it all occurs on one side of the foundation so as to produce some tilting, and (3) distributing the total settlement over the minimum footing width, to emphasize differential settlement with adjacent structures. Tr. at 11,349-50 (Bartlett). In reality, the assumption of uniform pad settlement is the only one supported by physical considerations, as pointed out by Mr. Trudeau and Dr. Ofoegbu.

D.83 The main consequence posited by Dr. Ostadan of the long-term settlement of the pads would be altering the pattern of cask sliding on the pad by giving rise to a “dishing” effect in the middle of the pad that would make it somewhat more difficult for a cask to slide at some points and easier to slide at others. Tr. at 7501-02 (Ostadan). However, assuming that there was a 0.5-inch differential settlement in the center of a pad relative to the pad’s edges, the average slope measured along the short end of the pad would be only 0.159 degree. Soler Reb. Post Tr. 10,557, at 4. Such a slight slope would have no significant impact on the motion of the casks. *Id.*

D.84 The State witnesses sought to distinguish this effect from the expected local variations in the coefficient of friction between the cask and the pad. Tr. at 7502-06 (Ostadan/Bartlett). However, as discussed above, the cask stability analyses performed by Holtec utilized a variety of friction coefficients, including random variations in such coefficients, and in no case was a substantial amount of cask displacement observed. Therefore, it does not appear likely that the long-term settlement phenomenon will induce cask motions that differ significantly from those obtained in the Holtec analyses. Soler Reb. Post Tr. 10,557, at 4.

D.85 Another potential consequence of long-term settlement of the pads postulated by the State was a “slight inclination” or tilting of the pads. Tr. at 7500, 11,323-24 (Bartlett). However, the maximum angle of tilting of the pad resulting from such settlement would be on the order of only 0.64 degree. *See* Tr. at 7761-63 (Bartlett). That level of tilting could result in effectively changing slightly the coefficient of friction between the cask and the pad. Tr. at 7504 (Bartlett). Pad tilting is accounted for in the Holtec analysis and shown to have only secondary effects on the stability of the casks. Tr. at 6012-14 (Soler/Singh).

D.86 Witnesses for both Applicant and the Staff testified that the anticipated long-term settlement of the pads does not pose a concern in terms of the dynamic stability of the foundations and constitutes, at most, a maintenance issue. Trudeau Section D Reb. Post Tr. 11,275, at 5; Pomerening/Ofoegbu Post Tr. 11,001, at 10-11. Based on the evidence in the record, we agree.

g. CTB Analysis

D.87 The State argues that PFS cannot meet a factor of safety of at least 1.1 without the buttressing effect of soil-cement around the foundation perimeter of the CTB basemat, yet not until some distant future date will PFS acquire any data that it may arguably rely upon to support its use of soil-cement. State Findings ¶ 241. The design calculations for the sliding stability of the CTB under a 2000-year DBE are found in PFS Exhibit UU and as the State notes, there are no sliding calculations for a 10,000-year mean return period earthquake. Tr. at 6348 (Trudeau). The State contends that furthermore, there are no engineering calculations or performance data to support the presumed passive resistance PFS expects to obtain from using such a mass of soil-cement around the perimeter of the CTB mat foundation for the 2000-year DBE. Bartlett/Ostadan Post Tr. 7268, at 21. Nor, continues the State, is there any analysis of the effects of separation and cracking caused by out-of-phase motion of the CTB mat foundation and the soil-cement buttress or how bending and tensile stresses that develop in the soil-cement will resist seismic forces without cracking or separation. Bartlett/Ostadan Post Tr. 7268, at 21. Furthermore, the State notes that the basemat of the CTB is expected to settle 3 inches; however, the State claims that the effects of this settlement on the integrity of soil-cement and its separation from the CTB on the passive resistance have not been considered by PFS. State Findings ¶ 241.

D.88 The State also challenges Mr. Trudeau’s statement that he considered SSI in the CTB Analysis contained in PFS Exhibit VV: “[i]nasmuch as the loads came from our structural dynamics people.” State Findings ¶ 242 (*citing* Tr. at 6191 (Trudeau)). According to the State, however, there has been no dynamic analysis of the interaction of the soil-cement with the CTB mat foundation for the 2000-year DBE. Bartlett/Ostadan Post Tr. 7268, at 21. Under the DBE, the maximum horizontal acceleration response of the CTB mat is 1.047g. Tr. at 6192

(Trudeau). The free-field peak horizontal ground acceleration response of the adjacent soil-cement buttress is 0.71g. Tr. at 6264 (Trudeau). Consequently, the State argues that there is a 47% difference between the horizontal response of the CTB and the surrounding soil-cement. *Id.* The soil-cement buttress is not structurally tied to the CTB mat foundation, and given the large differences in horizontal acceleration response between those two masses, the State believes there is a significant potential for out-of-phase motion resulting from this inertial interaction. Bartlett/Ostadan Post Tr. 7268, at 21; Tr. at 6265 (Trudeau). According to the State, the Applicant has not considered the reduction of foundation damping and the concomitant higher seismic loads or the kinematic motion of the CTB caused by the blanket of soil-cement around the CTB foundation. Bartlett/Ostadan Post Tr. 7268, at 21. The State's additional concern here is that soil-cement will not provide passive resistance. All of these factors, the State argues, affect the PFS design calculation in meeting a factor of safety of at least 1.1. Bartlett/Ostadan Post Tr. 7268, at 21.

D.89 Similar to the concerns the State raised on the rigidity or flexibility of the storage pad, the State questions whether the Applicant has appropriately treated the CTB mat as rigid. Bartlett/Ostadan Post Tr. 7268, at 21. Mr. Ebbeson testified that the "potential effect of mat flexibility is accommodated by the factor of safety applied in the seismic stability calculations." Ebbeson Post Tr. 6357, at 14. The State insists, however, that the factor of safety against sliding in Calculation No. G(B) 13 has one case at a minimum of 1.15 and another, which PFS claims to be a conservative analysis, of 1.26. State Findings ¶213. Furthermore, the State argues that there are no design calculations to support the Applicant's assumption that the foundation mat is rigid. *See* Bartlett/Ostadan Post Tr. 7268, at 21.

D.90 Because the use of soil-cement is contributing to the PFS demonstration of meeting a factor of safety of 1.1 against sliding, the State insists that it is essential that there be analyses, data, and engineering calculations to support the claimed resistance to sliding, including whether the soil-cement will, in fact, perform as intended during an earthquake. In that regard, the State believes that PFS has made no such showing. *See* State Findings ¶244.

D.91 The only failure mechanism that is being raised as potentially occurring with respect to the CTB is sliding. *See* Tr. 7655-56 (Bartlett); Tr. 7663, 7674 (Ostadan). If such sliding were to occur, we note that it would have no safety consequences, since there are no safety-related structures connected to the building that could be adversely affected by the sliding. Tr. 7323-25 (Bartlett, Ostadan); Trudeau Section D Post Tr. 6135, at 21; Ebbeson Post Tr. 6357, at 14.

D.92 Also, as the Staff witnesses testified, it is not necessary to meet a factor of safety of 1.1 against sliding in order to satisfy the regulatory requirements of Part 72. Part 72 requires that the SSCs important to safety be shown to perform their safety functions when subjected to seismic loadings. The sliding analyses

performed by PFS indicate that this condition will be met, whether or not the factor-of-safety recommendations in the Standard Review Plan for nuclear power plants are satisfied. Tr. at 6594-96, 6739-41 (Ofoegbu). Therefore, the claims raised by the State in Section D of Contention L/QQ with respect to the dynamic stability of the CTB have no licensing significance.

h. Transfer Options

D.93 During the hearing, the Applicant's expert Mr. D. Wayne Lewis testified that the process of transferring an MPC containing spent fuel from the shipping cask in which it is brought to the PFS site to a storage cask located on its pad takes approximately 20 hours. Testimony of Donald Wayne Lewis on Section E of Unified Contention Utah L/QQ [hereinafter Lewis] Post Tr. 8968, at 4. He also testified that, within that period, the total time that the MPC is not completely sealed within either a shipping cask or storage cask is 9 hours per operation (from initiation of the removal of the HI-STAR cask closure plate bolts to completion of the installation of the HI-STORM cask lid and bolts). Lewis Post Tr. 8968, at 4. Finally, he testified that the total time the canister is being lifted directly or in the transfer cask and held by the crane in the transfer cell while being transferred from the shipping cask to the storage cask is approximately 3 hours per transfer operation. Lewis Post Tr. 8968, at 4.

D.94 The gist of the State's arguments is that the testimony of Mr. Lewis provides a potentially inaccurate estimate of the duration of the cask transfer operations in the CTB. The State presented no testimony on cask transfer issues. *See* State Findings ¶¶ 165-168.

D.95 Counsel for the State sought to cast doubts on the estimates provided by Mr. Lewis and he was asked to explain in detail how each estimate was obtained, the basis for the estimated length of the operations involved, and the manner in which the various lengths were computed. *See, e.g.*, Tr. at 8984-86, 8997-99, 9008-10, 9020-22, 9039-41, 9043-44 (Lewis). Despite intense probing by counsel, the State was unable to elicit any retraction or modification of the estimate.

D.96 The State argues that the evidence does not support Mr. Lewis' claim that the times in the Holtec Table (PFS Exh. AAA) are based on experience in loading Holtec casks. State Findings ¶ 165. To support this argument, the State notes that the CoC for HI-STORM was issued May 31, 2000; the first HI-STORM cask was loaded on June 26, 2001; and the first HI-STAR loaded with an MPC occurred on July 6, 2000. *Id.* Further, the State notes that Table 5.1-1, Rev. 0, is part of the Applicant's original 1997 license application. The State also argues that the table from which PFS estimates the canister transfer operations time is not derived from actual Holtec cask transfer operations. State Findings ¶ 165.

D.97 Mr. Lewis testified that many of the activities encompassed by the estimate routinely take place at operating nuclear plants such as Hatch and Dresden. Tr. at 9046-47 (Lewis). He also stated it was his understanding that the estimates are based on operational or preoperational activities at those plants. Tr. at 9059, 9078-80 (Lewis). Mr. Lewis also worked with personnel from utilities that have been actually involved in loading similar casks at the Point Beach and Palisades nuclear power plants to develop his estimates. Tr. at 8982 (Lewis).

D.98 The State tries to undercut the 20-hour total estimate by noting that it is an operational worker exposure time that would occur over a 3-day period. State Findings ¶ 166. Mr. Lewis explained that the entire transfer operation described in PFS SAR Table 5.1-1 (PFS Exh. ZZ) could extend for up to 3 days, but 20 hours would be the duration of the actual operation. Tr. at 9074-76 (Lewis).

D.99 The State attacks the 9-hour estimate of the time that it will take to transfer the MPC from the transportation to the storage cask by pointing out that there are no licensing commitments or regulatory requirements that require PFS to complete the operation within a working day. State Findings ¶ 167. However, Mr. Lewis made it clear that there was no condition under which the MPC would be allowed to remain overnight outside the protection of a shipping or a storage cask. Tr. at 9073-74, 9077 (Lewis).

D.100 Finally, the State tries to undercut Mr. Lewis's testimony that it will take 2.8 hours from the time the MPC is placed in a transfer cask to the time it is placed in a storage cask. The State makes reference to the deposition testimony of Holtec's Dr. Singh that it should be possible to complete the transfer "during the course of the day," with a day meaning a working day, which can be 8 to 12 hours. State Findings ¶ 167. However, Mr. Lewis interpreted this testimony to mean that the transfer should be completed within a day, but not necessarily take the whole day, which was consistent with his testimony. Tr. at 9031 (Lewis).

D.101 Mr. Lewis repeatedly testified that the estimated durations of the various activities involved in the transfer of the MPC from the transportation cask to the storage cask were conservatively high and that some of the steps could be accomplished concurrently, thus further saving time from the overall duration. *See* Tr. at 8974, 8975, 9011, 9033, 9041, 9044, 9066 (Lewis). Therefore, even if there was some imprecision in the estimated durations of some of the activities, the estimates would still remain conservative and would represent upper limits to the portion of the time during which the safety-related equipment in the CTB would be required to operate, or during which the MPC would be without the protection of a transportation or storage cask.

E. Cask Stability

1. General Overview

E.1 The HI-STORM System consists of a massive cylindrical steel and concrete storage cask surrounding a multipurpose stainless steel canister in which the SNF is sealed. Each cask is approximately 20 feet tall (239.5 inches) and approximately 11 feet in diameter (132.5 inches). When loaded with a spent fuel canister, the casks will weigh approximately 180 tons. The steel and concrete cylindrical walls of the cask form a heavy steel weldment, consisting of an inner and outer steel shell, within which shielding concrete is installed. These walls are approximately 30 inches thick. The MPC in which the spent fuel is sealed is stored vertically within the storage cask. Singh/Soler Post Tr. 5750, at 7.

E.2 The storage cask has four air inlets at the bottom and four air outlets at the top to allow air to circulate naturally through the annular cavity to cool the MPC. The inner shell of the storage cask has channels attached to its interior surface to guide the MPC during insertion and removal. These channels would also provide a flexible medium to absorb impact loads under postulated, nonmechanistic tip-over events, while allowing cooling air to freely circulate through the cask. *Id.*

E.3 The HI-STORM System storage cask is designed as a buttressed ASME Section III, Class 3, Subsection NF cylindrical structure. The outer steel shell (which is 0.75 inch thick) and the inner steel shell (which is 1.25 inches thick) are both welded to a 2-inch-thick steel baseplate, and are joined by four full-length intershell radial steel support plates, each 0.75 inch thick and welded to the inner and outer shells. The concrete shielding is placed within this steel weldment. The cask provides an internal cylindrical cavity, 191.5 inches in height and 73.5 inches in diameter, for housing the MPC. The top steel closure plate is also a steel weldment with confined concrete. Finally, a steel pedestal with enclosed concrete is provided for shielding, missile penetration, canister drop, and cooling flow considerations. As stated earlier, steel channels are located on the interior surface of the inner shell, which act to minimize the loadings that would be imparted to the MPC in a postulated, hypothetical cask tip-over scenario. *Id.* at 10. The circular gap between the channels and the MPC varies from 0.75 to 4.75 inches diametrically. Thus, the effective radial gap between the MPC and the channels that retains the MPC in place over most of its axial extent is $\frac{3}{8}$ of an inch. Tr. at 6104-05 (Singh).

E.4 The multipurpose canister is the component in which the spent fuel is placed. The spent fuel is loaded into the MPC at a nuclear power plant site, after which, the MPC is filled with an inert gas (helium) and welded shut for storage at the plant site or ready for transport offsite. The MPC consists of (1) the stainless steel enclosure vessel and (2) the fuel basket. The enclosure vessel is a cylindrical container with flat ends designed to meet the applicable provisions of Subsection NB of the ASME Code. The fuel basket is a stainless steel, continuously welded,

stiff honeycomb structure that is designed to meet Subsection NG of the ASME Code, as applicable, and serves to position the fuel in the MPC enclosure vessel. Singh/Soler Post Tr. 5750, at 11.

E.5 Holtec performed seismic analyses for the HI-STORM 100 to be used at the PFS facility, using the general design parameters for the HI-STORM 100 together with the site-specific earthquake ground motions for the PFS site and other relevant site-specific parameters. The analyses showed that under DBE conditions for the PFS facility, the loaded HI-STORM 100 casks have large safety margins against overturning or sliding. In no case did the analyses predict that there would be any cask tip-over or any cask-to-cask impacts. Singh/Soler Post Tr. 5750, at 20-24.

E.6 Under the DBE, the Holtec model showed a maximum displacement of the cask on the order of 3 to 4 inches. The maximum angle of tilt indicated by the analysis for the 2000-year DBE for an upper-bound coefficient of friction of 0.8 is 1.026 degrees. Singh/Soler Post Tr. 5750, at 24-26. This can be compared to the angle of tilt of 29.3 degrees at which a cask would tip if slightly disturbed, due to the moment of its own weight (i.e., the orientation at which the center of gravity of the cask is directly over the edge of the cask). This provides a safety factor against cask tip-over for the PFS facility DBE of $29.3/1.026$, or 28.6. Singh/Soler Post Tr. 5750, at 26.

E.7 Holtec also performed an analysis of the performance of a loaded HI-STORM storage cask subject to accelerations from a postulated, beyond-design basis, 10,000-year return period earthquake for the PFS site. The earthquake had a vertical peak ground acceleration (PGA) of 1.33g and horizontal PGAs of 1.25g and 1.23g. Singh/Soler Post Tr. 5750, at 27. The loaded cask exhibited larger rotations relative to the pad (approximately 10.89 degrees from the vertical) than in the earlier analyses using the DBE levels, but the results of this analysis still showed the existence of significant margins against tip-over. Using the same definition of safety factor against cask overturning as before, the safety factor against overturning for the 10,000-year return period earthquake was 2.69 ($29.3/10.89$). *Id.*

E.8 Holtec performed a series of additional beyond-design-basis analyses under a variety of assumptions. Those using the 10,000-year return period earthquake showed maximum rotations on the order of 10 to 12 degrees, confirming the large margins of safety against cask tip-over stated above. Tr. at 5774-76, 5787-88 (Soler).

E.9 Holtec also evaluated the results of a hypothetical cask tip-over event with the attendant impact of the cask on the pad. This tip-over analysis showed that the maximum fuel deceleration is below 45g, which is a licensing limit set by the NRC Staff. Singh/Soler Post Tr. 5756, at 32-33. As discussed below, staying within the 45g limit ensures that, in reality, a very large safety margin exists against canister breach and potential releases of radioactivity. Therefore,

even assuming that a cask were to tip over, the cask tip-over analyses conducted by Holtec show that no breach of the cask or release of radioactivity from the cask would occur.

E.10 To perform its design basis analyses, Holtec used its specially developed computer code known as DYNAMO. Singh/Soler Post Tr. 5750, at 14. This code has been validated and has been reviewed and accepted by the NRC for the licensing of freestanding spent fuel storage systems. *Id.* at 14-17, 19-20. It has been used by Holtec to perform the seismic analyses in its SAR for the HI-STORM System which supports the CoC that the NRC has issued for the HI-STORM 100 Cask Storage System under 10 C.F.R. Part 72. *Id.* at 14. Holtec has also performed site-specific seismic analyses using DYNAMO for the HI-STORM System for spent fuel systems for Pacific Gas and Electric (Diablo Canyon), Exelon (Dresden), Energy Northwest (Columbia Generating Station), Entergy Nuclear Northeast (J.A. Fitzpatrick), and Tennessee Valley Authority (Sequoyah). All of these analyses have been for storage casks on concrete storage pads. *Id.*

E.11 In addition, Holtec has extensive experience in using DYNAMO for the seismic analysis of spent fuel racks used to store spent fuel at nuclear power plants. *Id.* The spent fuel racks are large freestanding rectangular structures of honeycomb construction that sit in the spent fuel pool. These racks are square or rectangular, are supported by four or more stubby legs, and rest on the spent fuel pool floor slab. During a seismic event, the racks may slide, tip, and rotate with respect to the spent fuel pool in a manner similar to the potential motions of a storage cask on a concrete storage pad. The same nonlinear phenomena (sliding and tip-over) are modeled with the additional feature that fluid coupling between racks, and between racks and walls, is also considered. Holtec has employed its wet storage seismic simulation methodology using DYNAMO at numerous nuclear sites (more than forty), both in the U.S. and abroad. *Id.* at 14-17.

E.12 In order for DYNAMO to be approved by the NRC for use in licensing analyses, the code had to be validated to demonstrate that it produces acceptable results for the class of problems for which it is used in accordance with ASME NQA-2a-1990, Part 2.7, “Quality Assurance Requirements of Computer Software for Nuclear Facility Applications.” A series of classical problems having known solutions were modeled using the code and were shown to give results in good agreement with the analytical results. The problems were chosen to demonstrate all of the features that are built into DYNAMO. In addition, problems that had no simple analytical solutions were also evaluated and shown to give good agreement with numerical solutions using other industry codes such as ANSYS. Finally, some features of DYNAMO were validated by comparing results from experiments designed to be capable of simulation using DYNAMO. During the course of license submittals, DYNAMO was subjected to additional validation at the request of NRC’s reviewers. In every case, the DYNAMO code proved

capable of providing acceptable solutions to the problem. Thus, DYNAMO has been extensively benchmarked to confirm its adequacy as a nonlinear dynamics code. Singh/Soler Post Tr. 5750, at 20.

E.13 In performing the seismic cask stability analysis for the PFS facility, Holtec modeled the casks as freestanding structures on the concrete storage pads with compression-only contact and friction elements modeling the interfaces between casks and the pad. The casks, along with their loaded internals, were modeled as rigid bodies. *Id.* at 20-21. The concrete storage pad was modeled as a rigid rectangular slab, and the effect of the soil/soil-cement foundation was modeled by springs and dampers to characterize the soil resistance in deflection and rotation. *Id.* at 20. Data characterizing the earthquake excitation (acceleration time histories) and the soil response (soil properties used to characterize the soil springs and dampers) were provided to Holtec as design inputs by Geomatrix. *Id.* at 21.

E.14 Specifically, Geomatrix provided Holtec with sets of “Best Estimate,” “Lower Range,” and “Upper Range” soil properties for the soil under the pad, including the effect of soil-cement, as applicable. Holtec then computed the values of the spring constants and damping coefficients for use in its analyses using the soil property values supplied by Geomatrix. This was done in accordance with the formulas provided in ASCE Standard 4-86, “Seismic Analysis of Safety Related Nuclear Structures and Commentary,” Tables 3300-1 and -2, and Figure 3300-3. Singh/Soler Post Tr. 5750, at 21-22. These formulas are derived from a well-recognized technical treatise, N. M. Newmark, and E. Rosenblueth, *Fundamentals of Earthquake Engineering*, Prentice-Hall, Inc., Englewood Cliffs, N.J. (1971). Tseng Reb. Post Tr. 10,727, at 5.

E.15 Geomatrix also supplied Holtec with the ground motions for the 2000-year return period design basis seismic event in the form of three acceleration time histories entitled “Fault Normal,” “Fault Parallel,” and “Vertical.” These seismic ground motions were developed to match a 5%-damped response spectra having the following zero-period acceleration (ZPA), also known as the PGA values:

Fault Normal — 0.711g
Fault Parallel — 0.711g
Vertical — 0.695g

The actual time histories used in the dynamic analyses, developed in accordance with section 3.7.1 of the NRC Staff’s Standard Review Plan (NUREG-0800), had the following peak acceleration amplitudes:

Fault Normal — 0.73g
Fault Parallel — 0.71g
Vertical — 0.73g

In the design basis analysis, Holtec applied these acceleration time histories at the base of the soil springs with the spring constants and damping values computed as described above. Singh/Soler Post Tr. 5750, at 21-22.

E.16 For the design basis analysis, Holtec modeled various configurations of one to eight casks on the concrete pad using the lower-bound, best-estimate, and upper-range soil properties. To model the effect of friction between the cask and pad, Holtec used an upper-bound coefficient of friction of 0.8 at the cask-pad interface (to emphasize or increase the likelihood for cask tipping) and a lower-bound coefficient of friction of 0.2 (to emphasize or increase the likelihood of cask sliding). *Id.* at 23. To model the compression contact at the cask-pad interface, Holtec used a vertical contact stiffness of 454,000,000 pounds per inch, and to model the loss of energy that would occur should the cask lift up and impact down on the pad, Holtec used an impact damping value of 5%. *Id.* at 41, 79. The vertical contact stiffness and impact damping were modeled using springs and dampers at the cask-pad interface with the appropriate values. *Id.* at 41.

E.17 Nine cases were run for the upper-bound coefficient of friction of 0.8, and one case was run for a lower-bound coefficient of friction of 0.2 for the configuration that gave the limiting results using the upper-bound coefficient of friction of 0.8. As explained during the hearing, the reason only one case was run at the 0.2 coefficient of friction was that previous cask stability analyses that Holtec had performed for the PFS facility for different earthquakes showed that the bounding solution for cask displacement (as measured at the top of the casks) was for a coefficient of friction of 0.8. *Id.* at 24.

E.18 As stated above, for the 2000-year DBE, the Holtec analysis using the upper-bound coefficient of friction of 0.8 showed a maximum displacement of the cask on the order of 3 to 4 inches with a corresponding maximum angle of tilt of 1.026 degrees, which provides a factor of safety in the angle of tilt of 28.6 when compared to the angle of tilt at which a cask would tip over from the moment of its own weight. The case evaluated for a coefficient of friction of 0.2 produced a maximum sliding displacement on the order of 2 inches. *Id.* at 25-26.

E.19 In addition to its design basis cask stability analyses using DYNAMO, Holtec undertook various beyond-design-basis cask stability analyses. For these analyses, Holtec used the VisualNastran computer code because the beyond-design-basis analyses that Holtec conducted were mostly for the 10,000-year earthquake level. DYNAMO is a small deflection program, which means that it cannot accurately model large cask rotations or displacement, whereas Visual-Nastran is capable of modeling large rotations of the cask that could occur under the 10,000-year earthquake event. *Id.* at 62.

E.20 Holtec ran various cask configurations under different assumptions to evaluate the response of the casks to a 10,000-year return period earthquake with a vertical PGA of 1.33g and horizontal PGAs of 1.25g and 1.23g and to respond to specific issues raised by the State and its witnesses. The results

of these analyses are set forth in the report, “PFSF Beyond Design Basis Scoping Analyses” (Holtec Report No. 2022854) (PFS Exh. 86C) [hereinafter PFS Scoping Analyses], which is supported by PFS Exhibit 86D. The results are also set forth in the report “Additional Cask Analysis for the PFSF” (Holtec Report No. 2022878) (PFS Exh. 225) which is supported by PFS Exhibits 225B, and 225D. In addition, using VisualNastran, Holtec produced visual simulations from the analyses, which are contained in the “movies” collected in PFS Exhibits OO and 225A.

E.21 The simulations of the 10,000-year beyond-DBE showed some instances of large cask rotations, on the order of 10 to 12 degrees. Tr. at 5774-76 (Soler). Even with such large rotations, the casks still have a factor of safety in excess of 2 when compared to the angle of tilt (29.3 degrees) at which a cask would tip over from the moment of its own weight. Singh/Soler Post Tr. 5750, at 26.

2. Singh/Soler

a. Asserted Conflict of Interest for Drs. Singh and Soler

E.22 The State argues that Drs. Singh and Soler have a unique interest in the outcome of this hearing compared to all the other witnesses, in that Drs. Singh and Soler have an extensive financial interest in the Applicant prevailing in this case. Dr. Singh is the president and chief executive officer of Holtec, and Dr. Soler is the executive vice president. Tr. at 5907-08 (Singh). Drs. Singh, Soler, and another individual hold sole interest in the privately owned company, Holtec. *Id.* at 5917.

E.23 At the time of the hearing, Holtec had only approximately twelve storage casks in use, all of which are HI-STORM 100 casks. Tr. at 5918 (Singh). If the PFS facility attains fruition, Holtec (effectively Drs. Singh and Soler) has the potential to sell 4000 storage casks and other products such as the HI-TRAC canister cask to the PFS project. *Id.* at 5910-11, 5920. Dr. Singh admitted that sales to PFS could reach hundreds of millions of dollars. Tr. at 5910-11, 5920 (Singh).

E.24 Thus, the State contends the financial rewards from the successful outcome of this proceeding in favor of the Applicant are substantial. If the PFS facility is licensed, the State contends that the financial benefits to Drs. Singh and Soler, as two of three sole owners of the privately owned company Holtec, will pale in comparison to the usual expert witness compensation. The State argues that Drs. Singh and Soler have a substantial interest in both the licensing of the PFS facility and the affirmation by this Board of the Holtec analyses, including those conducted with the DYNAMO code, also owned, in part, by Drs. Singh and Soler. Based on the Licensing Board’s decision concerning the propriety of

Holtec's codes and methodologies, the State contends that the outcome in this case may have far-reaching effects on Holtec's business. State Findings ¶ 259.

E.25 In response, the Applicant argues that there does not exist a legal doctrine to support the State's claim of a conflict of interest. According to the Applicant, a conflict of interest typically implies that a party has assumed conflicting obligations, a situation that the Applicant contends is not present here. Applicant Reply at 148.

E.26 Bias or interest in the outcome of this case "goes only to the persuasiveness or weight that should be accorded the expert's testimony." *Louisiana Power and Light Co.* (Waterford Steam Electric Station, Unit 3), ALAB-732, 17 NRC 1076, 1091 (1983) (citing 11 J. Moore & H. Bendix, *Moore's Federal Practice* ¶ 702.30[1] (2d ed. 1982)). The State alleges that Drs. Singh and Soler have a bias and interest in the outcome of this case. Accordingly, the State requests that the Board consider those biases and interest in our deliberation of the weight to accord their testimony and other evidence relevant thereto. We have considered the potential biases and interests raised by the State and find no reason to discredit the testimony of either Dr. Singh or Dr. Soler.

b. Experience

E.27 Holtec testified that it performed site-specific cask stability analyses for the PFS site and five other ISFSIs. Singh/Soler Post Tr. 5750, at 14. The State argues that only at three of the five ISFSI sites did Holtec analyze freestanding casks: the Dresden site, where ZPA is 0.2g (State Exh. 121 at 38); the Entergy Northwest (Columbia Generating) site, where the ZPA is about 0.5g (State Exh. 120 at 18); and the Tennessee Valley site, where the ground motion is approximately 0.5 to 0.6g (State Exh. 121 at 38). At the fourth ISFSI, J.A. Fitzpatrick, there is no record evidence of the ground motions. According to the State, other than for the PFS site, the only other site where Holtec has conducted a nonlinear analysis is at Diablo Canyon, a site where the ground motions were as high as the 2000-year earthquake at PFS, but this was on the HI-STORM 100SA, the anchored version of the HI-STORM 100 cask. The State contends that Holtec's analysis of the anchored HI-STORM 100SA is not comparable to an analysis of an unanchored cask. In addition, the State believes that the record does not support the Applicant's claim that Dr. Soler and the other Holtec analysts have any previous experience conducting nonlinear seismic analysis of freestanding casks at ground motions that equal or exceed the 0.7g ground motion for a 2000-year earthquake at the PFS site. State Findings ¶ 262.

E.28 Additionally, according to the State, there are no known or anticipated sites that store or will store the unanchored casks supported by soil-cement or cement-treated soil. State Findings ¶ 263. The State also contends Dr. Soler and other Holtec analysts have no previous experience conducting nonlinear seismic

analyses of freestanding casks supported by cement-treated soil or soil-cement foundations.

E.29 Furthermore, regarding Holtec's prior experience analyzing freestanding spent fuel racks, the State claims that in the analysis of spent fuel racks, the racks are submerged in water and there are very small gaps between the racks; therefore, the nonlinear stability analysis of a cask is "very different" from a freestanding spent fuel rack. Tr. at 7143 (Khan). The State argues that the record lacks sufficient facts to conclude that the analyses of freestanding spent fuel racks are relevant to the experience and training necessary to conduct nonlinear seismic analysis of objects potentially subject to large deformation and rotations at high ground motions. State Findings ¶ 264.

E.30 In its analysis, Holtec modeled the effects of SSI through soil springs (linear and rotational) and dampers. Tr. at 5993 (Soler). Dr. Soler and Chuck Bullard, a Holtec employee, authored the various cask stability reports for the PFS site. Tr. at 5992 (Soler). The State claims that Dr. Soler admitted that neither he nor Mr. Bullard had expertise in analyzing soil dynamics and foundation design (calculating the soil springs and dampers). The State argues that besides the analysis for Tennessee Valley Authority, the only soil dynamic work that Dr. Soler has performed is for this case. State Findings ¶ 265.

E.31 In sum, the State argues that (1) Holtec has not performed seismic analyses of freestanding casks at sites with ground motions equal to or greater than the 2000-year earthquake at PFS; (2) neither Dr. Soler nor any other identified Holtec analyst are experts in soil mechanics; (3) Dr. Soler and another Holtec analyst have calculated the soil springs and dampers at only one other site; (4) evidence is lacking that Holtec has prior experience analyzing seismic pad-to-pad interaction; and (5) there is a lack of evidence to link the relevance of prior freestanding spent-fuel-rack seismic analyses to the analysis in this case. Thus, the State concludes that Holtec and its witnesses have limited experience in performing nonlinear cask stability analyses at sites similar to the proposed PFS facility, and asks the Board to consider Holtec's limited experience in the context of the weight given on various issues. State Findings ¶ 267.

E.32 Contrary to the State's arguments, the Board finds that Dr. Singh and Dr. Soler have extensive professional experience in conducting cask stability analyses. Dr. Singh has a Ph.D. in Mechanical Engineering, which he received from the University of Pennsylvania in 1972. He has extensive experience in the design and licensing of nuclear spent fuel systems which extends back to 1979. Over the past 23 years, Dr. Singh has personally led the design and licensing of spent fuel storage systems for over forty nuclear plants, and for Holtec's HI-STAR 100 System and HI-STORM 100. Dr. Soler is responsible for all corporate engineering activities at Holtec, including overseeing the analyses performed to establish the stability of the HI-STORM 100 under postulated seismic events. Dr. Soler has either performed or reviewed all HI-STORM 100 seismic analyses

conducted in support of deployment of the HI-STORM 100 at the PFS facility. Likewise he has either performed or reviewed dozens of seismic analyses for freestanding storage casks and storage racks over many years. Together, they have approximately 40 years of experience in dynamic analyses of spent fuel racks, storage, and transportation casks. Singh/Soler Post Tr. 5750, 1-2, 4-5.

3. *Reliability of Analysis*

a. *DYNAMO Program*

E.33 According to the State, Holtec modified a published “general lumped mass analysis” code to create the predecessor to DYNAMO, the code used to generate the result in the Holtec 2000-year report. State Exh. 120 at 24-28. Thus, the State insists that DYNAMO is a “small deformation code” that is not capable of processing “large” cask rotations. State Findings ¶ 273.

E.34 The State argues that although not quantified, Dr. Soler opines that the maximum angle of rotation for which DYNAMO is capable of accurately processing results, is less than 15 degrees. State Findings ¶ 274. Dr. Soler’s opinion is that as long as the deflections predicted by DYNAMO “are not too large,” he is confident DYNAMO is generating accurate results. Tr. at 9930-31 (Soler). The State claims there is no evidence to support Dr. Soler’s confidence in DYNAMO producing accurate results in this case. State Findings ¶ 274.

E.35 According to the State, except for the PFS site, DYNAMO has not been used to analyze the stability of a freestanding cask where the ground motions are equal to or greater than those for a 2000-year earthquake at the PFS site (0.7g). Khan/Ostadan Post Tr. 7123, at 5.

E.36 The State argues that by using the same input parameters, DYNAMO failed to predict cask tip-over, when in a Holtec nonlinear seismic analysis of its HI-STAR 100 cask using VisualNastran, Holtec determined the HI-STAR cask would in fact tip over at a ZPA of 0.6g. State Findings ¶ 276. Although the HI-STAR cask has different features than the HI-STORM cask, both were analyzed as freestanding casks. Additionally, the State notes that the Holtec 2000-year report (State Exh. 173) references the methodology described in the HI-STAR technical paper (State Exh. 199) that discusses DYNAMO’s failings as compared to VisualNastran. State Findings ¶ 276. In fact, the State contends that Dr. Soler testified the reason, in part, for the technical paper comparison was to be cognizant that “you can’t just say, because the computer program says it’s so, that means it’s so.” *Id.* (citing Tr. at 9775 (Soler)).

E.37 Because Holtec holds its DYNAMO code as proprietary information which, the State claims, has not been provided to the Staff or the State, the State insists that the parties have had no opportunity to test the reliability and limits of the DYNAMO code. State Findings ¶ 277. The State argues that “a trier

of fact would be derelict in the discharge of its responsibilities were it to rest significant findings on expressions of expert opinion not susceptible of being tested on examination of the witness.’’ *Id.* (citing *Virginia Electric and Power Co.* (North Anna Nuclear Power Station, Units 1 and 2), ALAB-555, 10 NRC 23, 26 (1979)).

E.38 Additionally, the State highlights the testimony in which Dr. Soler admitted that the contact spring stiffness computations used in State Exhibit 173 are not all included in that report, but referred to earlier documents that “set forth” the theory. State Findings ¶278 (*citing* Tr. at 9780 (Soler)). These “earlier documents,” the State argues, are not in evidence and therefore their reliability, and the reliability of the contact spring stiffness computations, has not been tested. State Findings ¶278. We find the State’s arguments in this regard to be unpersuasive. As the State has done in analogous circumstances, it could have requested this information during discovery or during the hearing. Thus, we are unpersuaded by the State’s argument that it was not given adequate information to challenge Holtec’s results.

E.39 The State contends that the question of whether DYNAMO, as a small deformation code, generated accurate results in the Holtec 2000-year report is a “significant finding” in which the opportunity to test the witnesses on cross examination is limited, in part, by the unavailability of the DYNAMO code. In addition, the State claims there is an incomplete computation of input parameters in the record. As a result, the State requests that the Board consider the opposing parties’ ability to test witnesses on cross examination as a factor in weighing the evidence of the reliability of DYNAMO. *Id.* ¶279.

E.40 To support its use, Dr. Singh testified that DYNAMO has “been used in over a thousand discrete structures, qualifying them,” and is a “well tested program.” Tr. at 6099-6100 (Singh). The State claims that PFS offered no evidence with respect to the type of “discrete structures” qualified by DYNAMO and how those DYNAMO analyses are relevant to this case, given the unique and unprecedented design posed by PFS. State Findings ¶280.

E.41 According to the State, the Staff cites and accepts the results obtained with DYNAMO in the Holtec 2000-year report, but does not specifically refer to the code used to obtain the Holtec results. State Findings ¶281 (*citing* SER at 5-30). Holtec claims that the Staff also reviewed and accepted that DYNAMO performed at other spent fuel storage sites. Singh/Soler Post Tr. 5750, at 14. The State argues that there is no evidence in the record concerning (1) the basis of the Staff’s acceptance of Holtec’s use of the DYNAMO code to accurately predict the dynamic behavior of unanchored casks under high seismic ground motions at the PFS site or sites with similar design characteristics; (2) whether the Staff independently validated the results obtained with DYNAMO; and (3) whether the Staff’s previous acceptance of DYNAMO results has any direct bearing in this case where the Applicant has proposed to place freestanding dry storage

casks on a shallowly embedded foundation supported by cement-treated soil in a seismically active location. Furthermore, the State claims that the Staff did not have access to the DYNAMO code for any purposes, including verifying the input parameters, the model, or results. State Findings ¶ 281.

E.42 During his testimony, Dr. Singh had with him DYNAMO's training manual in which he testified the manual contained over a dozen cases in which DYNAMO simulated a "wide variety of problems [such as] harmonic resonance, bifurcation, [and] dynamic responses of nonlinear structures." Tr. at 9679 (Singh). Dr. Singh testified that the DYNAMO training manual demonstrates that DYNAMO has been validated for both fuel rack and cask stability analyses. Dr. Singh also testified that DYNAMO has been validated for dynamic responses of nonlinear structures. Tr. at 9678-80 (Singh). However, the State argues that it is significant that the Applicant failed to proffer supporting documentation from the DYNAMO training manual to document the scope and relevance of Dr. Singh's claims in this matter. State Findings ¶ 282.

E.43 Additionally, Drs. Singh and Soler testified "problems that had no simple analytical solutions were also evaluated [with DYNAMO] and shown to give good agreement with numerical solutions using finite element codes such as ANSYS." Singh/Soler Post Tr. 5750, at 20. The State argues that this statement is inconsistent with other statements made by Holtec that indicate that ANSYS was not reliable. State Findings ¶ 283 (*citing* Tr. at 6099-6100 (Singh)). In light of Dr. Singh's testimony as to the credibility of ANSYS to accurately model the seismic behavior of freestanding structures — the issues at the heart of this case — the State insists that Holtec's comparison between DYNAMO and ANSYS in this instance is unreliable. State Findings ¶ 283.

E.44 Holtec testified that DYNAMO produced results in "good agreement" with known solutions for a "series of classical problems." Singh/Soler Post Tr. 5750, at 20. According to Holtec, the classical problems demonstrated DYNAMO features such as compression-only behavior and friction resistance. *Id.* The State claims that no evidence was offered that demonstrates the relevance of the classical problems to the unique issues under consideration here. State Findings ¶ 284.

E.45 We find that the record does not support the State's criticisms. First, the results of the Holtec DBE analyses show that in the event of a DBE, the casks will undergo small, not large, rotations. As stated above, the maximum rotation of the casks from the nine configurations evaluated by Holtec for the DBE was 1.026 degrees. Dr. Soler testified that he would consider large rotations to be somewhere on the order of 20 degrees or less. *See* Tr. at 6101-02 (Soler). Therefore, the rotations obtained through the use of DYNAMO are well within the code's capabilities. Dr. Soler himself has extensive experience in the running of the DYNAMO code and is well aware of its small-deflection limitations, and yet he was comfortable with using DYNAMO for the DBE (Tr. at 9930-31 (Soler)).

In that regard, Dr. Soler decided to use VisualNastran for evaluating cask stability for the 10,000-year beyond DBE because of the potential for large cask rotations in that case. Singh/Soler Post Tr. 5750, at 62.

E.46 Second, contrary to the State's claim, Holtec has validated its DYNAMO results for the 2000-year DBE at the PFS site against another structural analysis code, that is, VisualNastran. As part of its beyond-design-basis scoping analysis, Holtec ran one of the nine configurations of the original design basis analysis using VisualNastran. The VisualNastran run of the DBE predicted cask displacements on the order of several inches, similar to the DYNAMO results, thus showing that the DYNAMO runs were within the capabilities of that code. Singh/Soler Post Tr. 5750, at 65-71.

E.47 Third, as discussed above, DYNAMO has been extensively benchmarked, validated, and accepted by the Staff, and it has been shown, to the Staff's satisfaction, to provide valid predictions. *Id.* at 19-20, 77.

E.48 As the State correctly points out, Dr. Soler cautioned against using DYNAMO for predictions of large displacements or cask rotations (on the order of 15 degrees or more), because the results may not be accurate because the code's capability is being exceeded. State Findings ¶ 274.

E.49 The ability of DYNAMO to accurately make predictions for the PFS facility 2000-year DBE was confirmed by Holtec's use of VisualNastran to model one of the cases for the 2000-year PFS facility DBE that had initially been modeled using DYNAMO. The results obtained by Holtec using VisualNastran showed cask displacements of only a few inches and cask rotations on the order of 1 degree, similar to those obtained by DYNAMO. PFS Exh. 86C at 20-21.

E.50 The appropriateness of using DYNAMO for the cask stability analysis of the 2000-year DBE at the PFS facility is further supported by the results of the Dr. Luk's simulations for the PFS facility 2000-year DBE, which similarly predicted maximum cask displacements on the order of a few inches and minimal cask rotations of less than 1 degree. Vincent K. Luk *et al.*, Seismic Analysis Report on HI-STORM 100 Casks at Private Fuel Storage Facility, Rev. 1 (Mar. 31, 2002) (Staff Exh. P) at 30 [hereinafter Luk Report]. Thus, there is no technical merit to the State's claim that DYNAMO gives unreliable predictions of the performance of the HI-STORM storage casks for the PFS facility 2000-year DBE.

b. VisualNastran Results

E.51 In their testimony, Drs. Singh and Soler described additional computer simulations that they conducted, using the VisualNastran code, to address various claims raised by the State in Part D of this contention, including: (1) the failure to consider non-vertically propagating waves, (2) the lack of sufficient time histories, (3) overestimation of soil damping, and (4) failure to consider resonance. These further analyses generally used a 10,000-year return period earthquake as the

ground motion input, to eliminate any issue as to whether the analyses used a bounding input.⁴⁰ In addition, the analyses conservatively utilized a soil damping factor of 1% of critical damping (based on the spring constant determined and the vibrating weight), and included consideration of resonance effects. Drs. Singh and Soler testified that because these analyses used the 10,000-year return period earthquake, they bound the 2000-year design basis seismic event. Furthermore, by virtue of their increased strength, these analyses would bound any issues raised by the State concerning the appropriateness of the PFS evaluation of the response to the 2000-year DBE. Singh/Soler Post Tr. 5750, at 62-64.

E.52 Eleven cases were analyzed in these computer simulations, in which different values were utilized for the number of casks on a pad, the stiffness, damping, and coefficient of friction. *See* Singh/Soler Post Tr. 5750, at 66. The results of these analyses were described by Drs. Singh and Soler in their testimony, and were also presented in the form of computer-animated videos in which various cask motions were visible (PFS Exh. OO). The animation illustrated the following results:

- (1) The results of the VisualNastran simulation using a 2000-year return period event and the lower-bound set of soil stiffness and damping elements, agree with the results predicted by DYNAMO. To the extent that there may be differences, these are due to the fact that VisualNastran recomputes the equilibrium equations at each instant in time and accounts for the changes in orientation (even though they are small) throughout the entire run duration. DYNAMO, by contrast, uses the original equilibrium equations and does not update them continuously. Thus, the results from VisualNastran more accurately display slightly larger rotations than those predicted from DYNAMO if the rotations reach the upper end of small rotations.
- (2) The VisualNastran simulations using the 10,000-year return period event experience significant rocking behavior and out of phase motion of the casks when the coefficient of friction is 0.8. At certain instants, some casks impact each other with the net result that one of the two casks involved in the impact, slows down almost completely for a period of time following the contact.
- (3) For coefficients of friction of 0.2, the casks move in phase and there are no contacts between casks.
- (4) No overturning of any cask was experienced in any of the analyses.
- (5) Random coefficients of friction reduced the rocking behavior of the casks.

⁴⁰Drs. Singh and Soler included some analyses using the 2000-year return period seismic event, in order to demonstrate the dramatic difference in results that that variation produces, and to provide an independent check of their DYNAMO results. Singh/Soler Post Tr. 5750, at 63.

- (6) While there was some effect on the system behavior due to “tuning” the soil spring stiffness values to match an input seismic frequency, the major contribution to the large motions was the earthquake strength.
- (7) The use of conservatively low soil damping values, while increasing the cask response, does not lead to a condition where severe pad oscillations occur.
- (8) Maximum excursions of the pad horizontally are generally below 0.5.

Singh/Soler, Post Tr. 5750, at 68-69.

E.53 While the design basis event (Case 1) showed very little cask movement, *id.* at 69, large motions were observed in a 10,000-year event (case 8), in which conservatively “tuned” soil stiffness and 1% soil damping is assumed, and a significant contribution from out-of-phase effects is experienced. Despite the orientations observed, all of the casks concluded the simulation in a vertical orientation, although perhaps in a new location (e.g., cask 1 came to rest approximately 8 inches away from its starting point). Singh/Soler Post Tr. 5750, at 70.

E.54 Significantly, the computer simulations performed by Drs. Singh and Soler used input values for earthquake, soil stiffness, and soil damping that were chosen to maximize any deleterious effects (as opposed to using expected real-world values). The results of these analyses demonstrated that the casks and the storage pad, under worst-case scenarios, show no significant detrimental effects that would lead to cask tip-over. Accordingly, these bounding analyses confirmed the Applicant’s conclusion that the HI-STORM 100 casks will perform satisfactorily in a DBE at the PFS site. Singh/Soler Post Tr. 5750, at 71.

E.55 The State claims these VisualNastran results are unreliable. *See* State Findings ¶ 288. According to the State, many times throughout cross examination, Dr. Soler could not identify specific details or results of his various nonlinear analyses, because he either (1) did not personally seek the requested results, (2) he observed the data visually and did not record the results, (3) he did not know the inner workings of VisualNastran, or (4) he needed additional time to locate the details. *Id.* For example, as documented in the transcript, the untracked casks in Dr. Soler’s animations appeared to move greater distances than the tracked cask. Tr. at 5761-62 (Soler). Dr. Soler did not have the ability to identify the actual deflection or angle of rotation of these untracked casks. Tr. at 5779 (Soler). Thus, the State argues that although VisualNastran is a publically available code, the ability of parties and the Licensing Board to test the reliability of Dr. Soler’s testimony based on the nonlinear analyses was severely restricted. State Findings ¶ 288.

E.56 Additionally, the State notes that Dr. Soler admitted that no document in evidence lists every input value for each of his simulations. *Id.* ¶ 289. Furthermore, the State points out that Dr. Singh admitted that the Holtec Beyond Design Basis

Report does not list “each numerical value.” State Findings ¶289 (*citing* Tr. at 5796 (Singh)). Nor could Dr. Soler provide the critical damping used in his analyses of case 11 but relied upon “whatever ASCE 486 would ask you to use for the soil properties given to us, that is what we used.” Tr. at 5788-89 (Soler). Furthermore, the State points out that Dr. Soler was unaware of “the equations for equilibrium of rigid bodies [which are] built into the [VisualNastran] code.” Tr. at 5968 (Soler).

E.57 The State contends that the reliability of Holtec’s opinions which rely on the results generated using VisualNastran is a “significant finding” in which the opportunity to test the witnesses on cross examination is limited, in part, by the parties’ inability to test the VisualNastran results through cross examination. State Findings ¶291.

E.58 Dr. Singh testified that the Staff’s grant of a CoC for Holtec’s HI-STAR 100 shipping cask was supported in part by analyses generated with VisualNastran. Tr. at 6111-12 (Singh). The State claims there is no evidence in the record concerning: (1) the basis of the Staff’s acceptance of Holtec’s use of the VisualNastran code; (2) whether the Staff independently validated the results obtained with VisualNastran; and (3) whether the Staff’s previous acceptance of VisualNastran results has any direct bearing in this case where the Applicant has proposed to place freestanding dry storage casks on a shallowly embedded foundation supported by cement-treated soil in a seismically active location. The State also argues that there is no evidence that VisualNastran has been independently validated with test data for the sliding and uplift of freestanding casks in an area with high seismic ground motions. Based on the lack of supporting evidence, the State argues that the Staff’s previous acceptance of VisualNastran with respect to the HI-STAR 100 cask is unpersuasive in this case. State Findings ¶292.

E.59 Although the State criticizes the VisualNastran simulations because Dr. Soler did not have the computer track and record the data on cask displacements for each cask, Dr. Soler explained that the evaluations were a “scoping analysis.” Furthermore, as the full title of the report reflects, the primary purpose was to see “whether at the end of the earthquake do we have eight casks still standing.” Tr. at 5771 (Soler).

E.60 The focus of the analysis was not on the specific measurements of the displacement of the casks. *See* Tr. at 5771 (Soler). Accordingly, as Dr. Soler explained, he had initially set the computer to record the measured displacements of cask 1 for all eleven cases, which remained stored in the computer and could be retrieved from the computer. Tr. at 5761-62 (Soler). At the request of the Board, Dr. Soler produced a table showing the cask displacements and angle of rotation for cask 1 in all eleven runs of the Holtec Beyond Design Basis Report. Tr. at 5773-76 (Soler). As Dr. Soler explained, obtaining displacement for all casks would take a significant amount of time, and the Board decided to have Dr.

Soler produce the information for cask 1 already stored in the computer, and have more steps taken later to obtain measured displacement data on additional casks if the parties or Board deemed that necessary. Tr. at 5773-76. The State did not pursue this matter and we now find the additional data to be unnecessary.

E.61 Furthermore, we find that the lack of detailed recorded information on the other casks did not restrict the State's ability to cross-examine Holtec on its results. The VisualNastran computer runs were beyond-design-basis scoping analyses whose primary function was to determine whether the casks would tip over under the 10,000-year earthquake event, given various bounding and worst-case assumptions. Tr. at 5771 (Soler); Singh/Soler Post Tr. 5750, at 62-71. Another purpose was to establish whether the 2000-year runs using VisualNastran would provide responses similar to those obtained with DYNAMO for the 2000-year DBE, i.e., inches of displacement, not feet of displacement. PFS Scoping Analyses at 20-21. Both of these points are evident from the simulations. Thus, the points for which the computer cases were offered did not require detailed results for each cask.

E.62 Regarding the State's claim that Dr. Soler could not provide the percentage of critical damping used in the formulas, we note that Dr. Soler explained that the formulas for damping provided by ASCE Standard 4-86 (which as discussed earlier are based on well-recognized sources) are not developed based on a percent of critical damping. *See* Tr. at 5788-89 (Soler). Instead, Dr. Soler provided the actual damping input values used in the run in question and similarly provided the actual damping input values used for the other runs. *See* PFS Exh. 86D.

E.63 We also find the State's concern that Dr. Soler was "unaware" of the equations for equilibrium for rigid bodies built into the VisualNastran code to be unnecessary. In response to the State's question on how a particular figure showing the casks in motion "was modeled mathematically," Dr. Soler replied "the equations for equilibrium of rigid bodies [are] built into the code. I do not externally model anything mathematically." Tr. at 5967-68 (Soler). Contrary to the State's concern, we find that this statement does not discredit Dr. Soler's testimony. Furthermore, the record reflects that the equations are well known by him.

E.64 For the same reasons, the State's objections to the visual simulations that were raised during the hearing are found to be without merit. During the hearing, the State claimed that without supplemental data the animations merely represent one analyst's simulation of cask behavior. Tr. at 5853-54, 10,532-54. We do not agree, however, with this characterization. The visual simulations are computer-generated visual representations of the results of the computer analysis. As explained by Dr. Soler, "these videos were not created outside the program, they are part of the program, and they use the results as they are calculated." Tr. at 5756-57 (Soler). Therefore, they are only a visual portrayal of the numerical computations made by the VisualNastran code for the input

parameters used, and not some abstract “simulation” produced by Dr. Soler. As stated, the points for which PFS relies on the simulations are (1) to demonstrate that VisualNastran and DYNAMO provide comparable results for the 2000-year DBE, and (2) to demonstrate that the casks do not tip over. Establishing those points, or questioning Holtec on them, does not require the quantitative data on cask displacements.

c. Input Parameters

(i) CONTACT STIFFNESS

E.65 Vertical contact stiffness represents the amount of force applied at the interface points of contact between two bodies that would be required to have one of the bodies approach or penetrate the other a unit-distance. The parameter is measured in the pounds of force required to cause one body to approach the second body by one inch. For example, for a pad of undefined material on which a HI-STORM 100 cask weighing 360,000 pounds is placed, which causes a deformation or deflection of the pad of 0.01 inch, the contact stiffness would be 360,000 pounds per 0.01 inch or 36×10^6 lb/in. Singh/Soler Post Tr. 5750, at 78.

E.66 For its cask stability analysis for the 2000-year DBE, Holtec used a vertical contact stiffness of 454×10^6 lb/in. *Id.* at 79.

E.67 As a result of his study, Dr. Khan argues that nonlinear mathematical models are highly sensitive to the assumed contact stiffness between the cask and the storage pad. *See* Khan/Ostadan Post Tr. 7123, at 6. Dr. Khan explains that local contact stiffness is needed in a mathematical simulation before any sliding occurs. *Id.* at 9. After sliding occurs, the horizontal displacement is a function of the inertial forces overcoming the coefficient of friction times the mass. *Id.* Thus, according to Dr. Khan, displacement of the cask from seismic ground motion should not be very sensitive to the contact stiffness values. *Id.*

E.68 Additionally, Dr. Khan maintains that in nonlinear analytical solutions, high-contact stiffness values also absorb significant amounts of energy before sliding actually occurs, by reducing instantaneous velocities for the next successive iteration in the nonlinear analysis. As a result, Dr. Khan believes high contact stiffness could underestimate vertical displacement of the cask. *Id.* at 9.

E.69 The State argues that in its model, Holtec used contact stiffness to “define the stiffness of the vertical-only ‘compression springs’ at the interface of the cask and the pad.” State Findings ¶300 (*citing* Singh/Soler Post Tr. 5750, at 79). Holtec used a single vertical contact stiffness value for its simulations in the Holtec 2000-year report. *Id.*; Tr. at 6042-44 (Soler). The State claims that notwithstanding its challenge to Holtec’s contact stiffness value, Dr. Soler opined that “we got acceptable answers in the 2000-year return earthquake, so there was no incentive for us there to lower the contact stiffness.” State Findings ¶300

(citing Tr. at 6043) (Soler)). In its simulations of the 10,000-year earthquake, Holtec used a vertical contact stiffness of 18,864,480 lb/in. Tr. at 9575 (Soler).

E.70 Prior to his parametric study, Dr. Khan had not had occasion to select a contact stiffness value for sliding or tipping. Tr. at 7217 (Khan). Similarly, the State claims that neither Dr. Soler nor Dr. Singh has proffered evidence that they have prior experience selecting a contact stiffness value for a sliding or tipping analysis of a freestanding cask where the ground motions are equal to or exceed those for a 2000-year earthquake at PFS. State Findings ¶ 301.

E.71 A vertical contact stiffness of 450×10^6 lb/in. for unanchored casks is too high, opines Dr. Khan, because the contact stiffness makes the vertical frequency of the cask too rigid, which underestimates the vertical displacement of the cask. Khan/Ostadan Post Tr. 7123, at 11. Dr. Khan testified that “[o]nce [cask] sliding begins, the high [contact] stiffness values artificially treat the solution as linear [e.g., as if the cask is anchored to the pad] without amplifying it in the upward direction and give non-unique or invalid results.” *Id.* According to Dr. Khan, a high contact stiffness corresponding to a high-response-spectra frequency will never amplify the cask motion. *See* Tr. at 7231 (Khan). Holtec notes its contact stiffness corresponds to a frequency in the rigid range of 111 hertz. Tr. at 9634-35 (Soler).

E.72 In the absence of test data, it is Dr. Khan’s opinion that to conservatively capture the dynamic behavior of the cask, including cask rotation or rocking, the appropriate contact stiffness for unanchored casks must correlate with a frequency that falls within the amplified range of the response spectra curve. Khan/Ostadan Post Tr. 7123, at 12; Tr. at 9362, 9373-74, 9482-83 (Khan). He believes that the rotational stiffness or rotational springs in the model will move the cask with a certain damping at an associated frequency. Tr. at 9482 (Khan). According to Dr. Khan, if the contact stiffness does not correlate with the frequency in the amplified region of the response spectra, then the mathematical code will treat the problem as linear as if the cask is anchored to the pad. Khan/Ostadan Post Tr. 7123, at 12.

E.73 Paramount to Dr. Khan’s opinion is that the Applicant has offered no test data to support its nonlinear cask stability results. If the real dynamic behavior of the structure is unknown, Dr. Khan is adamant that structural analysis design philosophy mandates that the structure’s behavior be analyzed using the “peak of the spectra times the weight and other factors into consideration.” Tr. at 7236 (Khan). Thus, for design purposes in the absence of test data, to estimate the dynamic response of the cask, Dr. Khan believes a range of contact stiffness is selected that correlates with the rocking frequencies in the earthquake response spectra that give the maximum dynamic response. *Id.* at 7208, 7215.

E.74 Dr. Khan opined that contact stiffnesses in the range of 1×10^6 lb/in. and 10×10^6 lb/in. correspond to frequencies in the amplified spectral range of the response spectra. Khan/Ostadan Post Tr. 7123, at 13.

E.75 As explained above, Dr. Khan testified that he would choose the contact stiffness so that the natural vertical frequency of the cask on the pad was in resonance with the amplified spectral range of the earthquake. Tr. at 7215-16 (Khan). Several consequences, however, flow from following the approach suggested by Dr. Khan. First, such an approach artificially maximizes the vertical response of the cask by assuming that the natural frequency of the cask and the earthquake are in resonance. Second, because the amplified spectral range of an earthquake will vary depending on the geology and soils of its location, setting the contact stiffness to artificially cause the cask and the earthquake to be in resonance means that the choice of contact stiffness will vary depending on the geographic location of an ISFSI and the assumed earthquake excitation.

E.76 Contrary to Dr. Khan's position, however, Drs. Singh and Soler testified that contact stiffness is a physical property of the cask-pad interface that can be determined from the physical characteristics of the cask and the pad, and as such it would not change depending on geographic location or earthquake excitation. Tr. at 9618-19 (Soler).

E.77 Drs. Singh and Soler testified that often, in computer modeling, one will choose a value of contact stiffness that is lower than the actual physical contact stiffness to avoid excessive computing time, but one should always avoid using such a low value that the corresponding cask frequencies fall into the amplified spectral range of the earthquake spectra. *See* Tr. at 9641-45 (Soler). If that was done (as proposed by Dr. Khan), the results of the analysis would be contaminated by introducing an artificial excitation of the cask that does not exist in fact, since the actual physical contact stiffness of the cask-pad interface does not produce cask frequencies in the amplified spectral range of the earthquake. Therefore, choosing a contact stiffness that would cause resonance of the cask with the earthquake should be avoided because it would produce unrealistic results that would not be expected to occur under earthquake conditions. Tr. at 9633-45 (Singh/Soler).

E.78 Drs. Singh and Soler also state that a correct computer model should be able to predict accurately both dynamic and static conditions (Singh/Soler Post Tr. 5750, at 88) and that choosing a contact stiffness of 1×10^6 lb/in., as suggested by Dr. Khan, would result in a deformation of $\frac{3}{8}$ of an inch of the reinforced concrete pad under static conditions, which is an obviously incorrect result that defies reality. Singh/Soler Post Tr. 5750, at 80-81.

E.79 Dr. Khan does not dispute that a deflection of $\frac{3}{8}$ of an inch resulting from a HI-STORM 100 cask that just sits on the surface of a concrete pad is contrary to physical fact (Tr. at 7218-19 (Khan)), but takes exception to the concept that a model should be able to accurately predict both static and dynamic conditions. *Id.* at 7211-15 (Khan).

E.80 We are presented here with a situation in which experts from opposing parties provide conflicting technical testimony. As we explain below, we agree

with the interpretation of Drs. Singh and Soler on the proper application of vertical contact stiffness and decline to follow Dr. Khan's suggested approach.

E.81 Contact stiffness is a physical parameter of contacting objects and their intrinsic material properties. Tr. at 9618-22 (Singh/Soler). The contact stiffness at the interface of two objects can therefore be derived from nature's physical laws, as shown by Heinrich Hertz in 1881. Tr. at 9618-19 (Singh). Holtec computed the vertical contact stiffness of 454×10^6 lb/in. for its DYNAMO design basis analysis using a well-established methodology developed by Timenshenko and Goodier for calculating the contact stiffness between two objects. Tr. at 9622-24 (Singh); Multi-Cask Seismic Response at the PSF ISFSI (PFS Exh. 226) [hereinafter Multi-Cask Seismic Response]. The approach used by Holtec is in accordance with guidance from the ANSYS Training Manual, which states that the "[h]ertz contact stiffness often provides an appropriate basis" for determining the contact stiffness to be used for modeling bulky objects. ANSYS Training Manual at 3-6; Tr. at 9625-26 (Singh) (PFS Exh. 221). The Hertzian theory of contact is the standard state-of-the-art technique used to simulate the interface between two bodies. Tr. at 9628-29 (Singh/Soler).

E.82 Similarly, in Sandia's modeling of cask stability for the NRC, contact stiffness was not treated as a "physical behavior." It was determined in accordance with the intrinsic properties of the contacting materials and the applicable physical relationships for determining contact stiffness. Tr. at 6809-11 (Luk).

E.83 Because contact stiffness is an intrinsic property of the contacting bodies, it does not vary from one geographic location to another as the earthquake characteristics change, as it would under the approach espoused by Dr. Khan. Tr. at 9617-19 (Soler).

E.84 Drs. Singh and Soler refer to guidance provided in ANSYS manuals on choosing appropriate contact stiffness for computer modeling to support their position concerning the proper choice of contact stiffness here. Singh/Soler Post Tr. 5750, at 79-82. ANSYS is a recognized, general-purpose computer modeling program accepted by Dr. Khan as an authoritative source. Khan/Ostadan Post Tr. 7123, at 8. The ANSYS Training Manual refers to the hertz contact stiffness theory applied by Holtec as "often provid[ing] an appropriate basis" for choosing a contact stiffness. ANSYS Training Manual 3-6 to 3-7 (PFS Exh. 221). The Training Manual also contains more than 100 pages devoted almost entirely to friction and contact problems. In addition, the ANSYS Verification Manual contains sample problems covering friction and contact issues and related guidance. See ANSYS Training Manual (PFS Exh. SS); Singh/Soler Post Tr. 5750, at 79-80.

E.85 The guidance provided by the ANSYS Training Manual included in PFS Exhibit SS makes it clear that, in order to achieve realistic modeling, the choice of stiffness for the contact springs between two contacting surfaces should not produce analysis results predicting a measurable penetration or deflection of

one of the bodies in contact, because such penetration or deflection is contrary to physical fact. In this respect, the guidance states that a contact stiffness that results in minimum penetration or deflection provides the “best accuracy,” and “[t]herefore, the contact stiffness should be very great.” ANSYS Training Manual at 3-3 (PFS Exh. SS). The guidance goes on to note, however, that in order to avoid convergence difficulties that may arise from “too stiff a value,” determining “a good stiffness value usually requires some experimentation” but that “if you can visually detect penetration in a true-scale displaced plot of the entire model, the penetration is probably excessive.” In that case, one should “[i]ncrease the stiffness and restart.” ANSYS Training Manual at 3-3, 3-14 (PFS Exh. SS).

E.86 As explained by the Applicant’s experts, the selection of contact stiffness is a well-defined and -understood problem when dealing with known properties of materials. Tr. at 9628-29, 9639-40 (Singh/Soler). Guidance exists for selecting contact stiffness values in general-purpose, validated, and well-established computer modeling programs, such as ANSYS, using tested mathematical solutions. Rather than being an unknown quantity to which dynamic analyses are extremely sensitive, the appropriate setting of a contact stiffness value is relatively straightforward for an experienced modeler.

E.87 A decisive factor in assessing Dr. Khan’s suggested approach is that his choice of contact stiffness produces results that are contrary to physical reality. Using a contact stiffness of 1×10^6 lb/in., as suggested by Dr. Khan, results in a deflection of $\frac{3}{8}$ of an inch in the pad simply from having the cask rest on its surface. Singh/Soler Post Tr. 5750, at 80-81. This is totally unrealistic, since the pressure applied by a fully loaded cask on the reinforced concrete pad is 26 psi, equivalent to a man standing on one foot. Singh/Soler Post Tr. 5750, at 50. Dr. Khan does not dispute that $\frac{3}{8}$ of an inch deflection is totally unrealistic. Tr. at 7218-19 (Khan). Drs. Soler and Singh maintain that a model should be able to provide a physically correct answer for all conditions, including the initial static case, and dynamic loading. Singh/Soler Post Tr. 5750, at 88. Dr. Luk agrees. Tr. at 6816-17 (Luk). We also agree.

E.88 Further, Dr. Soler testified that there are simple mathematical relationships between the natural frequency of the cask under dynamic conditions, the static deflection of the pad caused by the cask resting on its surface, and its contact stiffness. Tr. at 9632-34 (Soler). Those relationships involve the same formula that Dr. Khan cites as the basis for choosing a contact stiffness. According to those relationships, the frequency of the cask vibrating or oscillating on the pad is a function of the static deflection of the pad caused by the cask resting on its surface, or in other words, the static contact stiffness. *See* Khan/Ostadan Post Tr. 7123, at 12-13; Tr. at 9382-89 (Khan); Additional Cask Analyses at 21; Tr. at 9632-34 (Soler).

E.89 Dr. Khan's assertion that contact stiffness should vary according to geographic location and as an earthquake's characteristics change is without any support and belies the guidance provided by modeling programs, such as ANSYS, that make no mention of this supposedly essential fact. Dr. Khan's concerns about the use of an appropriate contact stiffness are not credible when looked at in terms of the results of Dr. Khan's choice of a vertical contact stiffness of 1×10^6 and a horizontal contact stiffness of 100,000 lb/in. Not only would the use of these values result in a storage cask literally sinking nearly half an inch into a reinforced concrete storage pad, they would result in a model that predicts displacement of $\frac{3}{4}$ of an inch, before actual cask sliding occurred. Neither of these predictions about how the cask and storage pad would behave comports with physical reality.

E.90 Furthermore, in response to Dr. Khan's claims, Holtec performed additional VisualNastran computer simulations using a lower contact stiffnesses than in its analyses using DYNAMO. Holtec ran VisualNastran using a vertical contact stiffness in the middle of the range of values that Dr. Khan claimed should have been used. Even though this brought the model within the spectral range of the earthquake input spectra, and thereby contaminated the results, the program still showed displacements on the order of inches and not feet as claimed by Dr. Khan. Additional Cask Analyses at 29-30; Tr. at 9671-76 (Soler). Holtec also ran Dr. Khan's model using the unreasonably low values for vertical contact stiffness (1,000,000 lb/in.) and impact damping (1%) that Dr. Khan had used in his analysis. Even at these values the casks did not tip over or impact each other. Additional Cask Analyses at 24-26; Tr. at 9606-07, 9611-14 (Soler).

E.91 The State attacks Dr. Soler for saying that "we got acceptable answers in the 2000-year return earthquake, so there was no incentive for us there to lower the contact stiffness." State Findings ¶ 300 (*citing* Tr. at 6043(Soler)). However, the context of Dr. Soler's statement was that, while the "actual contact stiffness is indeed very high," the use of a high contact stiffnesses can lead to excessive computation time. Tr. at 6041 (Soler). Accordingly, as explained by Drs. Singh and Soler, analysts will often use a contact stiffness value that is less than the actual value of the stiffness in order to reduce computing time, but yet not so low as to corrupt the solution. Tr. at 6041-44 (Singh/Soler). This explanation parallels guidance found in the ANSYS training manual on the use of contact stiffness. ANSYS Training Manual at 3-6 to 3-7 (PFS Exh. 221); Tr. at 9641-45 (Soler).

E.92 Thus, for the 2000-year DBE there was "no incentive" or reason for Holtec to use a lower contact stiffness value because Holtec was able to arrive at a converging solution using a high value for the contact stiffness close to its actual value. Tr. at 6042-43 (Soler). With VisualNastran runs, because of the vast amount of data that were being collected, Holtec used a lower contact stiffness in order to decrease the computation time. However, it did test runs to ensure that the use of a lower contact stiffness would not "significantly alter" the results. Tr. at 6043 (Soler). In this respect, Dr. Soler explained that there is a relatively

wide range of contact stiffnesses over which the solution does not show a great variation in results. Tr. at 6039-41 (Singh). The objective is to select and use a contact stiffness value for the analysis that is within this range. Singh/Soler Post Tr. 5750, at 81-82. Thus, the Board finds the Applicant's choice of contact stiffness to be reasonable.

(ii) DAMPING VALUES

E.93 In Holtec's cask stability analysis for the 2000-year earthquake using DYNAMO, Holtec used a 5% value for impact damping at the cask-pad interface to represent the dissipation of energy that occurs when the cask and the concrete pad impact each other during an earthquake event. Singh/Soler Post Tr. 5750, at 90-91. In the subsequent analyses using VisualNastran, Holtec used higher impact damping values based on analysis and test data that showed that the dissipation of energy through impact damping between a steel and concrete surface is much greater and would justify impact damping values of 40% or more. Tr. at 6095-98 (Soler); Tr. at 6098-99 (Singh). Holtec also explained that the "extent of damping is directly related to the severity of the event." Tr. at 9671 (Singh).

E.94 To illustrate the reasonableness of the impact damping values used in Holtec's cask stability analysis, and to further support their analysis in light of the State's criticism, Drs. Singh and Soler also provided computer simulations showing the effect of impact damping on a ball or cask dropped from a height of 18 inches using impact damping values of 1%, 5%, and 40%. At 1% damping, which is the value that Dr. Khan would have Holtec use in accordance with structural damping guidelines, the ball or cask would require more than seventy-three bounces before it came to rest; at 5%, the ball or cask would come to rest after approximately fourteen bounces; and at 40%, the ball or cask would come to rest after two or three bounces. Tr. at 9664-68 (Soler); PFS Exh. 225A.

E.95 In another animation, Dr. Soler replaced the sphere image with a cylinder representing a cask where he dropped the cylinders from a height of 18 inches and each cylinder had either 1%, 5%, or 40% damping. In this case, the cylinders with 40% damping and 1% damping bounced three times and more than seventy-three times, respectively, before stopping. Tr. at 9665-68 (Soler).

E.96 Holtec also generated a number of additional animations, including an eight-cask animation with a 40-million-lb/in. contact stiffness, 5% damping, and lower-bound soil springs, for a 2000-year earthquake. Tr. at 9673 (Soler). Another eight-cask animation used a 40-million-lb/in. contact stiffness, 40% critical damping, and lower-bound soil springs, for a 2000-year earthquake. *Id.*

E.97 Dr. Singh also referred to publicly available test data from NRC-sponsored impact experiments that Holtec used to correlate its program and benchmark its calculations. Tr. at 9660-61 (Singh). The State would have this testimony ignored, because neither the Applicant nor the Staff offered any

supporting documentation concerning the impact tests, which Holtec program was correlated with NRC data, or how the NRC impact tests relate to damping of HI-STORM casks during a seismic event. State Findings ¶342. We note, however, that the State had ample opportunity to pursue this issue on cross examination, to obtain the publicly available test data, or to have its experts review the data and comment on them.

E.98 Regarding Holtec’s animations, Dr. Khan testified that he disagreed that a dropped sphere would be similar to the impact damping between the cask and a pad because the earthquake motion is moving the cask up and down. Tr. at 9400-01 (Khan). Furthermore, the State notes that Dr. Soler also testified that he expected a cask would not simply bounce vertically up and down, but uplift and rock from side to side, depending upon the earthquake. State Findings ¶351 (*citing* Tr. at 9932 (Soler)). Dr. Soler also agreed that during an earthquake, the frequency and peak intensity would change with time. *Id.* Highlighting these conclusions, the State argues that the seismic behavior of a cask would not simply bounce in a pure vertical direction, but could also rock from side to side. Therefore, according to the State, the bouncing sphere animation and bouncing cask animation are inconclusive to define the damping experienced by a HI-STORM cask during a seismic event. State Findings ¶351.

E.99 A careful review of Dr. Khan’s testimony regarding this issue, however, reveals that Dr. Khan did not disagree that there would be impact damping for a sphere dropping on a hard surface; rather he believed that in addition to impact damping, other damping mechanisms would also operate under earthquake conditions (such as structural damping and rattling of the casks’ internals). Tr. at 9400-01 (Khan). When asked to consider only impact damping, Dr. Khan did not disagree that the impact damping of a dropping sphere would be analogous to the impact damping of a cask hitting the pad under earthquake conditions. Tr. at 9402-03 (Khan).

E.100 Moreover, we note that the dropping-sphere analogy is simply intended to demonstrate the effect of the choice of impact damping on the behavior of the dropped object (sphere or cask). There is no physical distinction between an earthquake rocking a cask “up and down” and a ball bouncing up and down due to the effect of gravity in terms of loss of energy from the cask or the ball impacting the surface. Tr. at 9910 (Soler).

E.101 Furthermore, we do not agree with the State’s concern that no evidence was proffered that the ball or cask with 40% impact damping would “better simulate” cask impact damping under seismic ground motion than the other balls or casks with 5% and 10% damping. During the hearing, the Applicant offered the testimony of Dr. Soler, a witness with extensive background and experience, as to which of the animations’ damping ratios best represents the impact damping of the steel and concrete storage casks on the concrete pad. Dr. Soler testified that, “[o]n the basis of [his] experience, [he] would expect [a cask] to bounce . . .

maybe two or three, maybe four times,” and thus “in [his] view, a choice of a number around 40 percent of critical damping is correct.” Tr. at 9911 (Soler). We find Dr. Soler’s testimony to be adequate support for the Applicant’s conclusion.

E.102 The State also argues that the Applicant has not produced evidence to support a finding that impact damping increases with an increase in ground motion. State Findings ¶339.

E.103 We disagree. As Dr. Singh explained in his testimony, this relationship between the percent of critical damping and the severity of the event is recognized in NRC guidance for structural damping. Tr. at 9670-71 (Singh). In this respect, we note that Regulatory Guide 1.61 concerning structural damping does allow a greater percent critical damping for SSEs than for operating basis earthquakes because energy dissipation during an earthquake depends upon “a number of factors” including the design, the material used, and the “magnitude of the deformations experienced.” Tr. at 9670-71 (Singh). And while Regulatory Guide 1.61 refers to structural damping instead of impact damping, the State has provided no evidence to suggest that Dr. Singh is incorrect for relying on it to support his analysis.

E.104 Dr. Khan raised a concern that the dynamic response may be underestimated in a nonlinear horizontal sliding analysis where (1) it is assumed that energy is both dissipated and (2) is absorbed through use of a high damping value. Tr. at 9392-93 (Khan). Dr. Ostadan concurred that the damping has been overestimated, which resulted in reducing seismic loads in the dynamic analyses. Tr. at 10,389 (Ostadan).

E.105 We do not agree. In its model, Holtec does not include any dampers that would reduce the effectiveness of the horizontal friction springs. Tr. at 10,639-40 (Soler). Thus, as acknowledged by Dr. Khan, friction remains the energy dissipation mechanism in a situation involving sliding, and we, therefore, find Dr. Khan’s criticism to be unfounded. Tr. at 9399-400 (Khan).

E.106 The State takes issue with Dr. Singh’s testimony that the actual magnitude of the impact damping would be greater than 40% based on Holtec having calculated greater than 50% impact damping in a simulation of a cask dropped on a very thick concrete foundation. Tr. at 6098 (Singh). The State challenges this testimony, because PFS neither “proffer[ed] supporting calculations for the impact damping” of greater than 50% for a metal cask on a concrete foundation nor “explain[ed] the details” of the assumptions and relevance “to the impact damping for the HI-STORM 100” referred to by Dr. Singh as support for use of a 40% impact damping value. State Findings ¶341. The State was free to cross-examine Dr. Singh on the relevance and assumptions of the calculation to which he had referred, but chose not to do so.

E.107 Finally, the State highlights Dr. Soler’s testimony, which explains that the damping value changes, because critical damping is a function of stiffness. *Id.* ¶350 (*citing* Tr. at 9673-74 (Soler)). The State argues, however, that Holtec

did not proffer an animation where it simultaneously lowered both damping and stiffness; therefore, Dr. Soler's conclusion with respect to "both" has no basis. The State believes that because the associated damping is a function of stiffness and that the cask behavior during a seismic event is nonlinear, the additional Holtec animations varying either damping or contact stiffness are insufficient to show that the cask behavior is not sensitive to both a lower damping and a lower contact stiffness, than the values used in the Holtec simulations (e.g. 40% damping and 18.8×10^6 lb/in. contact stiffness). State Findings ¶ 350.

E.108 The State's concerns are unwarranted for several reasons. In the first place, as discussed above, the input parameter values for contact stiffness and damping used by Holtec are reasonable and appropriate. Second, the State cites no evidentiary support for its claim.

E.109 Moreover, the Holtec sensitivity study used, as its base parameters, reasonable values of contact stiffness and damping, i.e., 40 million lb/in. for contact stiffness and 40% for damping. Additional Cask Analyses at 29; Tr. at 6046 (Singh); Tr. at 9911 (Soler). The sensitivity analyses performed by Holtec show that a reduction of contact stiffness by a factor of 8 or of damping by a factor of 8 has little impact on the results. Additional Cask Analyses at 29; Tr. at 9676 (Soler). While there are slight increases in the cask displacements, these are minimal, and still on the order of inches and not feet. Tr. at 9676 (Soler). Thus, no adverse results are detectable when one departs from the reasonable values used by Holtec in its cask stability analyses.

E.110 The State's criticism is also unsupported since there are analyses on the record in which Holtec reduced both contact stiffness and damping at the same time from the base case of 40 million lb/in. for contact stiffness and 40% for damping. Case 1 of the Beyond Design Basis Report, based on the 2000-year earthquake and lower-bound soil springs, was run using a contact stiffness of 18.8 million lb/in. for contact stiffness and 27.5% damping — approximately a 50% reduction for contact stiffness and approximately a 30% reduction of damping from the base case. Again, the results show displacements of inches, not feet. PFS Exh. 86D at 13; PFS Exh. OO.

d. Angle of Rotation

E.111 (Utah 354) Without consideration of the effects from SSI, the State argues that Holtec predicted a maximum angle of rotation for a single cask of approximately 10 degrees, given a coefficient of friction of 0.8 and a 10,000-year earthquake. Tr. at 6031 (Soler). The HI-STORM 100 cask will "theoretically" tip over if the cask tips at an angle of approximately 29 degrees from vertical. Tr. at 6033-34 (Soler). However, Dr. Singh agreed that the cask could tip over if there is residual momentum when the cask reaches approximately 29 degrees

(point where the center of gravity is over the corner of the cask). Tr. at 6109-10 (Soler).

E.112 The State notes that, in a paper presentation, Drs. Soler and Singh state that “[a]fter a certain threshold value, the response (viz maximum tilting of the cask axis) increases rapidly with increase in the [zero-period acceleration] level.”⁴¹ Seismic Response Characteristics of HI-STAR 100 Cask System on Storage Pads (Jan. 1998) at 15-16 (State’s Exh. 174) [hereinafter HI-STAR 100 Seismic Response Characteristics]. The State also points out that during cross examination in this case, Dr. Soler disagreed with the quote from his publication in that he did not agree that after a certain point, the maximum tilting would “rapidly” increase as the ZPA increased. State Findings ¶355 (*citing* Tr. at 6032 (Soler)). Additionally, in the HI-STAR publication, Drs. Soler and Singh recommend that the maximum rotation of the cask be set to 25% of the ultimate cask tip-over value. HI-STAR 100 Seismic Response Characteristics at 15. However, in this case, the State contends that the Applicant did not offer evidence concerning the “ultimate” cask tip-over value. The State notes that 25% of the “theoretical” tip-over value of 29 degrees is 7.25 degrees. It also notes that Dr. Singh testified that the HI-STAR cask is more likely to tip over than the HI-STORM cask because of the HI-STAR’s lower height-to-diameter ratio. State Findings ¶355.

E.113 According to the State, for the HI-STORM 100 cask, to ensure an adequate safety factor to prevent cask tip-over, Dr. Soler opined that the maximum excursion of the top of the cask should not exceed half the radius (33.16 inches). *Id.* ¶356 (*citing* Tr. at 6034-35 (Soler)). When considering the maximum excursion of the top of the cask of 33.16 inches with a cask height of 231.25 inches, the State argues that to ensure an adequate margin of safety, a maximum allowable rotation angle is 8.15 degrees from vertical. *Id.* ¶356.

E.114 In two reports, Holtec estimated maximum cask rotation angles of approximately 10 degrees for a 10,000-year earthquake, assuming a coefficient of friction of 0.8. This estimated maximum cask rotation angle exceeds the maximum rotation angle of 8.15 degrees suggested by Dr. Soler. Tr. at 6031 (Soler); PFS Exh. 86d at 13. In Applicant’s Exhibit 86d, the rotation angle from vertical was calculated based on 50% of peak-to-peak excursion instead of the maximum excursion of the top of the cask from the location at the start of the run. Applicant Exh. 86d at 13. The State notes that 50% of the maximum peak-to-peak excursion is lower than the maximum excursion recorded at the top of the cask. Thus, the State argues that the rotation angle calculated in Applicant’s Exhibit 86d may not reflect the maximum angle of rotation that occurred during the simulations. State Findings ¶357.

⁴¹ The paper was authored jointly by Dr. Soler, Dr. Singh, and Martin G. Smith.

E.115 The State notes that Dr. Soler also admitted, based solely on the animation, that in some runs in which he quantified only cask 1's movement, casks other than cask 1 (e.g., cask 5), appeared to move more than cask 1. State Findings ¶ 358 (*citing* Tr. at 5761-62 (Soler)). In an additional eight-cask simulation for a 2000-year earthquake, Dr. Soler actually quantified the movement for cask 1 and cask 5. In this simulation, he showed that the maximum excursion of the top of the cask for cask 1 was 3.4 inches and for cask 5 was 10.5 inches. *See* Additional Cask Analyses.

E.116 Dr. Singh claims that the "actual" maximum angle of rotation for the cask would be "much less" due to the "huge conservatisms" built into Holtec's model. Tr. at 6035 (Singh). The State points out, however, that notwithstanding any actual conservatisms, the record is devoid of any evidence quantifying the "huge conservatisms" claimed by Dr. Singh. State Findings ¶ 359.

E.117 We need not decide whether the Applicant must accept 8.15 degrees from vertical as the maximum acceptable angle of rotation as a design basis standard applicable to the 2000-year DBE, because the PFS facility meets that standard. The maximum angle of rotation from the DYNAMO design basis cask stability analysis for the 2000-year DBE is 1.026 degrees. The maximum angle of rotation that Holtec computed for its various 2000-year DBEs using VisualNastran was approximately 2.23 degrees. Likewise, the maximum angle of rotation computed by Dr. Luk for the 2000-year DBE was 0.40 degree. Luk Report at 30.

e. Time Histories

E.118 The State alleges as a deficiency the fact that the PFS cask stability calculations use only one set of seismic time histories. The State claims that nonlinear analyses are sensitive to the phasing of input motion, that more than one set of time histories should be used, and that "fault fling" (i.e., large-velocity pulses in the time history) and its variation and effects are not adequately bounded by one set of time histories. The concerns are expressed in the direct testimony of State witness Dr. Ostadan. Bartlett/Ostadan Post Tr. 7268, at 22-23.

E.119 Time histories represent the variation of ground acceleration with time during an earthquake. They are used to represent the motions to which the site structures would be subject during the design earthquake. Youngs/Tseng Post Tr. 5529, at 8.

E.120 NRC regulatory guidance (section 3.7.1 of NUREG-0800 and section 5 of NUREG-1567) allows the designer a choice between two alternative methods for developing design time histories. One approach is to use multiple sets of time histories that in the aggregate envelop the design response spectra, although any individual time history may fall well below the design spectrum at some frequencies. The second approach is to develop a single set of time histories

that envelops the design response spectra and a target power spectral density function. Time histories developed using the second approach are often called spectrum-compatible time histories. Youngs/Tseng Post Tr. 5529, at 8-9.

E.121 PFS elected to use the second approach, that is, to utilize a single set of time histories. Its consultant, Geomatrix, developed a set of time histories (consisting of three independent time histories, representing two horizontal and one vertical component of ground motion), in accordance with the methodology specified in the NRC regulatory guidance documents. *Id.* at 8. The three components of motion were then modified until their resulting response spectra enveloped the design response spectra following the criteria specified in NUREG-0800. Youngs/Tseng Post Tr. 5529, at 9.

E.122 The methodology used by PFS for developing the time histories for the stability analyses of the casks is appropriate and consistent with NRC Staff guidance. Pomerening/Ofoegbu Post Tr. 6496, at 26-27. The response spectrum envelops the design response spectrum and encompasses the power spectral density of the design spectrum over the requisite frequency range. Tr. at 6507-08 (Pomerening).

f. Cold Bonding

E.123 The State has raised the concern that PFS “has failed to consider the potential for cold bonding between the cask and the pad and its effects on sliding in its calculations.” Unified Utah L/QQ, at 4. As State witness Dr. Ostadan explained in his direct testimony, cold bonding occurs when two bodies (cask and pad) with such a large load (the cask) are in contact. Some local deformation and redistribution of stresses may occur over many years at the points of contact, which can create a bond in the form of a welding, which increases the resistance to sliding of the cask on the pad. Bartlett/Ostadan Post Tr. 7268, at 23.

E.124 The Applicant testified that the average pressure at the interface between the pad and the cask is approximately 26 psi. Singh/Soler Post Tr. 5750 at 50. Even assuming that the entire weight of the cask was supported only over a 12-inch-wide annulus around the periphery, the static contact pressure would rise only to 40 psi. *Id.* This pressure is well below the allowable bearing stress of 1785 psi in concrete with a compressive strength of 3000 psi. Pomerening/Ofoegbu Post Tr. 6496, at 25. Indeed, this level of pressure is comparable to a 200-pound man standing on the ball of one foot. Singh/Soler Post Tr. 5750, at 50. Such pressure is clearly insufficient to create a bonding between the steel bottom of the cask and the concrete surface of the pad. *Id.* at 50-51.

E.125 In order for cold bonding to occur, the pressure applied by the steel cask on the concrete would somehow have to increase significantly from the amount quoted above. Tr. at 5894-95 (Soler). However, Dr. Singh testified he could not visualize how this could occur, because concrete would crush with the

increasingly large pressure before it became bonded with the steel cask. Tr. at 6116-17 (Singh). Thus, occurrence of cold bonding between concrete and steel is highly improbable.

E.126 A calculation performed by the Staff established that the initial strain in the concrete caused by the presence of the cask is 8.33 microinch per inch, for a total deformation of 300 microinches. Pomerening/Ofoegbu Post Tr. 6496, at 25. Long-term creep accounts for an additional deformation of 672 microinches. Combining the initial and creep deformations gives a total deformation of 972 microinches. *Id.* This is an insignificant amount of deformation, which will not result in cold bonding of the cask and storage pad and will not have any influence on the overall stability of the casks under seismic load conditions. *Id.*

E.127 The State witnesses testified that the existence of cold bonding would operate to impede the initial sliding motion of the cask under seismic loadings. Tr. at 7720-21 (Ostadan). However, the seismic forces would readily break the bond and the cask would then slide on the pad in accordance with whatever coefficient of friction existed between the cask and the pad. Tr. at 7722-23 (Ostadan). Therefore, assuming the cold bonding phenomenon actually took place, its effect would be very limited both in duration and effect and, as Applicant's witnesses testified, would be subsumed in the variable coefficients of friction assumed in the Holtec analyses. Any small perturbations in the cask response due to irregular sliding would be within the range of results encompassed by the design basis simulations. Singh/Soler Post Tr. 5750, at 51-52.

4. Khan Report

E.128 At the request of the State, Dr. Mohsin Khan conducted a parametric study by modeling aspects of the seismic reaction of the HI-STORM 100 cask to evaluate Holtec's seismic analysis of freestanding casks at the PFS site. Khan/Ostadan Post Tr. 7123, at 7. For his parametric study, Dr. Khan utilized a finite-element structural analysis code, SAP2000, to model a single HI-STORM 100 cask as beam elements in which the base of the cask is connected to the storage pad using nonlinear elements. *Id.* Dr. Khan's methodology, analysis, results, and conclusions are described in the Analytical Study of HI-STORM 100 Cask System for Sliding and Tip-Over Potential During High-Level Seismic Event, Technical Report No. 01141-TR-000, Rev. 0 (Dec. 11, 2001) (State's Exh. 122) [hereinafter Khan Parametric Study].

E.129 Dr. Khan performed case studies using three mathematical single-cask models with varying degrees of complexity. Khan/Ostadan Post Tr. 7123, at 7. In the second and third case studies, Dr. Khan varied input parameters such as contact stiffness, the coefficient of friction, and damping. *Id.* at 8.

E.130 In the second case, which discounted rocking effects, for a coefficient of friction of 0.8 the horizontal cask displacement varied from 42.74 inches

to 0.057 inch with varying contact stiffness from 1×10^6 lb/in. to 454×10^6 lb/in., respectively. Khan Parametric Study, Table 2 at 11. Similarly, in the three-dimensional case, the horizontal and vertical displacement varied with the values of contact stiffness, coefficient of friction, and structural damping. Khan Parametric Study, Table 3 at 13.

E.131 Dr. Khan chose to perform his parametric analysis for different contact stiffnesses and impact damping values using the SAP2000 computer code. He testified that the only reason he chose SAP2000, as opposed to a more general-purpose program such as ANSYS, is because SAP2000 has a very efficient solution algorithm that takes less time to run than ANSYS. Tr. at 7171 (Khan).

E.132 SAP2000 is highly focused on the analysis of structures and was originally developed primarily for linear elastic analysis. Tr. at 9343-46 (Khan). It, however, does have the capability for a limited number of predefined nonlinear elements and may be used to model local structural nonlinearities such as gaps, isolators, and the like. Tr. at 9346-48 (Khan). Thus, SAP2000, like DYNAMO, is a small deflection program. Tr. at 7173-74 (Khan).

E.133 Dr. Khan insisted, on cross examination, that the fact that SAP2000 is a small deflection program did not bring into question the validity of the results of his analysis, in particular runs 1 and 3 of his third model, which show casks lifting off the ground by 1 or 2 feet and moving laterally 30 to 40 feet. Tr. at 9348-60 (Khan). Dr. Kahn explained these results by stating that in these runs, the casks (1) moved essentially straight up by more than 1 or 2 feet, but did not rotate significantly, and (2) moved laterally 30 to 40 feet in relation to the pad and the ground by bouncing up and down on the pad. Dr. Khan claimed that, because the casks assertedly did not rotate significantly, his analysis did not run afoul of the small-deflection limitations of SAP2000. *See* Tr. at 9354-60, 9512-15 (Khan). Only if the casks showed large rotations would Dr. Khan consider there to be geometric nonlinearities that would affect the validity of his SAP2000 results. Tr. at 9512-15 (Khan).

E.134 Dr. Khan's model was also unable to duplicate known classical solutions. Singh/Soler Post Tr. 5750, at 83-85.

E.135 The results obtained from Dr. Khan's model and his choice of contact stiffness are further cast into doubt by Dr. Khan's failure to verify his results. Although Dr. Khan's model was the first model of a large freestanding structure that he ever produced, the evidence indicated it had not been validated, verified, or benchmarked against either any classical problems or any real-world data. Moreover, his code was subjected neither to review by any third party nor to the kind of scrutiny that an NRC submission would ordinarily require to validate his results. Without such independent verification, the Board must view his results with some skepticism. Unlike Dr. Khan's model, Holtec benchmarked DYNAMO in a manner consistent with ASME NQA-2a-1990, Part 2.7 "Quality

Assurance Requirements of Computer Software for Nuclear Facility Applications.’’ Singh/Soler Post Tr. 5750, at 77.

E.136 Holtec performed an analysis of Dr. Khan’s model and input parameters for run 3 of his third model using VisualNastran, a code that is capable of handling large deflections. Tr. at 9603 (Soler); Additional Cask Analyses at 15-16, 24-26. Specifically, Holtec used the same contact stiffness (1,000,000 lb/in.) and damping at the cask–pad interface (1%) as Dr. Khan had used in his run 3, as shown on Table 3 of the Altran Report. As discussed above, these are the two parameters that Dr. Khan claimed that Holtec did not properly apply in its model and which gave rise to the difference between his results and those obtained by Holtec in its cask stability analyses.

E.137 Holtec could not duplicate Dr. Khan’s results using VisualNastran. Even with the unrealistic input parameters used by Dr. Kahn, the VisualNastran simulation did not show bouncing up and down of the cask by 1 to 2 feet over a lateral distance of 25 or more feet as predicted by Dr. Khan. Rather, there was only a slight bouncing of the casks up and down and although the casks rocked and tipped, they never came close to tipping over. Furthermore, instead of the lateral displacement of 25 feet or more, Holtec obtained displacements of less than a foot or two. *See* Additional Cask Analyses; PFS Exh. 225A; Tr. at 9602-04, 9610-15 (Soler).

E.138 In addition to the use of SAP2000 beyond its capabilities, the values that Dr. Khan used for vertical contact stiffness of 1×10^6 lb/in. and damping values of 0.01% and 1% that produced large cask movements were contrary to well-understood physical principles. The use of such parameters would, as a result, lead to totally unrealistic predictions.

5. State’s Request for a Shake Table Analysis

E.139 Dr. Khan opines that the only way to validate Holtec’s seismic analysis is to benchmark the cask displacement with actual shake table test data. Khan/Ostadan Post Tr. 7123, at 13. Consistent with this opinion, Dr. Khan testified that he could also not claim his parametric study results were correct without first validating his results with test data and calibrating his damping, stiffness, and rocking values. Tr. at 7178-79 (Khan). Moreover, Dr. Khan opined that the nonlinear cask seismic analyses should be validated with test data regardless of the analyst’s confidence in his solution. *Id.* at 9425.

E.140 As an example of what Dr. Khan believed to be the NRC philosophy supporting the need to validate nonlinear seismic analysis with test data, Dr. Khan referred to NRC Regulatory Guide 1.100, Institute of Electrical and Electronic Engineers, Inc., “Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations” [hereinafter IEEE Std. 344-1987]. Khan/Ostadan Post Tr. 7123, at 13-14. IEEE Std. 344-1987, section

6 states that “[t]he analysis method is not recommended for complex equipment that cannot be modeled to adequately predict its response. Analysis without testing may be acceptable only if structural integrity alone can ensure the design-intended function.” *Id.* at 14. IEEE Std. 344-1987 provides “good guidelines” for nonlinear seismic analysis, which have been applied in the qualification of structures. Tr. at 9431-32 (Khan). IEEE Std. 344-1987 requires test data validation for Class 1E electrical equipment defined as “electrical equipment and system that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or are otherwise essential in preventing a significant release of radioactivity to the environment.” *Id.* at 9428-29.

E.141 Dr. Khan testified that the IEEE Std. 344-1987 provision that states “analysis without testing may be acceptable only if structural integrity alone can ensure the design intended function” is not applicable to cask analysis because a designer cannot rely on its judgment that its design is adequate. Tr. at 9437-42 (Khan). In this case, shake table data would validate the cask dynamic response or whether the cask tips over under various ground motions.

E.142 The State contends that during the hearing, Dr. Luk confirmed he and the individuals in “his group” view shake table testing as “useful” in confirming his analysis. State Findings ¶ 367 (*citing* Tr. at 11,569, 11,572 (Luk)). In fact, the State claims that during the June 2002 hearings, Dr. Luk updated his previous testimony that he expected that a “true state-of-the-art” shake table test facility that could accommodate a full-scale cask would be available at the University of California at San Diego in the Spring of 2003 due to a recent grant from the National Science Foundation. Additionally, Luk testified that the Staff plans to request funding for shake table tests. *Id.* ¶ 367 (*citing* Tr. at 11,569-72 (Luk)). The State also highlights Dr. Luk’s testimony in which he states that he could “almost assure [that] the cask will not be damaged or destroyed on the shake table.” *Id.* at ¶ 367 (*citing* Tr. at 7111 (Luk)).

E.143 The State also argues that Dr. Cornell agreed that physical test data would reduce the amount of uncertainty in a seismic assessment. State Findings ¶ 369.

E.144 The State argues that although he was opposed to the shake table tests, Dr. Singh did acknowledge that shake table tests are necessary “when you have some ambiguities and some concern, some possible uncertainty with respect to performance,” albeit he believes there is no uncertainty with Holtec’s analysis. *Id.* ¶ 371 (*citing* Tr. at 9731 (Singh)). Moreover, the State pointed out that although both Dr. Singh and Dr. Soler initially denied ever discussing performing shake table tests with PFS (Tr. at 9732-33 (Singh/Soler)), in November 1997, Dr. Singh sought funding from PFS to verify their analytical work by conducting scale-model tests on a shake table (Tr. at 9738-40 (Singh)). *See* State Exh. 197A. Dr. Singh testified that because the Staff relied upon a “simpleminded static limit,”

NRC requested that Holtec conduct scale-model shake table tests to support the HI-STORM 100 application for a CoC at high earthquake levels. Tr. at 9739-40 (Singh). According to the State, Dr. Singh, in responding to the State's claim, denied ever recommending shake table tests to PFS, claiming instead the letter was "politically correct" and a result of "the guy who has the gold makes the rule," implying that NRC, not Holtec, desired the shake table tests. State Findings ¶ 371 (*citing* Tr. at 9745-48 (Singh)).

E.145 Although Dr. Singh does not define "high earthquake levels," it appears Holtec sought funding from PFS and Pacific Gas and Electric (PG&E) for shake table tests. *See* Tr. at 9742 (Singh). Dr. Soler testified that ground motions at the PG&E Diablo Canyon facility are 0.9g. Tr. at 5932 (Soler). According to the State, the peak horizontal ground accelerations at the PFS site are estimated as 1.15g for deterministic and 0.711g for a 2000-year event. State Findings ¶ 377.

E.146 Moreover, the November 1997 Holtec letter to PFS states "if PFS elects not to support [shake table testing], then we can provide all high seismic material stripped from Revision 1 of the HI-STORM [topical safety evaluation report] for direct incorporation in the Skull Valley site-specific submittal, and we will proceed with only anchored cask certification on this new docket." State Exh. 197A.

E.147 The State argues that no expert disagreed that the results of nonlinear analyses could be validated only with test data. The State asserts that the experts disagreed in various degrees as to the actual need for shake table data. Moreover, the State contends that given Dr. Luk's anticipation of a shake table test facility able to conduct full-scale tests becoming available, Dr. Luk's assurances that a cask would not be damaged by shake table tests, and the lack of convincing evidence of the accuracy and reliability of the Holtec 2000-year report, the Board cannot find without such testing that the Applicant has met its burden to demonstrate that freestanding HI-STORM 100 casks will not tip over under a 2000-year earthquake at the PFS facility. State Findings ¶ 376.

E.148 Although the State points to Dr. Luk's testimony concerning the "useful[ness]" of shake table testing, it neglects to highlight Dr. Luk's extensive discussion on the limitations of shake table testing for cask stability analysis.⁴²

⁴² Dr. Luk pointed to limitations on shake table testing other than size of a facility, such as being able to apply only one horizontal motion. Tr. at 6966-68 (Luk). More importantly, he noted that there are some limitations that cannot be technically overcome. For example, in situ soil conditions cannot be re-created on a shake table test, and as a result, SSI effects cannot be incorporated. Tr. at 6968 (Luk). Moreover, Dr. Luk never agreed with the State's implicit assumption that shake table testing is necessary to confirm whether a finite-element model is appropriately constructed. Indeed, in a complicated model like Dr. Luk's model that takes into account SSI, the shake table testing cannot, according to Dr. Luk, simulate that SSI.

E.149 Dr. Cornell, who has extensive knowledge of nonlinear seismic analysis, testified that one “would gain information” from shake table testing that would reduce the amount of uncertainty, but he went on to say that: “In practice, it’s seldom necessary to do so, seldom believed to be necessary to do so when doing nonlinear dynamic analyses of a facility.” Tr. at 7979 (Cornell). He further stated that it is his opinion that “in this case there is sufficient margin enough to demonstrate that this ten to the minus four accident failure probability is easily reached without the need” for shake table tests. Tr. at 8024 (Cornell).

E.150 Dr. Cornell further made the important point that “[a] shake table is another model” with its own uncertainties. While one would gain some information, the test would introduce a different set of uncertainties. Tr. at 8023-25 (Cornell). For example, it was widely recognized by all witnesses that it would be impossible to duplicate the PFS site conditions in a shake table test. *See, e.g.*, Tr. at 7982-83 (Cornell); Tr. at 9728-29 (Singh).

E.151 Dr. Singh emphasized the difficulty in “simulating the conditions of a cask on the pad” in a shake table test. Tr. at 9682-83 (Singh). He explained, for example, why it would be not be feasible to experimentally control the coefficient of friction between the cask and the pad so as to be able to obtain meaningful data that one could correlate with the numerical computer models of freestanding casks on a concrete pad. Tr. at 9682-84, 9888-91 (Singh). In other words, one would not be able to design a shake table test “to measure all [the] critical variables that participate in the dynamic behavior” of the cask and then set the input parameters of your computer model accordingly to see how well the results predicted by the program correlate with the test data. Tr. at 9892 (Singh). Absent such correlation, one could not use the data from a shake table test as a reliable benchmark for the numerical program. Tr. at 9890-91 (Singh). We find that, in light of the limitations that would be embodied in shake table testing of this nature and that would hamper its usefulness from a scientific point of view, such testing would not be particularly beneficial here in establishing reasonable assurance of adequate public health and safety.

6. *The Staff-Sponsored Sandia Report Conducted by Dr. Vincent Luk*

E.152 To verify the Holtec Analysis, the NRC Staff commissioned Dr. Vincent Luk of Sandia National Laboratories (SNL) to conduct an independent evaluation of the PFS project. Dr. Luk assembled and directed a team of experts in conducting an evaluation of the seismic behavior and stability of the freestanding, cylindrical HI-STORM 100 casks to be installed on concrete storage pads at the proposed PFS facility. He and his team developed a three-dimensional coupled finite-element model of the proposed PFS dry cask storage system to examine the nonlinear and dynamic behavior of the casks, and to simulate the effects of SSI, under prescribed seismic conditions. NRC Staff Testimony of Vincent K. Luk and

Jack Guttman Concerning Unified Contention Utah L/QQ (Geotechnical Issues) [hereinafter Luk/Guttman] Post Tr. 6760, at 2-3. These efforts culminated in the publication of a final report on March 31, 2002, entitled “Seismic Analysis Report on HI-STORM 100 Casks at Private Fuel Storage (PFS) Facility, Rev. 1” (Staff Exh. P) [hereinafter Luk Report].

E.153 Dr. Luk first became involved in NRC efforts to model storage cask behavior in a seismic event in an ongoing generic program for developing guidance on seismic hazards analysis, established by the NRC Office of Nuclear Regulatory Research. A research team consisting of analysts and engineers from SNL, ANATECH Corporation, and Earth Mechanics, Inc., was assembled for this purpose, under Dr. Luk’s leadership as Principal Investigator. As part of this ongoing effort, the Staff requested technical assistance from SNL in conducting an analysis of the behavior of loaded HI-STORM 100 storage casks under seismic conditions at the PFS facility. The Staff provided basic information to the research team, with respect to cask design, pad dimensions, soil-cement layers under and adjacent to the pad, the site-specific soil profile, and time histories of seismic accelerations. Luk/Guttman Post Tr. 6760, at 4.

E.154 In conducting this analysis, three-dimensional coupled finite-element models were developed, and seismic analyses were performed to examine the dynamic and nonlinear behavior of the HI-STORM 100 casks to be installed on the concrete storage pads at the PFS facility, including the SSI effects during a seismic event. Three different sets of seismic conditions were modeled: (1) the 2000-year return period earthquake for the PFS facility site, (2) the 10,000-year return period earthquake for the PFS facility site, and (3) a sensitivity study based on the 1971 San Fernando Earthquake (Pacoima Dam record). The analyses thus modeled ground motions for the design basis 2000-year event; the 1971 San Fernando Earthquake (Pacoima Dam record), for which the ground motions are somewhat similar to the ground motions of the PFS 2000-year event; and ground motions for the PFS 10,000-year event. *Id.*

E.155 The ABAQUS/Explicit code was used to analyze the three-dimensional coupled finite-element models that consist of (1) a single cylindrical HI-STORM 100 cask (with the MPC-68 option); (2) a flexible full-sized concrete pad (30 feet × 67 feet × 3 feet); (3) a shallow surface layer of compact aggregate around the pad; (4) a soil-cement layer adjacent to the pad (2 feet 4 inches thick); (5) a soil-cement layer under and adjacent to the pad (approximately 2 feet thick); and (6) an underlying, layered soil foundation. The layout of the entire coupled model is shown in Figure 1 of the Luk Report. Luk Report at 14. The cask was modeled as an elastic solid component, while the gravel, concrete pad, soil-cement, and soil were modeled as flexible linearly elastic materials. Structural damping ratios, whose values are tabulated in each horizontal layer and for each of the three cases of soil profile data (*see* Luk Report, Tables 2 to 7), were used for the soil and soil-cement materials, while a zero damping was used

for the concrete pad and the cask. In other words, the cask and pad were modeled as elastic bodies with zero damping. Luk/Guttmann Post Tr. 6760, at 5-6.

E.156 The shallow surface layer and the concrete pad are placed on a continuous 2-foot soil-cement layer that is on top of the soil foundation. The coupled model has three interfaces, which include the (1) cask-pad, (2) pad-soil-cement layer, and (3) soil-cement layer-soil foundation interfaces. In addition to incorporation of the structural elements discussed above, development and use of the model also required selection of appropriate cask-pad and soil material properties and application of properly prescribed seismic time history sets to the model. To this end, the Staff provided the research team with the basic information on cask design, pad dimensions, soil-cement layers under and adjacent to the pad, the site-specific soil profile, and time histories of seismic accelerations. The analytical results obtained from the model address the dynamic and nonlinear response of the cylindrical cask in terms of its wobbling and sliding by examining closely the nonlinear contact behavior at the three interfaces and accounting for SSI effects. *Id.* at 5.

E.157 The Staff's modeling effort focused on performing sensitivity studies on the cask response with respect to three key factors: (1) prescribed seismic loading, (2) coefficients of friction at the three interfaces in the coupled model, and (3) soil profile data used for the soil foundation model. *Id.* at 6.

E.158 With respect to the first of these factors (seismic loading), three sets of seismic time histories were used as input excitations in the coupled model analyses. First, a prescribed artificial time history of seismic accelerations with a duration of 30 seconds, using design basis response spectra for the PFS site for a 2000-year return period earthquake, was used to generate the response of the cask under design basis conditions. Second, a similar site-specific time history of seismic accelerations for a 10,000-year return period with a duration of 30 seconds was used to provide a limiting or upper-bound case assessment of cask response. Third, a sensitivity study was performed using the 1971 San Fernando Earthquake, Pacoima Dam record. *Id.*

E.159 Each set of seismic time histories has one vertical and two horizontal components of statistically independent seismic accelerations. For the 2000-year return period earthquake, the PGAs that were modeled, based on artificial time histories specific to the PFS site, were 0.728g (horizontal, east-west), 0.707g (horizontal, north-south), and 0.721g (vertical); these PGAs envelop the 2000-year design basis response spectra of 0.711g (horizontal) and 0.695g (vertical) stated in the SER for the PFS facility. For the 10,000-year return period event, the PGAs that were modeled, based on site-specific artificial time histories, were 1.25g and 1.23g for the horizontal components, and 1.33g for the vertical component, which envelop the PFS earthquake hazard spectra. For the 1971 San Fernando Earthquake, Pacoima Dam record, the PGAs that were modeled were

0.641g for the two horizontal components, and 0.433g for the vertical component. The duration for this event was 41.8 seconds. *Id.* at 6-7.

E.160 Each of the three seismic acceleration components of a set of time histories was treated with a deconvolution procedure to produce a modified time history of deconvoluted accelerations with properly adjusted amplitudes and frequencies of the surface-defined accelerations. All three components of deconvoluted accelerations were applied simultaneously at the base of the soil foundation in the coupled model. Deconvolution is a mathematically rigorous solution process that applies the wave propagation equation of the free-field surface along with the boundary conditions, which modifies the input to account for the site-specific soil properties (i.e., linear shear modulus and viscous damping model). This serves to preserve the dynamic characteristics of the original seismic motions and achieve the desired (i.e., appropriate) surface shaking intensity. *Id.* at 7.

E.161 Coefficients of friction at the three interfaces were modeled as follows. Three interfaces were used in the coupled model: cask–pad, pad–soil-cement layer, and soil-cement layer–soil foundation. In order to determine the governing cases for both (a) the maximum horizontal sliding displacement and (b) the angular rotation of the cask, different combinations with upper- and lower-bound coefficients of friction were used in the analyses. For the 2000-year (design basis) event, the best estimate soil profile data, a lower-bound coefficient of friction of 0.20 (for investigating cask sliding) and an upper-bound coefficient of friction of 0.80 (for investigating the potential for cask tip-over) were used at the cask–pad interface. Bounding coefficients of friction of either 1.00 or 0.31 were also assumed at the other two interfaces, as shown in Table 8 of the Luk Report (Best Estimate, Model Type 1). Luk/Guttmann Post Tr. 6760, at 7-8.

E.162 These sensitivity studies showed that the maximum horizontal displacement (sliding) of the cask was obtained when using a coefficient of friction of 0.20 at the cask–pad interface and 0.31 at the pad–soil-cement layer and soil-cement layer–soil foundation interfaces, as shown in Table 8 of the Luk Report (Best Estimate, Model Type 1). Consequently, this combination of coefficients of friction was selected as the governing case for other seismic analyses reported in Table 8 of the Luk Report for the 2000-year event. Luk/Guttmann Post Tr. 6760, at 8; Luk Report at 30.

E.163 Similarly, several studies were conducted for the 1971 San Fernando Earthquake (Pacoima Dam record) and the 10,000-year return period event, using a coefficient of friction of 0.20 at the cask–pad interface, and 0.31 at the other two interfaces, in order to maximize the potential for horizontal displacement (sliding) of the cask. The results of these studies are shown in Tables 9 and 10 of the Luk Report. Finally, two additional analyses were conducted for the 1971 San Fernando Earthquake and the 10,000-year return period event, using a coefficient of friction of 0.8 at the cask–pad interface and 1.0 at the other two interfaces, in

order to maximize the potential for cask tip-over. These results are also shown in Tables 9 and 10 of the Luk Report. Luk/Guttman Post Tr. 6760, at 8; Luk Report at 31-32.

E.164 With respect to the use of soil profile data, the compact aggregate surface layer and concrete pad are placed on top of a 2-foot-thick soil-cement layer that is on top of the soil foundation. The soil foundation submodel utilized in the model was 330 feet in the east-west direction and 757 feet in the north-south direction; these lateral dimensions exceed the recommended minimum as defined in U.S. Corps of Engineers soil-structure interaction modeling guidelines. Also, the coupled model partitions the soil into six horizontal layers to a depth of 140 feet, to represent the soil foundation; and the top surface was further divided into layers. The 140-foot depth was selected, in part, to reach a level below which the soil stiffness increases monotonically with depth. Sensitivity studies were performed to demonstrate the adequacy of this discretization scheme (using six layers to a depth of 140 feet) to incorporate the depth variation of soil properties such as shear wave velocity and damping profiles. As shown in section 3.4.1 and Tables 2-7 of the Luk Report, specific soil properties considered include: (1) Young's Modulus, (2) Poisson's ratio, (3) density, (4) damping ratio, and (5) a mass-related damping factor. This foundation modeling and its rationale are discussed in greater detail in sections 3.2.4 to 3.4.1 of the Luk Report. Luk/Guttman Post Tr. 6760, at 8-9; Luk Report at 7-12.

E.165 To provide for broad variation in the soil properties, three sets of soil profile data — the best estimate, the lower bound, and the upper bound — were used separately in the analysis. The same soil profile data (best estimate, the lower bound, and upper bound) were used in performing the cask analyses for the seismic event with a 2000-year return period and the 1971 San Fernando Earthquake, Pacoima Dam record, as shown in Tables 2 to 4 of the Luk Report. Different soil profile data were used for the 10,000-year return period seismic event, in which the shear modulus and damping of each layer of the soil foundation were adjusted for shear strains, as shown in Tables 5 to 7 of the report; in contrast, for seismic events with a 2000-year return period, the low strain shear modulus and damping were used. Luk/Guttman Post Tr. 6760, at 9; Luk Report at 10-12.

E.166 The results from the Staff's seismic analyses indicate that the maximum horizontal cask sliding displacements are 3.98 inches for the 2000-year return period event; 3.00 inches for the 1971 San Fernando Earthquake, Pacoima Dam record; and 15.94 inches for the 10,000-year return period event. Luk/Guttman, Post Tr. 6760, at 9-10.

E.167 The results predicted by the coupled model with respect to the maximum horizontal cask sliding displacements render it unlikely that collisions of adjacent casks would occur at the PFS site. The separation distance between neighboring casks is 47.5 inches. Half of this distance, or 23.75 inches, is regarded as the cask collision criterion. Inasmuch as maximum displacement under the

design basis 2000-year earthquake is 3.98 inches, no cask collisions were found to occur. Further, no collisions were found to occur at the PFS site for the 1971 San Fernando earthquake, Pacoima Dam record, for which the maximum displacement was 3.00 inches. Similarly, under 10,000-year seismic conditions, the maximum displacement was 15.94 inches, which is less than the collision criterion of 23.75 inches. Thus, even under the beyond-design-basis 10,000-year event conditions, cask collisions were not found to occur. *Id.* at 10.

E.168 Similarly, the model predicts that tip-over of the HI-STORM 100 storage cask is unlikely to occur at the PFS site during a seismic event. In this regard, with respect to the 2000-year return period seismic event, the coupled model analysis predicts that the maximum cask rotation in either horizontal direction with respect to the vertical axis is equal to or less than 0.03 degree, using a coefficient of friction of 0.20 for the cask-pad interface. Further, using a coefficient of friction of 0.80, in order to maximize the amount of cask rotation, results in a maximum cask rotation of about 0.22 degree in the east-west direction and about 0.40 degree in the north-south direction, with respect to the vertical axis, for the 2000-year earthquake. In sum, the maximum cask rotation, with respect to the vertical axis, is equal to or less than 0.40 degree under 2000-year return period seismic conditions. *Id.* at 11.

E.169 With respect to the 1971 San Fernando Earthquake (Pacoima Dam record), the maximum cask rotation in either horizontal direction with respect to the vertical axis, using a coefficient of friction for the cask-pad interface of 0.2, results in a maximum cask rotation with respect to the vertical axis of 0.02 degree in the east-west direction and 0.01 degree in the north-south direction. Further, using a coefficient of friction of 0.8, in order to maximize the amount of cask rotation, results in a maximum cask rotation of 0.06 degree in the east-west direction and 0.07 degree in the north-south direction for the 1971 San Fernando Earthquake (Pacoima Dam record). In sum, the maximum cask rotation with respect to the vertical axis is equal to or less than 0.07 degree for the 1971 San Fernando Earthquake (Pacoima Dam record). *Id.* at 11.

E.170 With respect to the 10,000-year return period seismic event, the maximum cask rotation in either horizontal direction with respect to the vertical axis, using a coefficient of friction for the cask-pad interface of 0.20, results in a maximum cask rotation with respect to the vertical axis of 0.10 degree in the east-west direction and 0.05 degree in the north-south direction. Further, using a coefficient of friction of 0.80, in order to maximize the amount of cask rotation, results in a maximum cask rotation of 0.65 degree in the east-west direction and 1.16 degree in the north-south direction, for the 10,000-year earthquake. In sum, the maximum cask rotation, with respect to the vertical axis, is equal to or less than 1.16 degrees even under 10,000-year return period seismic conditions. *Id.* at 11-12.

E.171 Based on the maximum cask rotation predicted by the model, Dr. Luk concluded that cask tip-over is unlikely to occur during either the 2000-year or 10,000-year return period seismic events at the PFS site. The cask rotation that is associated with a cask tip-over is approximately 29 degrees. A rotation of less than 29 degrees (as is predicted here) would be insufficient to result in tip-over of a loaded HI-STORM 100 cask. *Id.* at 12.

E.172 A detailed evaluation of cask movement in the vertical direction was also conducted. This evaluation indicates that the cask does not experience much displacement in the vertical direction in any of the three seismic events. During either the 2000-year return period seismic event or the 1971 San Fernando Earthquake (Pacoima Dam record), the cask base is never entirely lifted off the top surface of the pad, and the maximum vertical displacement at any location of the cask base is much less than 1 inch above the top surface of the pad. *Id.* During the 10,000-year return period seismic event, the cask base will entirely lift off the top surface of the pad by a maximum of 0.26 inch, for a total duration of less than 0.30 second, and the analysis results for the 10,000-year event indicate that the maximum vertical displacement at any point along the perimeter of the cask base is less than 2.7 inches above the top surface of the pad. *Id.* at 12-13.

E.173 In sum, based on its confirmatory analysis, the Staff concluded that excessive cask sliding, cask collisions, and cask tip-over will not occur during either a 2000-year return period or 10,000-year return period seismic event at the PFS site. *Id.* at 13.

E.174 The Luk Report performed by Dr. Luk did not attempt to duplicate the Holtec analysis, nor did it do so. The Luk Report utilized a methodology (a state-of-the-art three-dimensional finite-element analysis) that differed from the damper-and-spring model constructed by Drs. Singh and Soler. Indeed, Dr. Luk performed his analysis without ever having seen the Holtec analysis prior to testifying in this proceeding. Tr. at 6934, 6937-41 (Luk). These independent analyses resulted in specific quantitative results that differed to some extent. However, while Dr. Luk's specific quantitative results varied somewhat from the results obtained by Drs. Singh and Soler, using a wholly independent approach and different methodology his analysis clearly confirmed their conclusion — that the HI-STORM 100 casks will not collide into each other or tip over in the event of either the design basis (2000-year return period) earthquake or the 10,000-year return period seismic event. *See id.* at 13.

a. Conflict of Interest Involving Study's Advisory Panel

E.175 A review panel consisting of three NRC Staff and four industry representatives provided technical advice and input to the generic and site-specific cask stability studies conducted by Dr. Luk and his associates. Tr. at 6994-96, 7052-54 (Luk). The hearing testimony revealed that industry representatives

included representatives from Southern Company, San Onofre Nuclear Generating Station, the Electric Power Research Institute, and a private consultant, Dr. Robert Kennedy. Tr. at 6995 (Luk). Southern Company and Southern California Edison, owner of San Onofre, are members of the PFS consortium. SER at 17-1. The role of the industry panel members was to provide recommendations concerning the analysis methodology and range of input parameters used by Dr. Luk. Tr. at 7054 (Luk). The advisory panel, including industry representatives, reviewed the generic Luk finite-element model and provided their comments and recommendations. Tr. at 7076 (Luk). According to the State, Dr. Luk met with the advisory panel on three occasions, including November 2001, to discuss the details of the PFS model. State Findings ¶ 383 (citing Tr. at 7077-78 (Luk)). The panel provided comments on the completed 2000-year analysis for PFS at the November 2002 advisory panel meeting. The advisory panel meetings were not open to the public. Tr. at 7082-83 (Luk).

E.176 Although Dr. Luk testified that he had no knowledge that any of the industry representatives were associated with PFS (Tr. at 6995-96, 7053-54, 7081-86 (Luk)), the State contends that the Licensing Board should presume the Staff was aware that representatives from PFS member companies were on the advisory panel. State Findings ¶ 384. The State argues that “fundamental fairness” to the conduct of a licensing proceeding mandates the “disclos[ure] of all potential conflicts of interest,” whether or not a party believes them to be material and relevant to a licensing proceeding. *Long Island Lighting Co.* (Shoreham Nuclear Power Station, Unit 1), LBP-82-73, 16 NRC 974, 979 (1982). Furthermore, the State insists that such disclosure is necessary to enable the Licensing Board to determine the materiality of the potential conflict of interest. Due to the lack of disclosure of potential conflicts of interest of the industry representatives on Dr. Luk’s advisory panel, compounded by the lateness of the availability of the Luk Report to the State, the State insists that it has had little or no opportunity to probe the backgrounds of the advisory panel and its influence on the Luk methodology and analysis during discovery. Because of the constraints placed on the State to probe the issue and potential inability to raise it themselves, the State argues that the Board cannot find that at least two industry representatives on Dr. Luk’s advisory panel have no conflict of interest with the outcome of Dr. Luk’s cask stability analysis for the PFS site. Thus, the State requests that the Board weigh, in assessing the Luk Report, the impact of the potential conflict of interest from the PFS member companies in its assessment of the Luk Report. State Findings ¶ 384.

E.177 Although we agree that there is an appearance of a potential conflict, we find no reason for concern that Dr. Luk’s report may have been tainted due to this alleged potential conflict of interest. Based on our observation of Dr. Luk’s testimony, including his responses to cross examination and Board questions, we are fully satisfied as to his candor, objectivity, and professionalism. Furthermore,

Dr. Luk testified that he did not receive any comments from the review panel prior to completing his preliminary PFS site-specific analysis in October 2001; and while the review panel was then given an opportunity to review his site-specific analysis, that review did not result in any changes in the report before it was issued in March 2002, other than the manner in which the results were presented and the removal of irrelevant material. Tr. at 7102-05 (Luk).

E.178 There is no evidence to suggest that the utility representatives gave Dr. Luk incorrect technical advice, or that Sandia followed any such advice, or that any advice provided by the utility representatives adversely affected the validity of the results of Dr. Luk's PFS facility analysis.

E.179 What was gleaned from the extensive examination of Dr. Luk on the review panel was that the panel gave advice on technical issues such as what damping to use, the values of the coefficient of restitution, and the merits of using a single cask on a single pad for the analyses. Tr. at 7084-85 (Luk). At no point did the review panel members provide any advice that Dr. Luk considered inappropriate. *Id.* This is confirmed by the written minutes of the meetings of the panel, which reveal that the meetings were of a highly technical nature, as would be anticipated for such a panel. *See* Staff Exh. GG.

b. Dr. Luk's Relative Experience

E.180 According to the State, Dr. Luk's sole experience in modeling the freestanding, dry storage casks includes the site-specific analysis for PFS, Hatch, and San Onofre; however, the State contends that the site conditions for Hatch and San Onofre are not similar to those at the proposed PFS site. State Findings ¶ 385. The State argues that although Dr. Luk modeled ground motions in excess of those estimated for Hatch, the Hatch ground motions are approximately 0.15g horizontal and 0.1g vertical. Furthermore, the State suggests that although the Hatch site stores twelve casks on a concrete pad in a 2 × 6 array, Dr. Luk modeled a square pad with a 2 × 2 array. According to the State, the casks proposed for San Onofre are three unanchored, rectangular, horizontal casks tied together, unlike the individual cylindrical HI-STORM 100 casks. State Findings ¶ 385. Dr. Luk acknowledged that the seismic response of the horizontal casks at San Onofre is "very different" when compared to the cylindrical cask proposed for PFS. Tr. at 7056 (Luk). The State argues that the Hatch site conditions are different from those proposed for PFS. It further argues that the San Onofre site conditions and the facility design are substantially different from those proposed for PFS. Therefore, the State insists that Hatch and San Onofre do not provide relevant modeling experience for the PFS design or site conditions. State Findings ¶ 385.

E.181 The State claims that initially Dr. Luk testified that he has no expertise in SSI, but later recanted his testimony to claim he has such expertise. According to the State, Dr. Luk claims the evaluation of SSI effects is nothing more than a

systematic evaluation to address the dynamic coupling between a structure and soil. State Findings ¶ 389 (*citing* Tr. at 6917, 7036-37 (Luk)).

E.182 The State also claims that Dr. Luk professes to be an expert in SSI based on his work over the past few years in evaluating coupling between components in a nuclear power plant. However, the State insists that Dr. Luk's own SSI experience is limited to "the past few years" which would encompass the analyses he performed for the Hatch and San Onofre ISFSIs, and requests that we find the record bare in its support that Dr. Luk alone is qualified to model SSI effects. State Findings ¶ 390.

E.183 The State also contends that there is insufficient evidence to find that Dr. Luk's associates are qualified to accurately model the soil dynamics or the SSI effects. State Findings ¶ 391.

E.184 The State claims that Dr. Luk's experience in the nonlinear modeling of the seismic behavior of cylindrical, freestanding casks is limited to his generic study and the Hatch analyses. The State, therefore, argues that Dr. Luk does not have experience in the nonlinear modeling of the seismic behavior of cylindrical, freestanding casks supported by cement-treated soil and a relatively soft clay foundation at ground motions equal to or greater than the 2000-year earthquake at PFS. *Id.* ¶ 392.

E.185 For the reasons stated previously, we find that Dr. Luk and his team are quite experienced in conducting finite-element analyses of the type conducted here, and that their PFS site-specific analyses provide useful, relevant, and reliable evidence as to the stability of the casks at the PFS facility, in the event of either a 2000-year DBE, or a 10,000-year beyond-design-basis event.

E.186 Although the State attempts to portray Dr. Luk as having no expertise in soil dynamics, the record does not support this view. Dr. Luk described the members of his research team and their respective areas of expertise related to his PFS site-specific analysis. Tr. at 6765-66 (Luk). Dr. Luk stated that he is personally not an expert in soil mechanics, but he is very familiar with the dynamic coupling process involved in SSI. Further, he stated that he considers himself to be an expert in conducting SSI analyses. In addition, he obtained input for his analytical model from a member of his team (Mr. Po Lam), who developed the soil foundation model and the deconvolution process that is part of the soil foundation modeling. Tr. at 7036-37 (Luk). Based on this testimony, as well as our familiarity with Dr. Luk's ability to respond to questions concerning this aspect of this study, we are unable to adopt the State's suggestion that neither Dr. Luk nor any member of his research team is qualified to model soil dynamics or SSI effects.

c. Comparison of Dr. Luk's Report and the Holtec Report

E.187 According to the State, the Holtec witnesses agreed that the Luk Report did not confirm Holtec's methodology, but similarly concluded that the cask would not tip over. State Findings ¶394. Dr. Soler testified that the Staff's analysis "studies a different problem than [Holtec] simulated either with DYNAMO or VisualNastran." Tr. at 5898 (Soler). Dr. Soler further testified that the Staff's analysis "models certain features of the problem in a different manner than [Holtec]." *Id.* The State also claims that Dr. Soler did not know why there was a difference in the results between his analysis and the Staff analysis for a 10,000-year earthquake with a coefficient friction of 0.8. State Findings ¶394. Although Dr. Soler claims the Luk Report's magnitude of excursions are in the same order with those determined by Holtec (Tr. at 5998 (Soler)), the State claims that Dr. Luk testified that the Holtec and Luk results cannot be compared. State Findings ¶394 (*citing* Tr. at 6949-51 (Luk)).

E.188 The State also asserts that Dr. Luk did not compare his SSI effects for a 2000-year or 10,000-year earthquake with those predicted by PFS. Nor did Dr. Luk compare his deconvoluted time histories for a 2000-year or 10,000-year earthquake with those predicted by PFS at similar depths. State Findings ¶396.

E.189 According to the State, when probed about his confidence in the results from a "very complicated model" with large amounts of data, Dr. Luk further testified that the results are dependent on the input parameters. *Id.* ¶398 (*citing* Tr. at 6987 (Luk)). The Luk model has 4124 elements: 864 elements model the cask, 384 elements model the storage pad, 28 elements model the aggregate, 848 elements model the soil-cement adjacent and beneath the pad, and 2000 elements model the soil foundation. Tr. at 7026-27 (Luk). Given the complexity of Dr. Luk's model, at this juncture the State argues that it is appropriate to heed Dr. Cornell's affirmation not to be too enamored with the computer program itself. Furthermore, the State insists that Dr. Luk acknowledges the value in validating nonlinear results with test data. State Findings ¶387.

E.190 Due to the lack of test data to validate his results, the State contends that Dr. Luk relies on his sensitivity analyses and the experience he has gained in his NRC-related study to substantiate his model. *Id.* ¶399. In an effort to demonstrate the accuracy of his model, Dr. Luk points to his seismic analysis at Hatch where the ground motion was increased to demonstrate that his model could show cask tip-over. Tr. at 6988 (Luk). Although Dr. Luk relies on the Hatch analysis to support the accuracy of his PFS model, the State notes that he also testified that the PFS model was modified to simulate the soil-cement layer at the PFS site. State Findings ¶399 (*citing* Tr. at 7026 (Luk)). Moreover, the State contends that the soil-cement (cement-treated soil) layer, with interfaces both above and beneath the layer, "actually caused quite a bit of difficulties in the simulation portion." State Findings ¶399 (*citing* Tr. at 7028 (Luk)).

E.191 Based on the apparent complexity of the model, the differences in the PFS and the Hatch model, and the lack of test data to validate any results, the State insists there is insufficient evidence to conclude the PFS model developed by Dr. Luk accurately or conservatively estimates cask response, including displacement, angle of rotation, and tip-over. State Findings ¶400.

E.192 We find the State's concerns to be without merit. With respect to the differences in results obtained by the two models, particularly for the 10,000-year beyond-DBE and a coefficient of friction between cask and pad of 0.8, such differences are to be expected. As Dr. Singh testified, "[w]hen you model a complex problem and you take a different modeling path you're going to have some differences in the final results. But the solutions in the end are essentially in agreement with ours." Tr. at 5899 (Singh).

E.193 The difference in methodologies between the two analyses is not a basis for questioning either set of results. Indeed, had Dr. Luk used the same methodology and obtained the same results as Holtec, there would be little confirmatory value in Dr. Luk's results. It is the fact that Holtec and Dr. Luk used two different methodologies that makes the results of the Luk Report's analyses valuable in confirming the Holtec analyses. It is because the Luk analyses differ in many respects from Holtec's with respect to assumptions or methodological approaches about which the State expressed concern (e.g., choosing a particular contact stiffness value, choosing a particular damping value, not taking into account the effects of non-vertically propagating seismic waves, using soil springs to represent soil dynamic behavior, not modeling SSI fully, etc.), that the analyses are confirmatory, arriving at the same conclusions without using methodological assumptions the State contended were problematic in the Holtec analyses. *See* Tr. 6827-29 (Guttman).

E.194 As we have previously discussed above, the State's arguments on the need for shake table testing do not prevail. The State also offers explanation for why the absence of physical benchmarking renders the Luk Report analyses nonconfirmatory of the Holtec analyses. The absence of shake table tests does not mean that the adequacy of the Luk model has not been independently established. The ABAQUS code has been benchmarked against a wide variety of classical problems. For the specific case of the PFS facility, Dr. Luk and his team checked the results produced by the analysis against test data to verify the appropriateness of the analytical results. Tr. at 6812-13 (Luk).

d. Luk's Modeling

E.195 In Table 8, column 2, of the Luk Report, μ_1 is the interface coefficient of friction between the casks and the storage pad; μ_2 represents the coefficient of friction at two different interfaces: between the bottom of the pad and the top

of the cement-treated soil, and between the bottom of the cement-treated soil and the top of the upper Lake Bonneville clays. Tr. at 10,347-48 (Bartlett).

E.196 To model the interfaces, including interfaces above and below the cement-treated soil (μ_2), Dr. Luk used what he referred to as Coulomb's law of friction, $F = \mu n$, where F is the frictional resistance, μ is the coefficient of friction, and n is the normal stress. Tr. at 11,510 (Luk); Tr. at 11,407 (Bartlett). Dr. Luk observed that "the so-called coefficient of friction at the interface between two bodies is an estimate of the friction in the systems of one body in motion with respect to the other, basically, fitting Coulomb's Law of Friction." Tr. at 11,509-10 (Luk). In particular, Dr. Luk testified that "Coulomb's Law of Friction is a description of the frictional resistance at the interface, as material properties at the interface." Tr. at 11,510 (Luk).

E.197 By treating the interface conditions as frictional material, the State is adamant that Dr. Luk's model does not represent the actual PFS design or the PFS site soils. Tr. at 10,375-77 (Bartlett). Of particular concern to the State is the way in which Dr. Luk has modeled the interface conditions, μ_2 , and also the way in which Dr. Luk's model does not account for the post-yield behavior of the upper Lake Bonneville clays. State Findings ¶412.

E.198 The actual design of the storage pad system at the PFS site is undisputed: a 1- to 2-foot-thick cement-treated soil layer, the top of which is bonded to the underside of the concrete storage pads and the bottom of which is bonded to the top of the native soil layer (i.e., upper Lake Bonneville clay). SAR at 2.6-108 (PFS Exh. JJJ); Trudeau/Wissa Post Tr. 10,834, at 24-25; SER at 2-59. The State claims that unlike structural fill, which derives its resistance to seismic forces from friction, cement-treated soil derives its resistance to seismic forces from cohesion. State Findings ¶413.

E.199 The State contends that the PFS design intent to withstand seismic forces from the DBE is to rely on cohesion from bonding at the interface layers (the upper Lake Bonneville clays interface with the laminated cement-treated soil lifts; and the cement-treated soil with the underside of concrete pad) to transfer the horizontal earthquake forces downward from the storage pad to the underlying clay soils. Tr. at 10,375-76 (Bartlett).

E.200 According to the State, the soils characterization at the PFS site was conducted by Stone & Webster but these soil properties are not used in the Luk model. According to the State, Luk's model uses the dynamic soil properties — upper bound, best estimate, and lower bound for the PFS site — developed by Geomatrix. State Findings ¶415.

E.201 The State claims that clays are not a granular material — they are a relatively soft plastic material. Tr. at 10,377 (Bartlett). The State further claims that the clays that PFS is relying upon to transfer earthquake forces — the upper Lake Bonneville clays — derive their strength from cohesion (i.e., the undrained shear strength) not from friction. *Id.*

E.202 The State claims that cohesion is a material property — it is the shear strength or resistance to sliding within the material. Tr. at 11,687 (Bartlett). The State asserts that Dr. Luk indicated that his model does not incorporate cohesive strength of the soils. State Findings ¶417.

E.203 The State claims that cohesion is generally not thought of as a dynamic property — it is a shear-strength property that is measured by a static test. Tr. at 11,706 (Bartlett). The State believes that cohesion is also an interface property — it is the strength of the bond at the interface between two layers.⁴³ Tr. at 11,688 (Bartlett).

E.204 Furthermore, the State argues that cohesion was not an inherent property included in the dynamic soil properties that were developed by Geomatrix for the PFS site. Tr. at 10,409, 11,690-91 (Bartlett). The dynamic soil properties given to him by the Staff and apparently developed by Geomatrix are (1) maximum shear modulus, (2) soil density, (3) Poisson's ratio, and (4) an estimation of shear modulus degradation and damping degradation as a function of strain. Tr. at 11,710 (Bartlett). Dr. Bartlett, the State's soils expert, testified that he knows of no theory of obtaining cohesion of the upper Lake Bonneville clays from the dynamic soil properties developed by Geomatrix. Tr. at 11,711 (Bartlett).

E.205 In this regard, the State contends that the Board should give particular deference to Dr. Bartlett. The State claims his expertise in soils is unquestioned. The State asserts that Dr. Luk, on the other hand, admits that he has no expertise in soils and that he relied on a seismologist for the soil input to the numerical model. The State argues that Dr. Luk admits shear strength (i.e., cohesion) is not represented in his model. The State requests that the Board find that the Luk model does not incorporate cohesion through the use of the dynamic soils properties developed by Geomatrix. State Findings ¶420.

E.206 The State also argues that the Luk Report does not model the design PFS intends to employ at the site; does not model the actual interface conditions at the PFS site; and by using a frictional material to represent the behavior of the two μ_2 interfaces, employs an inappropriate constitutive relationship to use in the numerical model. *Id.* ¶425.

E.207 In sum, the State believes that the properties described in the Luk model at the interfaces designated as μ_2 do not properly represent the strengths of those interfaces, and therefore, the Luk model overemphasizes sliding, which potentially could dampen out the seismic energy that is delivered to the cask. *Id.* ¶426.

E.208 The Applicant, in response to the State's assertions, stated that in modeling the interfaces above and below the cement-treated soil, Dr. Luk used

⁴³ Strictly speaking, the term "adhesion" refers to the condition between two dissimilar materials; "cohesion" is the failure within the material itself. Tr. at 11,416-17 (Bartlett).

a well-established method of finite-element modeling. PFS Reply ¶ 353 (*citing* Tr. at 11,511-12 (Luk)). The Applicant asserted that the State and its witness Dr. Bartlett misunderstand Dr. Luk's methodology. PFS Reply ¶ 353. It was not, as Dr. Bartlett interpreted it, to treat the underlying upper Lake Bonneville clays as if they were "sand." Tr. at 10,530-35 (Bartlett). In reality, as Dr. Luk testified, modeling the interface using a frictional relationship does not represent the characterization of the properties of the materials, but that of the interface between them. Tr. at 11,510-12, 11,573, 11,580-81 (Luk). As described by Dr. Luk,

Coulomb's Law of Friction is a description of the frictional resistance at the interface, as material properties at the interface. It's also a parameter that has [*sic*] depends on the material, but more on the surface condition of the two bodies.

Tr. at 11,510 (Luk).

E.209 In response to the State request for the Board to give "particular deference" to Dr. Bartlett on this issue, the Applicant insists that Dr. Bartlett is admittedly unqualified to render an opinion as to how a finite-element model should be constructed or interpreted. PFS Reply ¶ 354. Furthermore, during the hearing, Dr. Bartlett acknowledged that he could not comment on the appropriateness of the modeling techniques used by Dr. Luk and his Sandia colleagues, but was limiting his comments to the properties of the materials analyzed by the report. Tr. at 10,347 (Bartlett). The Board notes that Dr. Luk testified that his model did not represent any particular material at the interface, but rather the "physical phenomenon associated with a sliding resistance, based on Coulomb's Law of Friction." Tr. at 11,586 (Luk).

E.210 Much of the State's concern with Dr. Luk's model centers on the State's disagreement with the coefficients of friction used. However, as Dr. Luk testified, the coefficient of friction at the interface does not represent a property of a material. Tr. at 11,573, 11,580-81 (Luk). Thus, the State's attacks are without merit since they rebut assumptions that have not been made and methodologies that have not been applied in Dr. Luk's analyses.

E.211 Contrary to the State's claim that soil cohesion was not taken into account as a property of the underlying soils by the Luk model, we note that during the hearing Dr. Luk testified that his model did take into account the internal cohesion of the materials modeled (Tr. at 11,573-75, 11,580-81 (Luk)).

E.212 Moreover, if there was error in Dr. Luk's model and it indeed treated the soils as cohesionless materials, such an error would maximize the tendency of the pads to slide. *See* Tr. at 10,535 (Bartlett). However, the results of the Luk analysis show that there was minimal pad displacement under both the DBE and the beyond-design-basis 10,000-year seismic event. Tr. at 11,516-29, 11,575-78, 11,586-88, 11,610-11 (Luk); Staff Exh. YY. Thus, if the State is correct and

the Luk analysis tends to disregard the cohesive properties of the soil, the actual behavior of the pads in an earthquake should exhibit even less sliding than predicted by Dr. Luk's report.

E.213 The third deficiency with the Luk model of the foundation soils alleged by the State is that it does not account for the post-yield behavior of the upper Lake Bonneville clays. However, Dr. Luk explained that such effects are not significant and, after a few months of evaluations, he and his team decided that using an elastic model to simulate the soil foundation was adequate. Tr. at 11,548. (Luk).

E.214 We find the State's final claim that Dr. Luk erred by using the soil properties provided by Geomatrix to Holtec rather than the soil properties developed by Stone & Webster, to be without merit for two primary reasons. First, Stone & Webster did not develop dynamic soil properties, but also used those developed by Geomatrix in that it used dynamic loads on the casks obtained from ICEC's design calculation, which in turn used the results of Holtec's dynamic analyses that utilized the soil properties developed by Geomatrix. *See* Tr. at 6235-37, 6340 (Trudeau). Second, by using the Geomatrix soils properties as input to the computer model, Dr. Luk incorporated soil cohesion into his analysis. Tr. at 11,573-75 (Luk). While Dr. Bartlett disputes that it is possible to incorporate soil cohesion from the dynamic soil properties provided by Geomatrix, we find Dr. Luk to be more experienced with the ABAQUS code. And Dr. Luk testified that incorporating soil cohesion is among the features of the ABAQUS code. Tr. at 11,574-75 (Luk).

E.215 Dr. Bartlett raised two other concerns about Dr. Luk's modeling of the foundation soils: (1) the assumed thickness of the cement-treated layer and (2) the value of the Young's Modulus used in the analysis. *See* Tr. at 11,481-82 (Bartlett). The Young's Modulus issue is discussed separately below. With respect to the thickness of the cement-treated soil layer, Dr. Bartlett expressed a concern that Dr. Luk's model assumed a uniform thickness of 2 feet for the cement-treated soil layer. Two feet is a maximum value and the actual thickness can be as little as 1 foot, depending on the amount of aeolian soil that needs to be replaced with a cement-treated soil mixture. Tr. at 11,445-46 (Bartlett). Dr. Luk explained, however, that while his team was aware that the thickness of the cement-treated soil mixture was variable, the decision was made to use the higher value for the thickness of the cement-treated soil, because with a thicker layer of cement-treated soil, more of the energy that is associated with the ground excitations will go to the pad and the cask, so in that sense, more conservative results will be generated in evaluating the dynamic behavior of the cask. Tr. at 11,544 (Luk).

e. Young's Modulus

E.216 The Luk Report uses a 270,000-psi Young's Modulus for the cement-treated soil under the pads. Luk Report at 10-12.

E.217 None of the parties disagree that Holtec has constrained the Young's Modulus of cement-treated soil to less than 75,000 psi. However, the State believes that meeting a Young's Modulus of 75,000 psi is an integral part of the PFS soil-cement testing that PFS has yet to conduct. State Findings ¶ 428.

E.218 Dr. Luk testified he obtained the 270,000 psi from a member of the NRC Staff, Mr. Mahandra Shah. Tr. at 11,625 (Luk). According to the State, there is nothing in the record to describe Mr. Shah's technical background, qualifications, or experience. State Findings ¶ 429. Counsel for the Staff represented that Mr. Shah conducted a literature review in which 270,000 psi was referenced for soil-cement, and he decided to use that value. Tr. at 11,629 (Turk).

E.219 The State insists that there is no support for Luk's use of a value of 270,000 psi when the actual value is known for the cement-treated soil at the PFS site. Further, the State argues that the Young's Modulus for cement-treated soil is not some obscure technical reference. State Findings ¶ 430.

E.220 According to the State, the question then arises as to the effect of misrepresenting Young's Modulus for cement-treated soil in the Luk model. The State's expert testified that nonlinear models are extremely sensitive to input parameters and was unwilling to hazard a guess at the effect. The State points out that the issues of changes of input parameters to nonlinear modeling is at the heart of the dispute between the State and PFS in Holtec's cask stability analysis. *Id.* ¶ 431.

E.221 In its challenge, however, the State's experts did not state what, if any, difference they believed that the Young's Modulus value may have on the accuracy of Dr. Luk's results. Dr. Luk testified that the higher value of Young's Modulus would conservatively maximize the seismic loads transferred from the underlying soil foundation to the storage pad and cask, and therefore maximize the potential for horizontal cask displacement due to sliding, cask rotation, and potential tip-over. Tr. at 11,542-44 (Luk). Likewise, as discussed above, using a higher value of Young's Modulus does not affect the dynamic behavior of the cement-treated soil, because the soils have been demonstrated by sensitivity studies to be relatively insensitive to variation in the value of Young's Modulus. Thus, changes in the Young's Modulus value would not likely have significant nonlinear effects in a dynamic analysis of cask stability. Tr. at 11,631-32 (Luk).

E.222 We find the State's concerns regarding the modeling of the interface, the allowance for sliding in some cases, and the value of the Young's Modulus for the cement-treated soil layer in Dr. Luk's analyses to be unfounded. Dr. Luk's analyses appropriately model the properties of each of the materials present in the PFS facility design and at the PFS site. The use of a higher Young's Modulus for

the cement-treated soil is a conservative design element that addresses, *inter alia*, the State's concern about underestimating forces transferred to a cask. Likewise, the model appropriately takes into account bounding conditions at the interfaces between these materials. It also demonstrates that sliding of the pads is beneficial to cask stability, and that even in the absence of any sliding of the pads, cask displacement and rotation remain minimal under any possible conditions at the PFS site.

F. Seismic Exemption Request

1. Background

F.1 Applicable regulations in 10 C.F.R. § 72.102(b) and (f) provide for the assessment of design basis seismic ground motions for ISFSIs at sites west of the Rocky Mountains based on the deterministic procedures and criteria formerly used for nuclear power plant seismic design (10 C.F.R. Part 100, Appendix A). In 1996, the Commission changed the seismic design requirements for new NPPs by issuing regulations and guidance documents that provide for use of PSHA methodology. 10 C.F.R. § 100.23; "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion," Regulatory Guide 1.165 (Mar. 1997). The Commission is considering a similar rule change to employ the use of PSHA methodology for the seismic design of ISFSIs. *See* Geological and Seismological Characteristics for Siting and Design of Dry Cask Independent Spent Fuel Storage Installations and Monitored Retrievable Storage Installations, 67 Fed. Reg. 47,745 (July 22, 2002).

F.2 SECY-98-126 (June 4, 1998), referenced in the State's contention, was the initial rulemaking plan for implementing the change from deterministic methods to PSHA methods for the seismic design of ISFSIs. That SECY document discussed three different rulemaking options for the Commission for incorporating PSHA methods into 10 C.F.R. Part 72. The "preferred" approach set forth in SECY-98-126 proposed a 1000-year mean return period DBE for Category 1 SSCs important to safety (those whose failure would not result in radiological doses exceeding the requirements of 10 C.F.R. § 72.104(a)) and a 10,000-year mean return period DBE for Category 2 SSCs (those whose failure would result in radiological doses exceeding the requirements of 10 C.F.R. § 72.104(a)).

F.3 This initial rulemaking plan, however, was essentially superseded by SECY-01-0178, dated September 26, 2001, in which the NRC Staff recommended to the Commission that the rulemaking plan be modified to add another option, which it identified as the "preferred" one, in lieu of the two-tiered approach identified as the preferred option in SECY-98-126. This new "preferred" option features the use of a 2000-year mean return period earthquake as the design basis for all ISFSI SSCs. In a Staff Requirements Memorandum dated November 19,

2001, the Commission approved the modification to the rulemaking plan proposed by SECY-01-0178, further instructing the NRC Staff that the proposed rule should solicit comments on a range of “exceedance levels” from 5×10^{-4} through 1×10^{-4} to which the failure probability of SSCs should be set.

F.4 On July 22, 2002, the NRC issued a proposed rule to make the Part 72 regulations compatible with the 1996 revision to Part 100 that addressed uncertainties in seismic hazard analysis. 67 Fed. Reg. at 47,745-55. The proposed rule would require a new specific license applicant for a dry cask storage facility located in either the western U.S. or in areas of known seismic activity in the eastern U.S., and not co-located with an NPP, to address uncertainties in seismic hazard analysis by using appropriate analyses, such as a PSHA or suitable sensitivity analyses, for determining the DBE. The new proposed regulation, 10 C.F.R. § 72.103, would eliminate the current requirement to comply with the deterministic methodology of Appendix A to Part 100. *Id.* at 47,746. As part of the proposed rule, the Commission indicated it is considering using a MAPE value in the range of 5×10^{-4} to 1×10^{-4} for ISFSI applications. Draft Regulatory Guide DG-3021, “Site Evaluations and Determination of Design Earthquake Ground Motion for Seismic Design of Independent Spent Fuel Storage Installations and Monitored Retrievable Storage Installations,” has been developed to provide guidelines that are acceptable to the NRC Staff for determining the DE for an ISFSI. 67 Fed. Reg. at 47,750. The Draft Regulatory Guide currently recommends a MAPE value of 5×10^{-4} as an appropriate risk-informed value for the design of a dry cask storage ISFSI. *Id.* at 47,752.

F.5 On April 2, 1999, PFS filed an exemption request to use PSHA methods for determining the seismic design of the PFS facility using a 1000-year mean return period earthquake as the PSHA design basis. *See* Request for Exemption to 10 C.F.R. § 72.102(f)(1) Seismic Design Requirement Docket No. 72-22/TAC No. L22462 Private Fuel Storage Facility (PFS Exh. 247). On August 24, 1999, PFS amended its request for an exemption to seek the use of a 2000-year mean return period earthquake as the design basis for the PFS facility. *See* PFS Exh. 248. In its SER of October 2000, the NRC Staff approved the PFS request to use PSHA methodology for the seismic design of the PFS facility based on a 2000-year mean return period DBE. The final statement of the Staff’s reasons for granting the exemption is set forth in the SER issued in March 2002. *See* SER at 2-50 to 2-51.

2. *Legal Standards for Governing the Site-Specific Analysis Necessary To Obtain an ISFSI License*

F.6 The Commission’s requirements governing the seismic analysis and design for an ISFSI are set forth in 10 C.F.R. Part 72. In general, 10 C.F.R. § 72.90 requires an evaluation of site characteristics that may directly affect the

safety or environmental impact of the proposed facility, including an evaluation of the frequency and severity of external natural events that could affect the safe operation of the ISFSI. Pursuant to 10 C.F.R. § 72.92, an applicant must identify and assess the natural phenomena that may exist or can occur in the region of the proposed facility, with respect to their potential effects on safe operation, including consideration of the occurrence and severity of important natural phenomena. In addition, 10 C.F.R. § 72.98(a) requires identification of the regional extent of external phenomena that are used as a basis for the design of the facility.

F.7 Pursuant to 10 C.F.R. § 72.122(b)(1), SSCs “must be designed to accommodate the effects of, and to be compatible with, site characteristics and environmental conditions . . . and to withstand postulated accidents.” Further, section 72.122(b)(2) requires that SSCs be designed to withstand the effects of natural phenomena, including earthquakes, without impairing their capability to perform safety functions, and that the design bases for the SSCs must reflect:

(i)(A) [a]ppropriate consideration of the most severe of the natural phenomena reported for the site and surrounding area, with appropriate margins to take into account the limitations of the data and the period of time in which the data have accumulated, and

(B) [a]ppropriate combinations of the effects of normal and accident conditions and the effects of natural phenomena.

F.8 In addition, pursuant to 10 C.F.R. § 72.102, an ISFSI applicant is required to address the geological and seismological characteristics of its proposed site. For sites located west of the Rocky Mountain Front (west of approximately 104° West Longitude) and in other areas of known potential seismic activity, 10 C.F.R. § 72.102(b) requires that “seismicity will be evaluated by the techniques of appendix A of [10 C.F.R. Part 100].” Further, 10 C.F.R. § 72.102(f) requires that for sites that have been evaluated under the criteria in 10 C.F.R. Part 100, Appendix A, the “design earthquake (DE) for use in the design of structures must be . . . equivalent to the safe shutdown earthquake (SSE) for a nuclear power plant.”

F.9 Appendix A to 10 C.F.R. Part 100 (which is cited in 10 C.F.R. § 72.102(b) and (f)), establishes seismic and geologic siting criteria for NPPs. Appendix A sets forth the criteria to be used by NPP license applicants in conducting the geologic and seismic investigations necessary to determine site suitability. It describes “procedures for determining the quantitative vibratory ground motion design basis at a site due to earthquakes” and “information needed to determine whether and to what extent an [NPP] need be designed to withstand the effects of surface faulting,” and it identifies “[o]ther geologic and seismic factors required to be taken into account in the siting and design of [NPPs].” 10 C.F.R. Part

100, App. A, § II. Section IV of Appendix A describes the geologic, seismic, and engineering investigations that are required; section V describes the process to be followed in determining the seismic and geologic design bases for the facility; and section VI describes the application of these matters to the facility's engineering design. *Id.*

F.10 In particular, paragraph V(a) of 10 C.F.R. Part 100, Appendix A, discusses the process to be followed in determining the design basis for vibratory ground motion, including identification of the safe shutdown earthquake for a nuclear power plant. Appendix A, section III, defines the safe shutdown earthquake as that earthquake, "based upon an evaluation of the maximum earthquake potential" shown in site and regional investigations, which produces "the maximum vibratory ground motion" at the site for which certain SSCs are designed to remain functional; the SSE is commonly referred to as the NPP's "design basis earthquake." The approach specified in Appendix A implies the use of a "deterministic seismic hazard analysis" (DSHA) to calculate the SSE, because it considers only the largest possible earthquake that could occur on a seismogenic fault or within a seismic source at the closest possible distance to the site. Moreover, the DSHA methodology does not consider how frequently the seismic events occur, including the earthquake that is considered to control the deterministic ground motion. In addition, DSHA methods do not consider uncertainties associated with the identification and characterization of an earthquake at the site or uncertainties in ground motion modeling. Thus, analyses using the Part 100, Appendix A *deterministic* methodology would establish the SSE for an NPP without regard to the uncertainties associated with the evaluation of earthquakes (e.g., size, location, magnitude) and with the assessment of ground motions, and do not consider the probability of occurrence of the SSE within any period of time. *See* 10 C.F.R. Part 100, App. A.

F.11 As discussed herein, PFS has requested an exemption from the deterministic seismic requirements in 10 C.F.R. Part 72. Where, as here, an exemption is sought from the requirements in 10 C.F.R. Part 72, the regulations provide that the Commission "may . . . grant such exemptions from the requirements of the regulations [in Part 72] as it determines are authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest." 10 C.F.R. § 72.7.

3. *Classification of Hazardous Curves*

F.12 As discussed above, Part 72 currently requires PFS to assess the maximum vibratory ground motion that could be experienced at the PFS site using DSHA methodology. Part 72 cross references the standard that formerly applied to NPPs, i.e., 10 C.F.R. Part 100, Appendix A. Under the changes in the NPP requirement, codified at 10 C.F.R. § 100.23, an NPP applicant now refers

to NRC guidance (Reg. Guide 1.165) where the “reference probability” for determining the SSE from a PSHA is specified to be that probability that has an annual median probability of 1×10^{-5} of exceeding the SSE, which is equivalent to a MAPE of 1×10^{-4} (or a return period of 10,000 years) for the central and eastern United States (CEUS); there is the option that an applicant may request and justify the use of a higher reference probability for a site not in the CEUS (e.g., in the western United States (WUS)). “Identification and Characterization of Seismic Sources and Determination of Safe Shutdown,” Reg. Guide 1.165 (Mar. 1997), at 1.165-12 (State Exh. 201); Tr. at 8001-02 (Cornell).

F.13 As described in testimony by all parties, if an NPP were to be sited at the PFS site, acceptable design levels would be established using ground motions with a mean annual return period somewhere between 5000 years and 10,000 years. Tr. at 10,111-14, 10,120-24 (Arabasz); Testimony of C. Allin Cornell [hereinafter Cornell] Post Tr. 7856, at 47-48; NRC Staff Testimony of John A. Stamatakos, Rui Chen, and Martin W. McCann, Jr., Concerning Unified Contention Utah L/QQ, Part E (Seismic Exemption) [hereinafter Stamatakos/Chen/McCann] Post Tr. 8050, at 26-29.

F.14 The State challenges the Staff’s claim that based on a survey of five NPPs in the WUS, the reference probability for a hypothetical NPP at the PFS site would be a mean annual exceedance probability of 2×10^{-4} (5000-year MRP). According to the State, two of the five NPPs in the survey are located in California, one is in Arizona, and two are in Washington State. State Findings ¶454. For the following reasons, the State does not agree with Dr. McCann’s assessment and with Dr. Stamatakos’s position that the average MAPE of 2×10^{-4} from the five NPPs represents a value that is applicable to the entire WUS. First, at least three of the five NPPs in the survey are located near tectonic plate boundaries along the western coast, have steep hazard curves, and simply are not representative of the Intermountain area. Second, the Palo Verde site in Arizona is in an area of low seismicity, and with a mean exceedance probability corresponding to a 26,000-year return period earthquake, is not only an outlier in the calculation of the sample mean but its MAPE argues against the applicability of a 5000-year MAPE to the entire WUS. Third, the State does not believe that extrapolating an average MAPE from such a small number of NPPs to the Skull Valley site — or to any other hypothetical NPP site in the WUS away from the plate boundary — would withstand critical scrutiny in an NPP licensing hearing. Representing that the sample mean characterizes “nuclear power plants in the Western United States” is defensible only semantically. State Findings ¶454.

F.15 The State argues that although the 5000-year MRP may justifiably apply at WUS NPP sites where there are steep hazard curves, such as near tectonic plate boundaries, it does not necessarily apply in the Intermountain west. *Id.* ¶455. As an example, the State argues that DOE-STD-1020-2002 sets a greater probability of exceedance (i.e., a shorter return period) for sites located near tectonic plate

boundaries than other DOE sites. “Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities,” DOE-STD-1020-2002 (Jan. 2002), at Table C-3 (Staff Exh. QQ) [hereinafter DOE-STD-1020]. For PC-4 facilities — equivalent to NPPs — the standard for sites located near tectonic plate boundaries is 2×10^{-4} (i.e., a 5000-year return period) whereas for non-plate-tectonic sites the return period is 10,000 years. *Id.*

F.16 Dr. Arabasz presented a qualitative analysis of nuclear facility sites in the WUS, including the Basin and Range province, and used a literature review and the steepness of hazard curves at some of those sites to ascertain whether the implied probability of exceeding an SSE corresponded to a 5000-year MRP or a 10,000-year MRP. The State contends that Dr. Arabasz is an expert with extensive professional experience in studying and monitoring earthquakes in the Basin and Range province, and that the Board should give substantial deference to his analysis. State Findings ¶ 456.

F.17 According to the State, Dr. Arabasz first looked at the available information. *Id.* ¶ 457. SECY-98-071 (Staff Exh. S) documents the grant of an exemption to the Idaho National Engineering and Environmental Laboratory (INEEL) to store Three Mile Island, Unit 2 (TMI-2) fuel, including the following, at page 2: “Based on 10 C.F.R. 100.23 requirements, as described in Regulatory Guide 1.165, ‘identification and characterization of seismic sources and determination of safe shutdown earthquake ground motion,’ a future nuclear power plant in the western United States can use as a safe shutdown earthquake the 10,000-year return period mean ground motion.” Tr. at 10,093-94 (Arabasz). Thus, according to the State, in the foregoing document, issued in April 1998 — 8 months after August 1997 when DOE published the Yucca Mountain Topical Report YMP/TR-003-NP in which the average MAPE for five NPPs in the WUS was reported (State Exh. 202, Table C-2) — the Staff accepted a 10,000-year MRP as an appropriate SSE reference standard for an NPP at the INEEL ISFSI site. State Findings ¶ 457.

F.18 Next, Dr. Arabasz turned to DOE’s effort to equate a design basis at Yucca Mountain to the SSE reference probability for an NPP. Even though it had calculated an average MAPE of about 2×10^{-4} (5000-year MRP) for five NPPs in the WUS, as reported in its Yucca Mountain Topical Report YMP/TR-003-NP, Table C-2, Dr. Arabasz argues that DOE chose not to use 5000 years but 10,000 years as the MRP for the Yucca Mountain DBE. Tr. at 10,120-21 (Arabasz).

F.19 For more information relevant to an appropriate SSE reference probability eastward of the plate boundary into the Intermountain area, Dr. Arabasz turned to Kennedy and Short’s paper entitled, “Basis for Seismic Provisions of DOE-STD-1020” (Apr. 1994) in which they give an overview of the slopes of the seismic hazard curves and show how they vary across the country. Tr. at 10,099 (Arabasz). State Exh. 203 used a value, A_R , to describe “the ratio of ground motions corresponding to a tenfold reduction in exceedance probability.”

Tr. at 10,099 (Arabasz). In effect, the ratio is a measure of the increase in ground motion as the annual probability decreases. From seismic hazard curves at several nuclear sites, Kennedy and Short provide ratios for the probability intervals 1×10^{-5} to 1×10^{-4} , designated as A5/A4, and 1×10^{-4} to 1×10^{-3} (A4/A3). Tr. at 10,099-100 (Arabasz). As can be seen from State Exh. 203, eastern sites tend to have the relatively highest ratios, high seismic sites near tectonic plate boundaries tend to have the relatively lowest values, and western sites not near tectonic plate boundaries tend to have intermediate ratios. Armed with this information, Dr. Arabasz added to the Kennedy and Short Table A-2 after determining the value of A5/A4 and A4/A3 for four of the five western sites of DOE Table C-2, State Exh. 202 (Diablo Canyon values were already determined by Kennedy and Short), and for the Yucca Mountain site. Dr. Arabasz concluded that three of the five NPP sites on DOE Table C-2 (Diablo Canyon, San Onofre, and Washington Nuclear Plant 3 near Satsop) are near tectonic plate boundaries and have low ratios of A5/A4 (steep hazard curves) of about 1.5 or less; Palo Verde and Yucca Mountain have A_r ratios more like eastern sites. Tr. at 10,105-07 (Arabasz). From comparing Kennedy and Short's Table A-2, State Exh. 203, with Table C-3 of DOE STD-1020-2002 (State Exh. 207), Dr. Arabasz concluded the following for A5/A4 ratios in the neighborhood of 1.5:

Under the DOE framework using Table C-3, one would achieve large risk reduction ratios that would justify the use of the 5000-year P sub H value [probability of exceeding the seismic hazard]. When we have slopes of the order of 2 in A5/A4 space, for example, under western DOE sites not near tectonic plate boundaries, INEEL, Los Alamos, Hanford, the assumption is that the engineering judgment was made as part of the DOE design approach that these A5/A4 slopes did not justify the 5000-year return period motion.

Tr. at 10,108 (Arabasz).

F.20 (Utah 460) Dr. Arabasz continued his qualitative analysis of non-coastal western sites by using as a proxy for NPP information a review of the 84th percentile deterministic motions for the INEEL, PFS, Yucca Mountain, and Los Alamos sites. He observed, qualitatively, that without exception the ground motion values approach or exceed 10,000 years. Tr. at 10,109-14, 10,120-24 (Arabasz). The State argues that Dr. Arabasz's presentation credibly shows that as you move eastward from the plate boundary to Hanford, Palo Verde, Yucca Mountain, INEEL, Los Alamos, and the PFS site, the appropriate SSE reference probability for an NPP would not appropriately be pegged at 2×10^{-4} (5000-year MRP) but rather at approximately 1×10^{-4} (10,000-year MRP). State Findings ¶ 460.

F.21 The State contends that the weight of the evidence presented in the hearing is that a technically defensible SSE for an NPP sited in the Intermountain

area would have a return period of approximately 10,000 years and, therefore, the upper-end DBE benchmark for the PFS site should be a MAPE of 1×10^{-4} . State Findings ¶ 463. According to the State, a number of regulatory codes are now using a 2500-year return period as the basis for seismic design. For example, DOE-STD-1020-2002 uses a 2500-year ground motion for the design of PC-3 facilities — those facilities similar to ISFSIs — not near tectonic plate boundaries. Also, the International Building Code 2000 (IBC 2000) is based on seismic hazard defined in terms of Maximum Considered Earthquake ground motions associated with a 2500-year return period earthquake. State Findings ¶ 464.

F.22 Under the IBC 2000 (the building code currently in force in Utah), the design basis for certain buildings is a 2500-year return period earthquake. According to the Code, one first enters the hazard curve at 2500 years and obtains the ground motions; then one multiplies those ground motions by two thirds. An Importance Factor is used for certain structures, such as those that contain hazardous materials; in such cases, ground motions obtained after the two-thirds reduction are multiplied by 1.5, resulting in a return to the 2500-year ground motions. Tr. at 7902-05 (Cornell).

F.23 Dr. Bartlett testified that interstate highway bridges in Utah are constructed using a 2500-year DBE. Tr. at 12,807, 12,977 (Bartlett). Such structures must survive a 2500-year event with essentially no structural damage. *Id.* at 12,977.

F.24 The State believes that at the low end, the DBE benchmark for the PFS site sensibly must be at least 2500 years. Currently, interstate highway bridges in Utah, certain buildings under the IBC 2000 building code, and PC-3 facilities under DOE-STD-1020-2002 all use a 2500-year DBE. The State believes that this raises a public policy concern because by allowing a 2000-year DBE for the PFS facility, it will have a lower DBE than that now required by other standards. State Findings ¶ 467. At a minimum, the State argues that setting the DBE for a nuclear facility lower than that for other nonnuclear structures or DOE PC-3 facilities poses a real public perception problem, as Dr. Arabasz explained, “[a]bsent the coterie of the cognoscenti, who can explain it.” Tr. at 9208 (Arabas). Thus, the State concludes that the evidence presented in this proceeding does not justify a 5×10^{-4} MAPE that PFS has requested and the Staff has accepted. State Findings ¶ 467.

F.25 As previously demonstrated, the State has taken issue with Staff testimony that an appropriate benchmark for an NPP SSE at the PFS site would be a 5000-year return period earthquake, as opposed to a 10,000-year return period earthquake. The State and the Staff agree that whether a 5000- or 10,000-year earthquake for an NPP at the PFS site is the appropriate benchmark turns on whether the PFS facility is a high-seismicity site.

F.26 In this respect, as testified to by Dr. Stamatakos, the hazard curve produced by Geomatrix for the PFS site is similar to the hazard curves for many

high-seismicity sites along the San Andreas Fault. Tr. at 12,753-54 (Stamatakos). From this similarity, Dr. Stamatakos concluded that if the PFS facility is not a high-seismicity site, the real hazard curves should not be as high as those produced by Geomatrix, from which it would follow that the PFS facility has been designed to a significantly higher return period than the 2000-year return period ground motions obtained from the Geomatrix PSHA hazard curves. Tr. at 12,754 (Stamatakos). If that were the case, the design basis ground motions obtained from the Geomatrix PSHA would be overly conservative.

F.27 On the other hand, Dr. Stamatakos testified that if the hazard curve produced by Geomatrix accurately reflects the conditions at the PFS facility, and the 2000-year return period earthquake has a horizontal acceleration in excess of $0.7g$, then such a high ground acceleration for a 2000-year return period earthquake would, by definition, classify the PFS facility as a high-seismicity site, and it would be appropriate to use a 5000-year mean return period earthquake as the NPP SSE benchmark. Tr. at 12,754 (Stamatakos).

F.28 The State acknowledges that the Geomatrix investigators who conducted a PSHA for the PFS site, as contractors for the Applicant, are highly competent. Tr. at 9322-23 (Arabasz). Also, there is general agreement among the parties that Geomatrix conducted an adequate PSHA to depict the potential hazard at the PFS site. *See, e.g.*, Tr. at 9119-20 (Arabasz).

F.29 A PSHA typically is an enormous undertaking involving seismic source characterization, ground motion modeling, and hazard calculations. Tr. at 9115-18, 9330 (Arabasz). As such there is a large spectrum of parameters and values to be aggregated into the process of calculating the hazard. Tr. at 9878 (Arabasz).

F.30 We do not need to resolve the dispute over whether the PFS facility is a high seismicity site such that the appropriate benchmark NNP SSE would be 5000 years. We note that, although the Staff testified to a 5000-year NPP benchmark at the hearing, the SER only concludes that, because the PFS facility's risk is lower than that of an NPP, the PFS facility may have a DBE that has a MAPE greater than 1×10^{-4} . The 2000-year DBE selected for the PFS facility design is consistent with the Staff's determination. *See* SER.

F.31 Further, we note that the Staff has identified what it considers to be many conservatisms in the Geomatrix PSHA. Therefore, the 2000-year DBE constitutes a conservative prediction of the seismic hazard at the PFS facility. This conservatism is above and beyond the inherent conservatisms embodied in the PFS facility design, and provides additional confidence that the 2000-year DBE for the PFS facility provides sufficient protection of public health and safety.

4. Basis for Applicant's Exemption Request

a. Use of a Risk-Informed Seismic Design

F.32 The Applicant's witness, Dr. Cornell, articulated the PFS position on the appropriateness of using a 2000-year return period earthquake for the seismic design of the PFS facility based on accepted principles of risk-informed seismic design. Dr. Cornell has extensive experience in seismic risk analysis and the development of appropriate seismic codes and standards. He has been involved in seismic PRAs and seismic margin studies for dozens of nuclear projects and is among the foremost experts in seismic risk assessment for nuclear facilities. Cornell Post Tr. 7856, at 1-6. Given Dr. Cornell's recognized expertise and the other parties' general agreement with the risk principles enunciated by Dr. Cornell in his testimony, we will first set forth those general risk-based principles, which we adopt.

F.33 The first general principle of risk-informed seismic design is that there should be a risk-graded approach to seismic safety that allows facilities and structures with lesser consequences of failure to have larger mean annual probabilities of failure than those allowed for facilities for which the consequences of failure would be more severe. In other words, under a risk-graded approach to seismic safety, the less severe the anticipated consequences of failure, the larger the probability of failure that can be tolerated. Examples of seismic standards that explicitly incorporate a risk-graded approach are the draft International Standards Organization guidelines for offshore structures, Federal Emergency Management Agency guidelines for building assessment, and DOE Standard 1020. Cornell Post Tr. 7856, at 11-12.

F.34 Such a risk-graded approach was implemented in the Staff's approval of the PFS exemption request. The Staff concluded that, because an ISFSI like the PFS facility poses less radiological risk than an NPP, an ISFSI can be subjected to less stringent licensing requirements for seismic safety than those for an operating NPP. SER at 2-50 to 2-51. This conclusion is in accordance with the Commission's acknowledgment that the potential consequences of failure of ISFSIs are much less severe than those for NPPs, and therefore, the licensing standards for ISFSIs need not be as strict as those for operating NPPs. *See* Cornell Post Tr. 7856, at 12-13.

F.35 The State's expert witness, Dr. Arabasz, agreed that it is appropriate to use a risk-graded approach for the seismic analysis and design of facilities and structures. Tr. at 9122 (Arabasz). Likewise, he agreed with Dr. Cornell and the Staff that it is appropriate to allow a higher probability of seismic failure for ISFSIs, such as the PFS facility, than for NPPs since ISFSIs inherently pose less risk than an operating NPP. Tr. at 9122-24 (Arabasz). Thus, the parties are in full agreement that it is appropriate to use a risk-graded approach to seismic safety for licensing the PFS facility and that under such a risk-graded approach the PFS

facility can be subject to less strict seismic safety requirements than those for an operating NPP.

b. Use of Risk Reduction Factors

F.36 The second general principle of risk-informed seismic design articulated by Dr. Cornell is that the adequacy of a DBE to provide the desired level of seismic safety is judged based on two considerations or factors, often referred to as the “two-handed approach.” The first factor is the MAPE of the DBE. The second factor is the level of conservatism incorporated into the criteria and procedures for the design of the facility. Cornell Post Tr. 7856, at 11. Following DOE 1020 parlance, this second factor was referred to by PFS and the State as the risk reduction (RR) factor. *See, e.g., id.* at 16; Tr. at 9131-36 (Arabasz); Tr. at 12,804-05 (Bartlett).

F.37 Underlying this second general principle is the fact that the design procedures and the acceptance criteria (e.g., applicable codes and standards) for seismic design usually include conservatisms that reduce the risk of failure. These conservatisms are not explicitly identified, but are embedded in the design procedures and in the provisions of the various codes and standards pursuant to which seismic design is accomplished. Because of the conservatisms incorporated in seismic design procedures and acceptance criteria, the probability of failure of a seismically designed facility is virtually always less than the MAPE of the governing DBE. In other words, virtually all facilities designed against a given DBE have a mean return period to failure that is longer than the mean return period of the earthquake for which they are designed. In practical terms, this means that seismically designed SSCs are able to withstand a more severe, i.e., more infrequent, earthquake than that used as the DBE. Cornell Post Tr. 7856, at 13-15.

F.38 This second principle is of great import here, for it means that the actual probability of failure of a seismically designed facility, such as the PFS facility, is a function of both the MAPE of the DBE and the level of conservatism incorporated in the design procedures and the acceptance criteria for seismic design of the facility. This function can be expressed by the simple algorithm MAPE/RR. *See* Cornell Post Tr. 7856, at 11, 13-15.

F.39 The MAPE is the inverse of the DBE. Tr. at 9145-46 (Arabasz). For example, the MAPE of the PFS facility 2000-year DBE is 5×10^{-4} . Cornell Post Tr. 7856, at 11. Therefore, assuming that the seismic design procedures and acceptance criteria for the PFS facility achieved an RR on the order of 5, the annual probability of seismic failure for the PFS facility would be 1×10^{-4} , or 1 in 10,000. *See* Tr. at 9134, 9180-81 (Arabasz).

F.40 Therefore, the actual level of seismic safety achieved by the seismic design of a facility, such as the PFS facility, cannot be determined by simply

looking at its DBE. Equally important, the comparative level of seismic safety of two facilities cannot be evaluated solely on the basis of their relative DBEs, unless they are also designed to the same procedures and criteria. Rather, both factors — the MAPE of the DBE as well as the level of conservatism in the design procedures and acceptance criteria — must be considered when comparing the seismic safety of two facilities or structures. *See* Cornell Post Tr. 7856, at 13-15.

F.41 For example, the annual probability of seismic failure for a facility or structure with a 2500-year return period earthquake as its DBE (with a corresponding MAPE of 4×10^{-4}) but designed to seismic codes and standards providing an RR of only 2, would be 2×10^{-4} , or 1 in 5000. Therefore, even though the DBE of such a facility would be an earthquake of higher intensity than that for the PFS facility, its annual probability of failure would be twice that for the PFS facility (assuming an RR of 5 for the PFS facility seismic design), because the underlying seismic codes and standards for such a facility would embody significantly less conservatisms than those for the PFS facility. *See* Cornell Post Tr. 7856, at 51-53; Tr. at 12,961-63 (Cornell).

F.42 DOE-STD-1020-94, “Natural Phenomena Hazards Design and Evaluation Criteria for Dept. of Energy Facilities,” Apr. 1994 (PFS Exh. DDD) [hereinafter DOE-STD-1020-94], is a good example of the application of a risk-graded approach toward seismic design. This standard establishes a set of “performance categories” for seismically designed SSCs with increasing consequences of failure, and thus decreasing probabilities of failure, as their performance goals. DOE-1020-94 established performance goals (reflecting increasingly severe consequences of failure) of 1×10^{-3} for PC-1 structures (designed to protect occupant safety) 5×10^{-4} for PC-2 category structures (essential facilities and buildings, such as hospitals, that should continue functioning after an earthquake with minimal interruption), and 1×10^{-4} and 1×10^{-5} for PC-3 and PC-4 category structures (which correspond to ISFSIs and NPPs, respectively). The MAPE for the design basis ground motions under DOE-1020-94 were set as 2×10^{-3} , 1×10^{-3} , 5×10^{-4} , and 1×10^{-4} for PC-1, PC-2, PC-3, and PC-4 structures, respectively. *See* DOE-STD-1020-94.

F.43 To bridge the gap between the performance goals and the DBE MAPEs, DOE 1020 standards call for design procedures and acceptance criteria that vary among the categories, ranging from those “similar to . . . model building codes” for PC-1 and PC-2, to those for PC-4 which “approach the provisions for commercial nuclear power plants.” The quantitative effect of applying the conservatisms built into these various design procedures and acceptance criteria is to reduce the risk reflected in the MAPE of the design basis ground motions so that it meets the corresponding performance goals. DOE-STD-1020-94 at 2-2, C-4 to C-5.

F.44 The experts for both the Applicant (Dr. Cornell) and the State (Drs. Arabasz and Bartlett) “emphatically” agreed on the appropriateness of applying

this two-factor, or two-handed, approach to evaluating the seismic safety of the PFS facility. Tr. at 9120-21, 9187-89 (Arabasz); Tr. at 12,804-05, 12,859-60, 12,878 (Bartlett); Tr. at 8012-13 (Cornell). The NRC Staff also agreed in principle with the fact that conservatism in the PFS facility seismic design would reduce the probability of seismic failure of the PFS facility to be less than the MAPE for the 2000-year DBE, but the Staff's approach in evaluating those conservatisms, which is challenged by the State, differed from that of PFS and the State. The disagreement between the parties centers on the application of these principles.

(i) RISK REDUCTION FACTORS AT THE ISFSI VERSUS AT A NUCLEAR POWER PLANT

F.45 The State argues that NPP NRC Standard Review Plans (SRPs), cited by the Applicant, do not address the seismic performance requirements of unanchored casks supported by shallowly embedded pad foundations buttressed by cement-treated soil and subject to high levels of strong ground motion. State of Utah Testimony of Dr. Steven Bartlett on Unified Contention Utah L/QQ, Part E (Lack of Design Conservatism) [hereinafter Bartlett Part E] Post Tr. 12,776, at 13. Specifically, the State contends that freestanding storage casks are not typical of SSCs found at commercial NPPs. State Findings ¶532. According to the State, reactor pressure vessel and primary coolant systems at NPPs are anchored and not allowed to freely slide, rotate, or uplift under seismic forces. Furthermore, the State asserts that the methods used to analyze the sliding and tipping stability of freestanding casks are not normally encountered in NPP SSC analyses. Thus, the State contends the RR ratios encompassed in SRPs for reactor pressure vessel and primary coolant systems at nuclear power plants cannot be inferred under the PFS "similarity argument" to freestanding dry storage casks. *Id.* ¶532.

F.46 The State also believes that although not aware of the "details," Dr. Cornell testified that the NPP PRAs discussed in NUREG/CR-6728 accounted for the sliding, overturning, and bearing failures. Thus "infers" Dr. Cornell, NPP foundations have RR ratios at least in the range of 5 to 20. Assuming *arguendo* that the NPP PRAs did demonstrate RR ratios of between 5 and 20 for foundations, the State argues that Dr. Cornell has failed to demonstrate that the NPP RR ratios for foundations are applicable in this case. State Findings ¶532 (*citing* Tr. at 12,952-53 (Cornell)). According to the State, Dr. Cornell admitted that none of the NPPs evaluated were supported by cement-treated soil or soil-cement. Moreover, the State claims that when questioned, Dr. Cornell could not identify an NPP site where foundations are supported by soil-cement and relatively soft soils. *Id.* (*citing* Tr. at 7945-47, 12,968 (Cornell)).

F.47 Compared to the original deterministic standard, the 2000-year DBE results in a substantial reduction in the seismic demand against which PFS has designed its facility. Bartlett Post Tr. 12,776, at 6. Additionally, the State

claims that a 2000-year DBE reduces the safety level achieved (or increases the probability of failure) when compared to a deterministic DBE. State Findings ¶535.

F.48 The State contends that although a factor of safety may be the same for different DBEs, the amount of actual design margin is different. According to the State's experts, a factor of safety is a function of the capacity divided by the demand. Thus, if the factor of safety is kept constant and the demand is reduced from a 10,000-year DBE to a 2000-year DBE, then the capacity is also reduced. Although the factor of safety is the same for both earthquakes, the actual capacity — the design margin — is larger for the 10,000-year earthquake compared to the 2000-year earthquake. Tr. at 12,837-38 (Bartlett).

F.49 The State insists Dr. Cornell's opinion that SSCs at the PFS facility have RR ratios of "5 to 20 or greater" is inconsistent with his other testimony that the margins are 2 to 3 times the design basis capacity. State Findings ¶537. Thus, the State argues that the Applicant has not met its burden of demonstrating that its SSCs meet a supportable performance goal and RR factors for a 2000-year DBE. State Findings ¶538.

F.50 As stated, Dr. Cornell's conclusion that the RRs applicable to the SSCs important to radioactive material containment for the PFS facility are 5 to 20 or greater is based on his familiarity with the conservatisms embodied in nuclear codes and standards and evidence of actual conservatisms in the PFS facility seismic design. As we previously noted, Dr. Cornell is a recognized expert in the area of evaluating conservatisms that exist in codes and standards.

F.51 It is well established that the NRC guidelines on design acceptance criteria and procedures for NPPs set forth in the Standard Review Plan (NUREG-0800) contain many conservatisms that result in significant RR for typical NPP components. *See* Staff Exhs. CC to EE and 64. These conservatisms are introduced through prescribed analysis methods, specification of material strengths, and limits on inelastic behavior. However, unlike DOE-1020, the conservatism levels in the NRC acceptance criteria guidelines are not keyed to specific RRs. Nonetheless, the RRs achieved through the use of NRC guidelines for typical NPP SSCs have been found to be equal to, or higher than, the RR of 10 for PC-4 category facilities designed to DOE-STD-1020-94. Cornell Post Tr. 7856, at 19; DOE-STD-1020-94 at 2-2, C-4 to C-5.

F.52 The significant RR (of 5 to 20, or more) for typical NPP SSCs was established by seismic risk analyses performed at many NPPs. Virtually all the current NPPs in the United States were designed based on the Appendix A "deterministic" design basis ground motion approach, prior to the adoption of PSHA methodologies, and on SRP guidelines that were intentionally more conservative than, for example, corresponding building design standards. Subsequent PSHAs for these NPPs established that the Appendix A design basis ground motions had a mean return period of approximately 10,000 years. Further, numerous

seismic probabilistic risk analyses (PRAs) and seismic margin studies were also subsequently performed for SSCs at existing NPPs which established the beyond-design-basis robustness for SSCs designed to the NPP SRP. The results of these PRAs and margin studies provide the data upon which the general range of RR values of 5 to 20 or more for typical NPP SSCs designed to the NRC's SRPs is based. These conservatisms in the design of NPP SSCs enable NPPs to achieve a performance goal of about 1×10^{-5} . Rebuttal Testimony of C. Allin Cornell to the Testimony of State Witness Dr. Walter Arabasz on Section E of Unified Contention Utah L/QQ, [hereinafter Cornell Reb.] Post Tr. 12,951, at 4.

F.53 The NRC's SRPs for ISFSIs, NUREG-1567, and for dry cask storage systems, NUREG-1536, generally provide for use of the same codes and standards employed for NPPs under NUREG-0800. By virtue of this commonality of design procedures and acceptance criteria, similar levels of conservatisms can be expected for SSCs designed to the SRPs for ISFSIs and dry storage systems as for NPP SSCs designed to NUREG-0800. Cornell Post Tr. 7856, at 20-23. Additionally, those responsible for the PFS facility design testified that in designing the facility they generally used the same design criteria and procedures applicable to NPPs and applied the standards and codes applicable for nuclear components. Singh/Soler Post Tr. 5750, at 8-10; Ebbeson Post Tr. 6357, at 3-4; Trudeau Section D Post Tr. 6135, at 3-4; Young/Tseng Post Tr. 5529, at 11. Because SSCs at the PFS facility are designed following the same codes and standards as those for NPPs, the conclusion that the RR factors for typical SSCs designed to the NPP SRP are in the range of 5 to 20 (or greater) would apply to such SSCs at the PFS facility. Cornell Post Tr. 7856, at 23. For these reasons, we find the State's concerns to be without merit.

(ii) FRAGILITY CURVES FOR THE SSCs

F.54 A fragility curve describes the design margin and the variability of the design margin (*see* Tr. at 8020 (Cornell)) as a function of the amplitude of strong ground motion (Bartlett Part E Post Tr. 12,776, at 11). The fragility curve in combination with the seismic hazard curve provides the probability of failure for the SSC for a range of ground motions. Bartlett Part E Post Tr. 12,776, at 9. Importantly, according to the State, fragility curves would provide this Licensing Board better assurance in setting and evaluating the lower DBE sought by PFS because those curves allow as precise as possible an estimate of the actual seismic design margin and its variability for the range of ground motions. State Findings ¶ 507. PFS did not develop fragility curves for the proposed PFS ISFSI. Tr. at 8003 (Cornell).

F.55 Although proffering differing importance to the development of fragility curves in this case, no party disagreed that, absent brittle behavior in the system, the Applicant could still demonstrate an acceptable probability of failure absent

fragility curves if the SSCs are shown to meet the established performance goal and RR factors at the specified DBE. Thus, notwithstanding the comfort level that fragility curves would give us, we are reluctant to find that a properly justified DBE mandates fragility curves.

(iii) RISK REDUCTION FACTORS OF FREESTANDING CASKS

F.56 The State also claims that the Applicant has not conducted a probabilistic risk assessment to evaluate any design margins or the consequences of casks tipping over. Additionally, the State insists that there are no fragility curves for the HI-STORM 100 casks at the PFS site. State Findings ¶512. According to the State, Dr. Cornell's opinion that the storage cask will achieve a performance goal of 1×10^{-4} is based on the cask vendor's unanalyzed prediction of what will occur from strong ground motions generated by a 10,000-year return period earthquake; the Staff's assessment that "no sliding impact between the casks" will occur under a 10,000-year ground motion; and Holtec's tip-over analysis. State Findings ¶512 (*citing* Cornell Post Tr. 7856, at 39).

F.57 Although Dr. Cornell relies on Holtec's 10,000-year prediction of no cask tip-over, the State claims that he did not "believe" he reviewed Holtec's Beyond Design Basis Scoping Analyses, Rev. 1 (Apr. 19, 2002). Tr. at 7986 (Cornell). Moreover, the State argues that contrary to his opinion that uncertainties must be factored into estimates of safety margins, Dr. Cornell did not quantify the uncertainties in the cask vendor's nonlinear finite-element cask stability analysis. Dr. Cornell claims quantification of uncertainties was not necessary because the major source of uncertainty is nonlinear behavior and Holtec performed a nonlinear analysis. State Findings ¶513 (*citing* Tr. at 7972-73 (Cornell)). The State argues Dr. Cornell's opinion — that quantification of uncertainty in Holtec's nonlinear cask stability analysis is unnecessary because Holtec conducted a nonlinear analysis — is too tenuous a connection to show that PFS has met its burden of showing conservatism in the facility's SSCs. State Findings ¶513.

F.58 With respect to potential effects of cask tip-over or drop, the State notes that oral discussions with the cask vendor were the sole basis to support Dr. Cornell's opinion, because the State contends that he could not recall reviewing Holtec's drop/tip-over analysis entitled, "PFS Site Specific HI-STORM Drop/Tipover Analyses," HI-2012653, Rev. 2 (Oct. 31, 2001). State Findings ¶514 (*citing* Tr. at 7975-76 (Cornell)).

F.59 According to the State, Holtec's conclusions that the canister would not be breached are dependent upon its assumption that the angular velocity of a tipping cask is zero. State Findings ¶515. If the casks in fact tipped over during a seismic event, however, Dr. Cornell opined that "[t]he initial [angular] velocity [of the tipping cask] would probably clearly have to be something greater than zero or it would not be moving in that direction." Tr. at 7978 (Cornell). Thus, the

State argues that Dr. Cornell's testimony is inconsistent with that of the Holtec witnesses. State Findings ¶ 515.

F.60 In Dr. Cornell's opinion, the uncertainties in the SSI analysis for the PFS site would be comparable to uncertainties for an SSI analysis at an NPP. *See* Tr. at 8021 (Cornell). The State contends that somewhat contradictory to the foregoing is Dr. Cornell's admission that he is unaware of any NPP site that is supported by cement-treated soil and a layer of relatively soft soils such as at the PFS site. State Findings ¶ 517.

F.61 The State argues that the slope of the hazard curve for the PFS site may also be impacted by nonlinear soil behavior. According to the State, NUREG/CR-6728 recommends that nonlinear soil effects on the determination of the seismic scale factor be included in the development of the hazard curve slope. The NUREG/CR-6728 concept of accounting for nonlinear behavior is also applicable to any nonlinear behavior, such as a cask sliding on the pad. The State argues that PFS has not considered nonlinear effects, nor has it calculated the seismic scale factor based on considerations of the slope of the hazard curve. Bartlett Part E Post Tr. 12,776, at 12.

F.62 The HI-STORM 100 cask system is designed to the SRP for dry storage systems, NUREG-1536, including SRP-dictated accident conditions, such as hypothetical drop and tip-over events. Singh/Soler Post Tr. 5750, at 29-30. The cask and canister are not, however, "typical" NPP SSCs for which RR factors of 5 to 20 or more have been demonstrated. Therefore, some further analysis is necessary to provide confidence that the desired performance goal for the HI-STORM 100 cask system has been achieved. Both Holtec and Dr. Luk have performed beyond-design-basis analyses of the HI-STORM 100 cask system that demonstrate that the casks will not tip over during a beyond-design-basis 10,000-year return period earthquake and that significant margins still remain against tip-over even at the 10,000-year earthquake event. These analyses demonstrate that the effective RR of the HI-STORM 100 cask system is in excess of 5, because the casks can survive both the 2000-year DBE and the beyond-design-basis 10,000-year earthquake. Accordingly, the design of the HI-STORM 100 provides RR factors comparable to those available for typical NPP SSCs. These demonstrations are in themselves sufficient to provide confidence that a performance goal on the order of 1×10^{-4} has been achieved. Cornell Post Tr. 7856, at 24-25, 28-29; Cornell Reb. Post Tr. 12,951, at 3-4.

F.63 Specifically, the Holtec beyond-design-basis analyses showed maximum cask rotations for the 10,000-year return period earthquake event of approximately 10 to 12 degrees, still providing a factor of safety against tip-over on the order of 2 to 3, as measured against the center-of-gravity over corner location of 29.3 degrees at which the cask would tip over on its own accord. Further, many of the 10,000-year beyond-design-basis evaluations performed by Holtec assumed unrealistic, "worst-case" assumptions regarding soil damping and other factors.

The demonstration under such worst-case assumptions that the casks would not tip over, with significant factors of safety still remaining, provides confidence that the casks would not tip over during even a 10,000-year earthquake event. Singh/Soler Post Tr. 5750, at 95; Cornell Post Tr. 7856, at 28-29; Cornell Reb. at 3-4; Tr. at 6106-08 (Soler).

F.64 This conclusion is supported by Dr. Luk's analyses which used sophisticated modeling techniques. The Luk cask stability analyses showed cask rotations on the order of 1 degree for a 10,000-year return period earthquake event, suggesting even larger margins of safety against tip-over than those demonstrated by Holtec. Luk/Guttman Post Tr. 6760, at 11-12.

F.65 Assuming, however, that the casks were to tip over, it has been demonstrated that no breach of the confinement barrier of the canister containing the SNF would occur. Holtec has performed a hypothetical, nonmechanistic tip-over analysis that demonstrates the decelerations at the top of the canister due to tip-over would remain within the HI-STORM 100's 45g design basis limit. Singh/Soler Post Tr. 5750, at 24. Moreover, as is typical of design basis limits, large conservatisms exist in this analysis. In the first place, the actual "g" limit for the fuel cladding in the fuel assemblies is at least 63g. Additionally, there are large margins in the design of the MPC canister system that would prevent the release of radioactive material under much larger loadings. It has been demonstrated that the canister can withstand a 25-foot straight drop, unprotected by a cask onto a hard concrete surface, maintaining confinement when subject to forces up to 300g and maintaining significant margins against reaching the failure strain limit of the material. Singh/Soler Post Tr. 5750, at 11-12; Tr. at 12,075 (Singh). These large margins against breach of the radioactive confinement barrier provide additional confidence that a performance objective of 1×10^{-4} has been met with respect to the HI-STORM 100, since the cask will maintain containment of the radioactive matter even if it tips over in a beyond-design-basis earthquake. Cornell Post Tr. 7856, at 28-29; Cornell Reb. 12,951, at 3-4.

F.66 To reasonably assure public health and safety, the State believes that the DBE for the PFS facility must be formally linked to a specific performance goal and RR ratio. In this regard, the State claims that the Staff has not done so in that it has not established a performance goal (failure probability) for this facility or any previous ISFSIs. State Findings ¶ 506. The State, however, ignores two critical points. First, regardless of whether the Staff formally linked the 2000-year DBE to a specific performance goal and associated RR factor, the NRC's seismic design criteria and procedures contain numerous inherent conservatisms that give effect to the NRC's defense-in-depth policy. Cornell Post Tr. 7856, Attach. A. Further, the Staff has analytically confirmed by Dr. Luk's analysis (which shows no cask tip-over for the 10,000-year earthquake) that large safety margins exist with respect to the casks. *See* Seismic Analysis Report. Second, the PFS extensive analyses of the conservatisms in the PFS facility design show that the RR factor

for PFS facility SSCs is at least 5 or greater, and on that basis the PFS facility seismic design meets a performance goal of 1×10^{-4} . Cornell Post Tr. 7856, at 29-30. Thus, the fact that the Staff in its analysis did not formally couple a performance goal and RR ratio to the 2000-year DBE for the PFS facility is irrelevant here.

F.67 We do not agree with the State's claim that the Applicant has not met its burden of showing conservatism in SSCs at the proposed facility for the following reasons:

- (1) As noted above, Dr. Cornell's reference to factoring uncertainties into estimates of safety margins was in the context of performing a formal seismic PRA, which is not necessary here.
- (2) The State incorrectly asserts that Dr. Cornell concluded that quantification of uncertainties was not necessary here because the major source of uncertainty is nonlinear behavior and Holtec performed a nonlinear analysis. State Findings ¶ 513. To the contrary, Dr. Cornell testified — apart from any such potential uncertainty — that one could judge that the PFS design was capable of meeting a performance goal of 1×10^{-4} based on the results of Holtec's and Dr. Luk's cask stability evaluations for the 10,000-year earthquake “without going into more refined detail as to exactly how large that margin really is and how much uncertainty there is about it.” Tr. at 8019-20 (Cornell). Thus, it was not the nature of the analyses that made quantification of uncertainties unnecessary, but the large margins against failure predicted by the results of the analyses.
- (3) The Holtec simulations for the 10,000-year earthquake use a range of bounding, worst-case, and conservative assumptions, which give more than adequate account of potential input parameter uncertainties that could affect the results. These include: (1) using upper- and lower-bound coefficients of friction of 0.8 and 0.2 as well as random coefficients of friction; (2) using unrealistic radiation soil damping of 1% and 5%; and (3) choosing the stiffness of the soil springs to provide resonance of the cask-pad system with amplified spectral range of earthquake input spectra. Singh/Soler Post Tr. 5750, at 62-71.
- (4) Sandia's use of an entirely different methodology to model the 10,000-year earthquake, likewise showing no cask tip-over, accounts for any potential uncertainty due to the use of different modeling techniques.
- (5) Even if the casks were to tip over, the record establishes that there would be no release of radioactive material. Therefore, even if alleged uncertainties in Holtec's dynamic cask stability analyses somehow

resulted in cask tip-over, the public health and safety would still be adequately protected.

For these reasons, potential uncertainties in the dynamic cask stability analyses have been adequately considered and accounted for by using a wide range of input parameters and different modeling techniques as well. All these analyses show significant margins against cask tip-over still remaining, even for the 10,000-year earthquake. Further, even if the casks were to tip over, no radioactive release would occur. Accordingly, formal quantification of uncertainty, as stated by Dr. Cornell, is unnecessary and the record clearly establishes that PFS has met its burden of showing sufficient conservatism exist to meet a performance goal of 1×10^{-4} .

(iv) CTB FOUNDATIONS AND STORAGE PADS

F.68 In challenging the Applicant's analysis, Dr. Bartlett made two arguments to support his position that an RR of 5 to 20 or more typical for NPP SSCs is inapplicable to the storage pad and CTB foundations. Tr. at 12,812-17 (Bartlett). The State argues that Dr. Cornell's opinion that the CTB foundation would have an RR ratio of 5 or greater based upon Mr. Trudeau's and Mr. Ebbeson's estimate that the CTB foundation would be able to withstand 10,000-year ground motions is incorrect, because there are no engineering calculations to support the PFS supposition that its facility can withstand a 10,000-year DBE. If such were the case, the State argues, PFS would not need an exemption from the deterministic ground motions requirements. It notes that Geomatrix computed the deterministic ground motions for the PFS site to be approximately 1.15g, and those same ground motions are likely for a 10,000-year DBE. State Findings ¶¶ 525-526 (*citing* SER at 2-34).

F.69 The State contends that although Dr. Cornell's opinion relies, in part, on Paul Trudeau's testimony concerning the foundation stability of the storage pad and CTB for a 2000-year DBE, he did not review Mr. Trudeau's foundation stability design calculations, including his methodology or any of his assumptions. *Id.* ¶ 528 (*citing* Tr. at 7989-91 (Cornell)). Moreover, according to the State, neither Mr. Trudeau nor any other witness has performed any foundation stability calculations for a 10,000-year mean return period earthquake and has not shown that the foundations meet a factor of safety of 1.1 for that case. Tr. at 12,874-75 (Bartlett); Tr. at 6348 (Trudeau). Furthermore, the State notes that in attempting to make a point about no hazardous material release, Dr. Cornell, relying on other PFS witnesses, admitted there would be sliding of the storage pads for a 10,000-year mean return period earthquake. State Findings ¶ 528 (*citing* Cornell Post Tr. 7856, at 28).

F.70 Designing a structure in conformance with the NRC's SRP design acceptance criteria is entirely different than evaluating the margins embedded in

the design acceptance criteria called for by the two-handed approach endorsed by both the State's and the Applicant's experts. In designing for a 10,000-year earthquake, the Applicant would need to establish that its design meets the SRP acceptance criteria for the 10,000-year ground motions. In so doing, the Applicant would be in effect redesigning the facility so that it can withstand much higher earthquake acceleration, i.e., that from an earthquake with a return period much longer than 10,000 years. *See* Tr. at 12,963-66 (Cornell). The State's logic would then require the Applicant to design its facility to this much larger earthquake, creating a proverbial "catch 22" situation.

F.71 Similar to the discussion above, to require the performance of design calculations showing a factor of safety of 1.1 against sliding for the 10,000-year earthquake would be to impose the SRP design acceptance criteria for the 10,000-year earthquake which, as explained above, is contrary to the purpose of evaluating the beyond-design-basis margins to determine under what conditions failure would occur. Tr. at 12,954 (Cornell). One could do a beyond-design-basis calculation for the foundations analogous to the Holtec Beyond Design Basis Report for the casks. However, such is not necessary for the foundations. *Id.* at 12,954-56. PFS has quantified some of the major conservatisms that exist with respect to the storage pad and CTB foundations and has shown by this quantification that there are factors of safety inherent in the design of the foundations that would allow them to withstand loads from the 10,000-year earthquake. *Id.*

F.72 Specifically, for example, the factor of safety that PFS calculated for the storage pads against sliding was obtained by applying the following conservatisms:

- The calculated factor of safety of the pads against sliding of 1.27 in the east-west direction and 1.36 in the north-south direction did not take into account the passive resistance provided by the soil-cement around the pads. Taking credit for this conservatism would increase the factor of safety from 1.27 to 3.3 in the east-west direction and from 1.36 to 2.35 in the north-south direction without taking other conservatisms into account. Trudeau Section D Post Tr. 6135, at 9-10.
- In addition, the calculation for sliding is based upon the static shear strength of the underlying clay silt soils. Trudeau Soils Reb. Post Tr. 11,954, at 2-5. It is undisputed that the underlying clayey silt soils will exhibit greater strength under the dynamic loadings experienced under an earthquake of at least 30% and potentially up to 100%. Tr. at 11,967-68 (Trudeau); Tr. at 12,976-77 (Bartlett); Bartlett Soils Surrebutal Post Tr. 11,982, at 2-3. Assuming a 50% increase in strength would increase the factor of safety for the east-west base case from 1.27 to 1.9, again without

taking other conservatisms into account. Trudeau Soils Reb. Post Tr. 11,954, at 3.

- PFS computed the minimum 1.27 and 1.36 factors of safety using the lower-bound, worst-case static shear strength for the entire pad storage area. Tr. at 11,960-62, 11,966 (Trudeau). Further, this lower-bound strength was obtained from the weakest layer of soil underlying the pads, whereas the pads will be resting in most cases on the soils above this layer which are much stronger than the weakest layer for which the lower-bound shear strength was determined. Trudeau Soils Reb. Post Tr. 11,954, at 3.
- Any measurement of the strength of soils will disturb the soils and result in soil strength values that are less than the actual strength that the soils will exhibit in place. Therefore, when the measured value of strength is used in the factor-of-safety computations, there is a “built-in” conservatism because the actual strength of the soil in place will be higher. *Id.* at 4-5.
- The minimum factor of safety is applicable only when the earthquake reaches its peak magnitude. At all other times, there is considerably more margin available. *Id.* at 2.
- Further, due to the cyclic nature of the seismic loading, each of the peak accelerations that impart dynamic loads from the earthquake exists for only one very brief moment of time — typically less than 0.005 second — and then the seismic loading reverses direction, which minimizes any sliding displacement that would occur. *Id.* at 4.

F.73 There is similarly a large margin against pad failure due to the loss of soil bearing capacity. The minimum factor of safety of 1.17 against bearing capacity failure for the storage pads was computed using the extremely conservative assumption that 100% of the earthquake loads act in both horizontal directions at the same time. *Id.* at 11-12. If the load combinations allowed by ASCE 4-86 were used instead, the factor of safety against loss of bearing capacity would be increased to 2.1.

F.74 Another major conservatism in the computation of the factor of safety against loss of bearing capacity is the use of the lower-bound static shear strength of the weakest layer of soil underlying the pads. Standard practice for computing bearing capacity is to average the contributions of all soil layers over a depth equal to the shortest dimension of the foundation, in this case the 30-foot width of the pads. Approximately $\frac{2}{3}$ of this depth below the pads would have soils or cement-treated soils that would be much stronger than the weakest layer of soil from which the lower-bound static strength was measured. Using the average strength of the cement-treated soil and soil for the 30 feet below the pad and the soil’s dynamic strength rather than its static strength would have significantly

increased the factor of safety against bearing capacity failure. Trudeau Soils Reb. Post Tr. 11,954, at 4. Also, as noted with respect to pad sliding, the laboratory-measured strength of the soils would be less than their in-situ strength and the maximum earthquake magnitude to which the pads would be subject would be cyclic and of very short duration. Trudeau Soils Reb. Post Tr. 11,724, at 2-5; Trudeau Section D Post Tr. 6135, at 4.

F.75 Taking into account just two of the above many conservatisms (use of the load combinations allowed by ASCE 4-86 and the dynamic strength of the clayey soils) would increase the factor of safety for the pads against loss of bearing capacity to 3.63, which would provide a factor of safety of 1.0 against loss of bearing capacity for vertical and horizontal earthquake accelerations of 1.24g and 1.27g, respectively, essentially the same as the 10,000-year earthquake accelerations for the PFS site. Thus, the bearing capacity analysis performed by PFS for the 2000-year return period earthquake is adequately conservative. It provides ample margin to conclude that an RR factor of more than 5 applies with respect to the pads' capability to withstand a loss of bearing capacity. Cornell Post Tr. 7856, at 28.

F.76 The factor of safety against pad overturning is 5.6, without taking into account any conservatism. Trudeau Section D Post Tr. 6135, at 12. Thus, the margins against pad overturning are also sufficient to conclude that an RR factor of more than 5 applies with respect to pad overturning. Cornell Post Tr. 7856, at 28.

F.77 There are also numerous conservatisms included in the CTB foundation design. For example, removing some of the conservatisms in the analysis results in a factor of safety against loss of bearing capacity of the CTB on the order of 10, and the 2000-year return period earthquake accelerations would have to increase by a factor of more than 4 to reduce this factor of safety to 1.0. Trudeau Section D Post Tr. 6135, at 6-8. Similarly, the CTB would not overturn during a 10,000-year earthquake event. Ebbeson Post Tr. 6357, at 8. Therefore, the RR factors applicable to these foundation failure modes would be of 5 or more. Cornell Post Tr. 7856, at 27-28.

F.78 It is not necessary to do a formal 10,000-year return period earthquake evaluation to show a lack of SSC failure in the event of a 10,000-year earthquake. One can determine, as reflected by the discussion above, that sufficient conservatisms exist in the design of the SSCs and their foundations to meet the increase in loadings due to the higher ground accelerations for the 10,000-year event. Indeed, if anything, the demands placed on foundations would be proportionally less for higher earthquake levels due to the higher damping that would be associated with the higher strain levels in the soil for the 10,000-year event so that such an approach would be both appropriate and conservative. Tr. at 12,954-56 (Cornell); Ebbeson Post Tr. 6357, at 9.

F.79 Therefore, RR factors of 5 or more are appropriate for foundation failures associated with overturning, loss of bearing capacity, and sliding of the storage pads. Moreover, foundation failure of the pads would not by itself constitute ultimate failure of the PFS facility resulting in radioactive release, but would be part of a chain of events that one would need to analyze to determine whether the ultimate performance goal had been met. Tr. at 12,802-03 (Bartlett). In this respect, the record shows that the foundation failure mechanism of the pads of most concern to the State — sliding of the storage pads — would in fact reduce the loads transferred to the storage cask on the pad and reduce the likelihood of cask tip-over. Singh/Soler Post Tr. 5750, at 43. Similarly, the RR factors for turnover and loss of bearing capacity of the CTB would be 5 or more, and any potential sliding of the CTB that might occur for a 10,000-year event would result in no adverse health or safety impact.

(v) TIME TRANSFER ESTIMATES

F.80 The State challenges Dr. Cornell's determination of the appropriate RR applicable for the CTB and the seismic struts and cranes inside the CTB, because it disagrees with "the time in which the canister is potentially exposed and SSCs are in use during transfer at the PFS site" and the validity of the specific CTB conservatisms set out in Mr. Ebbeson's testimony relied upon by Dr. Cornell. State Findings ¶¶ 522-524. These challenges, however, ignore the primary rationale for Dr. Cornell's conclusion on the RR applicable to the CTB. Dr. Cornell testified:

The Canister Transfer Building itself and the cranes and seismic struts inside the building are typical of nuclear power plant components for which the RR factor has been shown to be a factor of 5 to 20 or more. That basis alone would be sufficient to conclude that the CTB and the cranes and seismic struts inside the CTB have a RR factor of five or more.

Cornell Post Tr. 7856, at 26. None of the State's experts took issue with the appropriateness of using an RR of 5 to 20 or more for the CTB and the cranes and struts therein. See Tr. at 9132 (Arabasz); Tr. at 12,786, 12,814 (Bartlett).

F.81 The State also challenges the use of an RR of 5 to 20 or more for the CTB and the cranes and struts therein, focusing on the two ancillary supporting reasons for the determination. The State claims there are serious shortcomings in the Applicant's estimation of the time during which the canister is potentially exposed and the SSCs are in use during the transfer operations between the storage and transportation casks. State Findings ¶¶ 522, 524. As discussed above, the time durations estimated by PFS for various aspects of the transfer operation are reasonable. In addition, and most importantly, the reduction in risk obtained by virtue of the intermittent use of the crane and seismic struts is an additional

reduction of the risk above and beyond the RR ratio of 5 to 20 or more that otherwise would apply to these SSCs. Cornell Post Tr. 7856, at 26-27. Therefore, any shortcomings in the PFS estimations of percentage use of SSCs in the CTB would be immaterial. Even if the SSCs were assumed to be constantly in use, their applicable RR ratio would still be 5 to 20 or more.

5. NRC Staff's Justification for Granting Exemption

F.82 To support its evaluation of the PFS exemption request, the Staff requested that the Center for Nuclear Waste and Regulatory Analysis (CNWRA) conduct a technical review of the seismic and faulting hazard investigations at the proposed PFS facility site. The objectives of these seismic and faulting hazard investigations were (1) to conduct an independent review of seismic and faulting hazard studies at Skull Valley and, in particular, to identify seismic and faulting issues important to siting the proposed PFS facility; (2) to evaluate the adequacy and acceptability of the PFS seismic and faulting design approach; and (3) to make recommendations regarding the PFS proposed seismic design approach and design basis ground motions. These objectives were accomplished through a survey of state-of-the-art literature (including documents submitted by PFS), analyses of relevant NRC regulations, and CNWRA independent analyses of geophysical data, sensitivity studies of model alternatives, and consideration of uncertainties. Seismic issues important to siting the proposed PFS facility included: (1) characterization of potential seismic sources, (2) estimation of ground motion attenuation, (3) assessment of probabilistic and deterministic ground motion hazards, (4) assessment of probabilistic surface faulting hazards, and (5) development of design basis ground motions in compliance with applicable regulations and regulatory guidance. Stamatakos/Chen/McCann Post Tr. 8050, at 9-10.

F.83 Based on the review of the PSHA conducted by Geomatrix, the Staff concluded that the PFS seismic and surface faulting hazard results provide an adequate basis for development of the design seismic ground motions for the proposed PFS facility. In fact, the Staff's analyses concluded that the results of the PSHA are conservative, mainly because of conservative assumptions in the seismic source characterization. *Id.* at 10.

F.84 Following issuance of the CNWRA report, the Staff continued to evaluate the exemption request in light of the additional site characterization information that was provided by the Applicant. This new information included the Applicant's updates to the PSHA in 2000 and 2001, some of which led the Applicant to increase its estimated seismic hazard at the site. These revisions included modifications to the site velocity model, the ground motion attenuation relationships adopted from the Yucca Mountain study, and the approach used in the site response analysis. In the aggregate, these revisions resulted in an increase

in the ground motion hazards estimated at the PFS site. For example, based on the new information, the Applicant increased its estimate of the peak horizontal acceleration (5×10^{-4} MAPE) from 0.53g (as reported in 1999) to 0.711g (as reported in 2001). The Applicant's PSHA revisions did not affect the Staff's conclusions regarding the acceptability of the PFS exemption request. Details concerning the Staff's evaluation and conclusions with respect to the adequacy and results of the Applicant's PSHA are documented in the SER (*see* SER §§ 2.1.6.1 and 2.1.6.2) and in the CNWRA report. Stamatakos/Chen/McCann Post Tr. 8050, at 10.

F.85 In determining whether a PSHA may be utilized in lieu of the deterministic approach required in 10 C.F.R. Part 72 for the seismic hazard assessment of an ISFSI site located west of the Rocky Mountain Front, the Staff considered that the Commission (and Staff) have previously taken certain actions that indicate general approval of the use of PSHA methodology. *Id.* at 11.

F.86 First, the Staff observed that the Commission had previously indicated that the uncertainty associated with evaluating seismic design ground motions for NPPs must be addressed. In this regard, the Commission issued regulations and regulatory guidance that approve this approach in determining the SSE for an NPP, as set forth in 10 C.F.R. § 100.23 and Regulatory Guide 1.165. In addition, the Commission initiated a rulemaking effort to amend 10 C.F.R. Part 72, to permit the use of a PSHA to establish the design basis ground motions for SSCs important to safety at an ISFSI. *See* SECY-98-126 (Staff Exh. T), as modified in SECY-01-0178 (Staff Exh. U). Second, as set forth in SECY-98-071, the Staff observed that the Commission had previously reviewed and approved a request for an exemption from the deterministic seismic requirements in 10 C.F.R. § 72.102(f)(1), to allow the use of a PSHA to establish the design ground motions at the TMI-2 spent fuel debris ISFSI, located at the INEEL. Stamatakos/Chen/McCann Post Tr. 8050, at 11.

F.87 The Staff reviewed the Commission's actions in considering an alternative to the deterministic approach specified in 10 C.F.R. Part 100, Appendix A, and observed that those actions appear to reflect the recognition that the PSHA methodology has certain advantages as compared to a DSHA. For example, a DSHA considers only the most significant earthquake sources and events with a fixed site-to-source distance. A PSHA, on the other hand, incorporates the contribution of all potential seismic sources and considers the range of source-to-site distances, earthquake magnitudes, and the randomness of earthquake ground motions. Most importantly, the PSHA methodology evaluates uncertainty in the assessment of seismic hazards. In doing so, it provides a more complete estimate of the earthquake hazards at a proposed site, for use in establishing the design basis ground motions. *Id.* at 11-12.

F.88 As set forth in section 2.1.6.2 of the Staff's SER, the Staff concluded that the use of the PSHA methodology and a MAPE of 5×10^{-4} (2000-year return

period) are acceptable bases to determine the seismic design ground motions of the proposed PFS facility. SER at 2-50 to 2-51. Accordingly, the Staff concluded that the Applicant's exemption request should be granted. The Staff considered a number of technical and regulatory factors in its evaluation of this matter. These included (1) the Applicant's exemption request and the PSHA submitted in support thereof; (2) the Staff's evaluation of the Applicant's PSHA; (3) the Commission's acceptance, in various regulatory documents, of a PSHA approach in determining the seismic design basis for NRC-licensed facilities (as reflected in amendments to 10 C.F.R. Parts 50 and 100, issuance of Regulatory Guide 1.165, and approval of the Rulemaking Plan in SECY-98-126); and (4) the Commission's 1998 approval of the exemption request for the TMI-2 ISFSI at INEEL. Stamatakos/Chen/McCann Post Tr. 8050, at 12-13.

F.89 With respect to the technical analysis supporting the Applicant's seismic exemption request, the Staff found the Applicant's PSHA results to be conservative. As stated in the SER, this determination was based upon a review of the geological and seismotectonic setting, historical seismicity, potential seismic sources and their characteristics, ground motion attenuation modeling, probabilistic and deterministic estimates of ground motion hazards, development of design basis ground motions, and independent Staff analyses. SER at 2-48; Stamatakos/Chen/McCann Post Tr. 8050, at 13.

F.90 One aspect of the Staff's review included the interpretations of fault geometries for the newly discovered East and West faults in Skull Valley, based on reflection seismic data and forward modeling of gravity data by Geomatrix, developed in 1999. Staff review of the Applicant's fault models (models defining the size, location, and activity of seismogenic faults in the region) shows that the assessment by Geomatrix may have led to an overly conservative hazard result (perhaps by as much as 50% or more, based on a comparison to Salt Lake City PSHA results, as discussed below). For example, independent analysis of proprietary industry gravity data (reported in CNWRA report) does not support the interpretation that the West fault (one of the faults very near the site) is an independent seismic source. Rather, the Staff concluded that the West fault is a splay of the larger East fault, incapable of independently generating large-magnitude earthquakes. By contrast, in the Geomatrix fault model, the West fault is considered capable of producing large-magnitude earthquakes. Stamatakos/Chen/McCann Post Tr. 8050, at 13.

F.91 Another aspect of the Applicant's seismic source characterization that appeared to be conservative, is the site-to-source distance models used in the ground motion attenuation relationships and the development of distributions of maximum earthquake magnitude based on the dimensions of fault rupture. This conclusion of additional conservatism is derived from a slip tendency analysis of the Skull Valley fault systems that was performed by the Staff. The Staff's slip tendency analysis, performed by Dr. Stamatakos, shows that segments of the

East fault and the East Cedar Mountain Fault nearest the PFS site have relatively low slip tendency values compared to segments farther north in Skull Valley. As discussed in the SER, these relatively low slip tendency results indicate that the seismic source characterization of the PSHA study conducted by Geomatrix is conservative. SER at 2-38 to 2-40; Stamatakos/Chen/McCann Post Tr. 8050, at 13-14.⁴⁴

F.92 The Staff's slip tendency analysis was completed using an interactive stress analysis program (3DStress™) that assesses potential fault activity relative to crustal stress. For Skull Valley, the stress tensor is defined with a vertical maximum principal stress (σ_1), a horizontal intermediate principal stress (σ_2) with an azimuth of 355 degrees, and a horizontal minimum principal stress (σ_3) with an azimuth of 85 degrees. The stress magnitude ratios are $\sigma_1/\sigma_3 = 3.50$ and $\sigma_1/\sigma_2 = 1.56$. This orientation for the principal stresses was based on recent global positioning satellite information and optimization of slip tendency values for segments of faults such as the Wasatch that are known to produce earthquakes. The Staff's slip tendency analysis assumed a normal-faulting regime, with rock density equal to 2.7g/cc, fault dip equal to 60 degrees, water table at a depth of 40 meters, and a hydrostatic fluid pressure gradient. Stamatakos/Chen/McCann Post Tr. 8050, at 14.

F.93 The results of the Staff's slip tendency analysis indicate that fault segments with approximately north-south strikes (azimuth = 175 degrees) are optimally oriented for future fault slip. Faults with north, northeast-south, and southwest strikes have high slip tendency values. In contrast, fault segments with northwest-southeast strikes, such as the East fault near the proposed PFS facility site and the southern segments of the East Cedar Mountain Fault also near the proposed PFS facility site, have relatively low slip tendency values. Therefore, these fault segments are less likely to slip in the future than fault segments further from the site. In this regard, it should be noted that fault rupture close to the site greatly influences the seismic hazard. The closer the earthquake is to the site, the larger the resulting ground motions will be as compared to an earthquake with an equal magnitude on a fault segment farther away from the site. *Id.* at 15.

F.94 By contrast, in the Applicant's site-to-source distributions used in the ground motion attenuation equations, Geomatrix assumed uniform distributions of earthquake ruptures along active fault segments, without regard to the orientation and slip tendency of the fault segment. Given the slip tendency analysis described above, the Staff found this assumption by Geomatrix to be conservative. Based

⁴⁴ In slip tendency analysis, the underlying assumption is that the regional stress state controls slip tendency and that there are no significant deviations due to local perturbations of the stress conditions. This assumption is supported by a similar slip tendency analysis of the Wasatch Fault, which shows the highest slip tendency values for the segments of the fault considered to be most active. Stamatakos/Chen/McCann Post Tr. 8050, at 14.

on its own slip tendency analysis, the Staff concluded that seismic source models that incorporate slip tendency would result in a lower ground motion hazard than the one developed by the Applicant. *Id.*

F.95 In addition, the slip tendency results in the Staff's analysis suggest that Geomatrix may have overestimated the maximum magnitude of the East and East Cedar Mountain faults near the proposed PFS site. In its SAR, the Applicant first developed conceptual models of the physical dimensions of fault rupture — either rupture area or trace length of surface fault rupture — based on the geologic record as described by Geomatrix. Second, the Applicant developed distributions of maximum magnitudes for each active fault using empirical scaling relationships developed from the magnitudes and associated rupture dimensions of historical earthquakes. In developing the fault segment models, the Applicant conservatively assumed that the entire mapped length of the surface trace length represents active fault segments. Thus, these maximum fault dimensions produced conservative estimates of maximum magnitude. *Id.* at 15-16.

F.96 The Staff's slip tendency analysis indicates that parts of the East and East Cedar Mountain faults near the proposed PFS facility site have relatively low slip tendency values. Thus, these faults may actually be smaller than is represented in the fault models used by the Applicant to estimate maximum magnitude. Fault rupture models developed using slip tendency analysis would lead to fault models with smaller rupture dimensions (length or area) than those used by Geomatrix (1999a). Because the Applicant derived distributions of maximum magnitude for each active fault from empirical scaling relationships of rupture area or rupture length, application of the slip tendency analysis would result in smaller predicted maximum magnitudes than those developed by the Applicant. Smaller maximum magnitudes would reduce the overall ground motion hazard. *Id.* at 16.

F.97 As described by Dr. Stamatakos, the conservative nature of the Applicant's source characterization and the PSHA results presented in the SAR is evident when the results are compared to PSHA results for other sites in Utah, especially those in and around Salt Lake City. Such a comparison shows that the seismic hazard in Skull Valley was calculated by the Applicant to be higher than the seismic hazards for sites at, or near, Salt Lake City — despite the fact that fault sources near Salt Lake City are larger and more seismically active than fault sources near the PFS site. For example, the results of the Applicant's PSHA for Skull Valley developed by Geomatrix suggest that it is 1.5 times more likely that a ground motion of 0.5g horizontal PGA or greater will be exceeded at the PFS site (assuming hard rock site conditions), than at Salt Lake City, based on a seismic hazard curve for Salt Lake City developed with United States Geological Survey (USGS) National Earthquake Hazard Reduction Program (NEHRP) data. This was graphically and clearly shown in Staff Exh. JJ entitled "Comparison of Western U.S. Hazard Curves," prepared by Dr. Stamatakos, in a highly illustra-

tive scientific notebook entry. Stamatakos/Chen/McCann Post Tr. 8050, at 16-17; Staff Exh. JJ, at 5.

F.98 Similarly, the Staff observed that the *2000-year* horizontal PGA for Skull Valley (soil hazard) as estimated by the Applicant, is actually higher than the *2500-year* ground motions for the nine sites along the Wasatch Front that were evaluated as part of the Utah Department of Transportation I-15 Reconstruction Project by Dames & Moore, Inc., in 1996. For example, the horizontal PGA calculated at the nine sites in the I-15 corridor study range between 0.56g and 0.686g, based on a MAPE of 4×10^{-4} (2500-year return period) — as compared to the Applicant’s estimated horizontal PGA of 0.711g, based on a MAPE of 5×10^{-4} (2000-year return period) at the PFS site. Likewise, the Staff observed that the ground motions estimated by Geomatrix in Skull Valley are higher than those estimated for the I-15 corridor, despite the close proximity of Salt Lake City to the Wasatch Fault — which has a slip rate nearly ten times greater than the Stansbury or East faults, and is capable of producing significantly larger magnitude earthquakes than the faults near the proposed PFS facility site in Skull Valley. In sum, the Staff concluded that because the Applicant’s estimate of the seismic hazard is conservative, the proposed ground motions based on the MAPE of 5×10^{-4} (2000-year return period) provides an additional margin of safety in the seismic design. Stamatakos/Chen/McCann Post Tr. 8050, at 17.

F.99 As further stated in the SER, pages 2-48 to 2-49, the Staff found that the Applicant’s exemption request was acceptable in that:

- (1) Seismic events that could potentially affect the site were identified and the potential effects on safety and design were adequately assessed.
- (2) Records of the occurrence and severity of historical and paleoseismic earthquakes were collected for the region and evaluated for reliability, accuracy, and completeness.
- (3) Appropriate methods were adopted for evaluations of the design basis vibratory ground motion from earthquakes based on site characteristics and current state of knowledge.
- (4) Seismicity was evaluated by the techniques of 10 C.F.R. Part 100, Appendix A. The seismic hazard, however, was evaluated using a probabilistic approach as stated in the request for an exemption from the requirements in 10 C.F.R. § 72.102(f)(1).
- (5) The liquefaction potential or other soil instability from vibratory ground motions was appropriately evaluated.
- (6) The design earthquake was found to have a value for the horizontal ground motion greater than 0.10g with the appropriate response spectrum and, thus, a site-specific analysis was appropriate.

- (7) The Applicant's considerations with respect to the approach taken to model the epistemic uncertainty in ground motions and near-source effects were adequate.
- (8) As discussed in Stamatakos, et al. (1999), the Applicant adequately applied adjustment factors for the near-fault effect using the state-of-the-art techniques and applied procedures described in Regulatory Guide 1.165 (1997) for developing the design-basis ground motion. The associated response spectra and design basis motion levels were found to be adequate.

Stamatakos/Chen/McCann Post Tr. 8050, at 17-18.

F.100 For the reasons set forth above, the Staff concluded that the Applicant's exemption request is acceptable, insofar as it is based upon use of the Applicant's PSHA and seismic design ground motions that have a MAPE of 5×10^{-4} (2000-year return period), and that this provides an acceptable basis for the seismic design of the proposed PFS facility. *Id.* at 18.

F.101 In addition to concluding that the PFS exemption request is acceptable based on considerations as to the acceptability of the Applicant's PSHA (discussed above), the Staff based its conclusions upon the following considerations with respect to the appropriate probability of exceedance (return period) to be utilized in establishing the seismic design of the proposed PFS facility, as set forth in the SER on pages 2-49 to 2-51. Stamatakos/Chen/McCann Post Tr. 8050, at 18-19.

F.102 First, as stated in SECY-98-071, the radiological hazard posed by a dry cask storage facility is inherently lower than operating commercial NPP. In this regard, SECY-98-071 stated that "a major seismic event at an ISFSI storing spent fuel in dry casks or canisters would have minor radiological consequences compared with a nuclear power plant, spent fuel pool, or single massive storage structure." SECY-98-071 at 2 (Staff Exh. S). As further stated therein, "the design earthquake for cask and canister technology need not be as high as a nuclear power plant safe shutdown earthquake." *Id.* (citing 45 Fed. Reg. 74,693 (Nov. 12, 1980)).

F.103 Second, as set forth in the SER, the seismic design for commercial NPPs is based on a determination of the SSE ground motion. SER at 2-50. Previously, this ground motion has been estimated using a deterministic approach in the initial licensing of an NPP. In Regulatory Guide 1.165, based on an analysis of the SSEs for existing NPPs, the Staff established the appropriate Reference Probability to determine the SSE at future NPP sites in connection with the use of a PSHA approach under 10 C.F.R. § 100.23; the Reference Probability was determined to be a 1×10^{-5} MAPE (approximately equivalent to a 100,000-year return period). As the Staff explained, this Reference Probability, which is defined in terms of the median probability of exceedance, corresponds to a MAPE of 1×10^{-4} . That is, the same design ground motion that has a median reference

probability of 1×10^{-5} , has a MAPE of 1×10^{-4} . Stamatakos/Chen/McCann Post 8050, at 19.

F.104 Further, analyses of SSEs at NPPs in the WUS (where the proposed PFS facility would be sited), show that the average mean annual probability of exceeding the safe shutdown earthquake is 2.0×10^{-4} — which is equivalent to an SSE with a 5000-year return period. This is demonstrated in a DOE publication entitled, “Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain,” TR-003-NP, Rev. 2 (Aug. 1997). State Exh. 202 at C-18; Stamatakos/Chen/McCann Post Tr. 8051, at 19-20.⁴⁵

F.105 Based on the foregoing considerations, the Staff determined that the MAPE of the seismic design ground motions at the proposed PFS facility may be greater than 1×10^{-4} (i.e., something less than a 10,000-year return period). Specifically, the Staff found that in considering the reduced risk posed by an ISFSI as compared to a nuclear power plant, a MAPE of 5×10^{-4} (2000-year return period) as a basis to determine the seismic design ground motions appropriately may be used for the proposed PFS facility. Stamatakos/Chen/McCann Post Tr. 8051, at 20.

F.106 (Staff 6.80) Finally, in addition to the above considerations, the SER indicates that the Staff favorably considered two other instances in which seismic design ground motions with an annual probability of exceedance of 5×10^{-4} (2000-year return period) were found to be appropriate. These were (a) the Department of Energy’s issuance of DOE-STD-1020-94, and (b) the Commission’s 1998 approval of a 5×10^{-4} MAPE (2000-year return period) for seismic design ground motions at the TMI-2 ISFSI at INEEL, described in SECY-98-071. Stamatakos/Chen/McCann Post Tr. 8051, at 19-20.

F.107 With respect to the first of these two matters, DOE-STD-1020-94 defines four performance categories for SSCs important to safety (in addition to a “PC-0” category that has no associated safety considerations). The Staff considered that DOE-STD-1020-94 provided an appropriate reference for characterizing the grades of radiological hazards at nuclear facilities such as ISFSIs and NPPs. Further, DOE-STD-1020-94 established the mean hazard annual probability of exceedance for seismic design for the range of SSCs at DOE sites, including ordinary structures (such as warehouses and office buildings) to structures presenting various levels of radiological hazards. Within this range of facilities considered by the DOE are nuclear fuel facilities like the proposed PFS ISFSI. In particular, DOE-STD-1020-94 requires PC-3 SSCs (which are analogous to SSCs at a dry

⁴⁵ Specifically, the MAPE for SSEs at the five WUS NPPs listed in the DOE TR-003 report, were reported to be as follows: Diablo Canyon — 1.7×10^{-4} /year (5882-year return period); Palo Verde — 3.8×10^{-5} /year (26,316-year return period); San Onofre — 3.0×10^{-4} /year (3333-year return period); Washington Nuclear Plant No. 2 — 2.8×10^{-4} /year (3571-year return period); Washington Nuclear Plant No. 3 — 2.2×10^{-4} /year (4545-year return period). State Exh. 202; Tr. 8031, 8327-28.

spent fuel storage facility) be designed for ground motions that have a MAPE of 5×10^{-4} (2000-year return period). Stamatakos/Chen/McCann Post Tr. 8050, at 20-21.

F.108 With respect to the second matter identified above (i.e., the TMI-2 ISFSI exemption), the Staff referred to the Commission's acceptance of a MAPE of 5×10^{-4} (2000-year return period) as the basis for establishing the seismic design ground motions for the TMI-2 ISFSI (designed to passively store SNF debris in dry storage casks), which is discussed in SECY-98-071 and CNWRA-98-007 (Chen and Chowdhury, 1998). In this regard, the Staff explained that it found the Commission's approval of the TMI-2 ISFSI seismic design ground motion to constitute an appropriate point of reference, notwithstanding the fact that it did not establish a regulatory criterion having generic applicability. Stamatakos/Chen/McCann Post Tr. 8050, at 21.

F.109 In summary, the Staff considered that the DOE standard and the TMI-2 ISFSI exemption provided relevant technical and regulatory insights for consideration in deciding that a seismic design based on ground motions that have a MAPE of 5×10^{-4} (2000-year return period) is appropriate for the proposed PFS facility. *Id.*

a. DOE Standard

F.110 Contrary to the concerns raised by the State during the hearing, the Staff did not "adopt" DOE STD-1020-94 in approving the 2000-year return period for use in the design of the proposed PFS facility. Rather, the Staff cited the DOE Standard as a reference point, in that it established a mean reference probability (corresponding to a 2000-year return period) as the basis for determining the design ground motions for SSCs at DOE Performance Category-3 facilities, which are generally comparable to NRC-licensed ISFSIs. Further, the Staff did not attempt to impose DOE STD-1020-94 as a regulatory standard on the proposed PFS facility, nor did it find any reason to require an NRC license applicant (here, PFS) to justify its seismic exemption request on the type of analysis that DOE might conduct under the DOE Standard, in order to meet all the specified DOE requirements. *Id.* at 30.

F.111 As the testimony of the Staff's experts explained, the underlying philosophy of DOE-STD-1020-94 is to use a risk-graded approach in establishing the seismic (or other) hazard's MAPE, and in establishing design and evaluation criteria to satisfy performance goals for different categories of critical facilities. Although not expressed in the same terminology, the Staff's evaluation and approval of a seismic design ground motion corresponding to a 2000-year return period for the proposed PFS facility also relies on considerations of risk. Thus, as discussed above, the Staff considered (1) the Commission's risk-related statements in the Statement of Consideration issued upon its adoption of the regulations in

10 C.F.R. Part 72; (2) the Commission's previous approval of the seismic design ground motion with a 2000-year return period for the TMI-2 ISFSI, which included a quantitative risk assessment; and (3) the DOE standard which similarly recognizes that PC-3 facilities present lower radiological risks than NPPs or PC-4 facilities (which present risks similar to an NPP). Stamatakos/Chen/McCann Post Tr. 8051, at 30-31. For example, in SECY-98-071, the Staff stated as follows:

The staff also considered the relative risk posed by the ISFSI. The staff examined relative risk by referring to DOE Standard 1020 This standard takes a graded approach to designing critical facilities, requiring facilities with greater accident consequences to use higher design requirements for phenomena such as earthquakes Dry spent fuel storage facilities such as the TMI-2 ISFSI, are PC 3 and must have a design earthquake equal to the mean ground motion with a 2000-year return period. Considering the minor radiological consequences from a canister failure, and the lack of a credible mechanism to cause a failure, the staff finds that the DOE approach of using the 2000-year return period mean ground motion as the design earthquake for dry storage facilities is adequately conservative.

Stamatakos/Chen/McCann Post Tr. 8051, at 31 (*citing* SECY-98-071). Thus, contrary to the State's argument, considerations of radiological risk did enter into the Staff's determination to approve the use of a seismic design ground motion with a 2000-year return period, as derived from the Applicant's PSHA for the proposed PFS facility. *See id.* at 31.

F.112 The Staff further addressed DOE's revision of DOE-STD-1020-94, in DOE-STD-1020-2002, dated January 2002. In this regard, the Staff observed that, in the 2002 revision of the 1020-94 Standard, DOE revised the hazard annual probability of exceedance for the seismic design ground motion for PC-3 SSCs, from a MAPE of 5×10^{-4} (2000-year return period) to 4×10^{-4} (2500-year return period). Further, the responsible DOE official had informed the Staff that this revision was not based upon technical considerations, but instead was undertaken in order to make the DOE standard consistent with USGS NEHRP maps and thereby result in analytical descriptions of seismic hazards that can be more readily used in conjunction with the USGS NEHRP maps. *Id.* at 31-32.

F.113 Notwithstanding DOE's revision of this Standard, the fact that DOE made this change in the hazard annual probability of exceedance for determining the seismic design ground motion for PC-3 facility SSCs from 5×10^{-4} (2000-year return period) to 4×10^{-4} (2500-year return period), is inconsequential. This revision results in a small change in the MAPE of the seismic design motion, as compared to the uncertainty in the estimate of the probability of exceedance of earthquake ground motions. For these reasons, DOE's revision to DOE-STD-1020-2002 did not affect the Staff's conclusion as to the acceptability of the PFS seismic exemption request, insofar as it is based upon an analogy to DOE's PC-3 hazard annual probability level. *Id.* at 32.

F.114 We share the Staff's view that DOE's revision of the return period for PC-3 facilities is not significant, for the reasons stated. Further, we find that DOE's substitution of a 2500-year return period ground motion in place of the previous 2000-year return period for DOE PC-3 facilities is of no consequence for a wholly different reason: As discussed above, in revising the specified return period, DOE simultaneously revised its seismic scale factor (SF) from 1.0 to 0.9, thus effectively leaving the seismic design standard for PC-3 facilities unchanged. *See* DOE-STD-1020-94 at C-10 to C-11. In light of DOE's revision of the SF factor, we find no basis for the State's criticism of the Staff's citation to DOE STD-1020-94 and the 2000-year return period established therein, inasmuch as the design standard has effectively remained the same in DOE-STD-1020-2002 with its use of a nominal 2500-year return period and a 0.9 SF factor.

b. INEEL Exemption for TMI

F.115 The State argues that the Staff also relies on the grant to DOE-INEEL of an exemption from 10 C.F.R. § 72.104(f) for storage in an ISFSI of rubblized fuel debris from the TMI-2 ISFSI to support its decision to grant the Applicant's exemption request. According to the State, the facts and site conditions at INEEL are different from those at PFS. State Findings ¶476. For example, the State notes that INEEL is located on a federal reservation of vast size — approximately 800-900 square miles — and the nearest resident is approximately 50 miles from the site. *Id.* (citing Tr. at 8185, 8187-88 (Chen)). At INEEL, the TMI-2 ISFSI is located on the Idaho chemical processing plant (IPCC) site. The State also points out that ground motions at the IPCC site are 0.30g for a 2000-year MRP and 0.47g for a 10,000-year MRP. The IPCC — a higher risk facility than the TMI-2 ISFSI — was designed to peak horizontal accelerations of 0.36g. *Id.* ¶476; Seismic Ground Motion at Three Mile Island Unit 2 [ISFSI] site in [INEEL] — Final Report (June 1998) at 4-1 (State Exh. 127). Further, the State contends that the TMI-2 ISFSI was also designed to 0.36g horizontal design value, which means its ground motions fall somewhere between a 3000- to 4000-year MRP. *See* Arabasz Post Tr. 9098, at 12. Fuel at INEEL is stored in thirty horizontal concrete modules that, under earthquake conditions, are not expected to slide. Tr. at 8186-87 (Chen).

F.116 In contrast to the INEEL site, the State contends that the proposed PFS facility is located within 2 miles of the nearest resident, and the land to the north of the site is contiguous with privately owned land. State Findings ¶477. Furthermore, the State argues that the Board cannot rule out that someday the land to the north of the PFS site could be developed for residential uses. PFS intends to store 4000 casks containing spent fuel from commercial NPPs, and the design values at PFS are those for a 2000-year MRP. Further, according to the State, PFS uses an unconventional design in which PFS and the Staff consider sliding of the

casks and the pads under earthquake conditions to be beneficial because sliding dissipates seismic energy that the casks and foundations would otherwise have to resist. *Id.*

F.117 In responding to the State's claims, Dr. Chen — the Staff expert who was involved in the agency's review of the TMI-2 ISFSI exemption request — observed that the Staff's evaluation of the TMI-2 ISFSI exemption request and the reasons for granting that request are clearly described in the TMI-2 ISFSI docket, including SECY-98-071. Referring to SECY-98-071, she explained that (1) "existing INEEL design standards for a higher risk facility at the INEEL host site" did not play any role in the approval of the TMI-2 ISFSI exemption request; and (2) although the TMI-2 ISFSI had been designed to a slightly higher standard than the 2000-year return period (5×10^{-4} MAPE) ground motion, the Commission in fact approved the lower 2000-year ground motion as the acceptable seismic design basis for the facility. Stamatakos/Chen/McCann, Post Tr. 8050, at 32-33 (*citing* SECY-98-071 (Staff Exh. S)).

F.118 In approving a design basis ground motion for the TMI-2 ISFSI, the Staff (and Commission) had approved the use of design ground motions that have a MAPE of 5×10^{-4} (2000-year return period), with an associated peak horizontal acceleration of 0.30g, as an acceptable design basis for the facility. Thus, SECY-98-071 states, "[g]iven the absence of radiological consequences from any credible seismic event, the Staff finds that the DOE Standard 1020 risk-graded approach of using the 2000-year mean return period ground motion as the DE (design earthquake) is adequately conservative." Stamatakos/Chen/McCann, Post Tr. 8050, at 33 (*citing* SECY-98-071).

F.119 The Staff also observed that the TMI-2 ISFSI exemption is also pertinent insofar as the Staff's (and the Commission's) approval of a 2000-year return period design basis ground motion for the TMI-2 ISFSI was based, in part, on an assessment of the radiological risks at that facility. Thus, in SECY-98-071, the Staff noted that it had considered the public health and safety consequences of a major seismic event occurring at the facility. Accident analyses for the design basis ground motion at the TMI-2 ISFSI showed that the consequences were bounded by a canister drop onto the concrete pad — and that the casks and canisters were designed to withstand such events with no release of radioactive materials. Similarly, accident analyses for the proposed PFS facility have concluded that a cask drop event would not result in the release of radioactive materials. Thus, the TMI-2 ISFSI example also provides a useful analogy, with regard to the issue of relative radiological consequences. Stamatakos/Chen/McCann Post Tr. 8050, at 33-34.

F.120 While the INEEL ISFSI was designed to a higher ground motion than that for the 2000-year MRP earthquake, the exemption was approved on the basis of the adequacy of the 2000-year MRP earthquake. The safety evaluation for the exemption expressly states that the "DOE Standard 1020 risk graded approach of

using the 2000-year return period mean ground motion as the DE is adequately conservative,” and concludes that the design earthquake of 0.36g for the INEEL ISFSI is acceptable because it exceeded the 0.30g value for the 2000-year MRP. SECY-98-071 (Staff Exh. S), Attach. Final Evaluation of Exemption Request to 10 C.F.R. 72.102(f)(1) Seismic Design Requirement, at 3 (attached to May 28, 1998 letter from NRC to INEEL). The design of the INEEL ISFSI to a higher level than a 2000-year DBE does not change the DBE standard upheld by the NRC there.

c. Geomatrix Probabilistic Seismic Analysis

F.121 There is general agreement among the parties that Geomatrix conducted an adequate PSHA to depict the potential hazard at the PFS site. The Staff, however, goes on to take the view that Geomatrix produced a “conservative” PSHA. Stamatakos/Chen/McCann Post Tr. 8050, at 13-17; Tr. at 8220-21 (Stamatakos). The State believes that the Staff’s reliance on the conservative nature of Geomatrix’s PSHA to support a grant of a 2000-year MRP to PFS (SER at 2-38 to 2-39) and its assertion that the Applicant’s conservative estimate of hazard provides an additional margin of safety in the seismic design (Stamatakos/Chen/McCann Post Tr. 8050, at 17) are founded on erroneous premises, questionable speculation about what the relative PSHA outcome should have been, and one-party analyses subject to scientific challenge. State Findings ¶ 479.

F.122 In that regard, the State notes that the Staff did not conduct its own PSHA, but instead, it chiefly reviewed the geological and seismological inputs to Geomatrix’s PSHA, evaluated Geomatrix’s probabilistic and deterministic hazard results, and performed some independent analysis, notably slip tendency. *Id.* ¶ 481 (*citing* Tr. at 8090-91 (Stamatakos); Stamatakos/Chen/McCann Post Tr. 8050, at 12-18). According to the State, in order to buttress its claim that the Geomatrix PSHA is conservative, the Staff uses the slip tendency analysis conducted by Dr. Stamatakos and his colleagues at Southwest Research Institute and also makes comparisons to PSHA results for sites in and around Salt Lake City. State Findings ¶ 481. The State argues, however, that scrutiny of the Staff’s analysis and its PSHA comparisons does not substantiate the Staff’s claim that Geomatrix’s PSHA results are conservative. *Id.*

F.123 Slip tendency analysis is a modeling technique designed to assess stress states and potential fault activity. The State insists that as used by the Staff, i.e., for the purpose of assessing potential fault activity, the analysis requires as a starting point a specification of the orientation and relative magnitudes of stresses acting on the local geology of Skull Valley. *Id.* ¶ 482. As the Staff explains in its prefiled testimony:

In slip tendency analysis, the underlying assumption is that the regional stress state controls slip tendency and that there are no significant deviations due to local perturbations of the stress conditions. This assumption is supported by a similar slip tendency analysis of the Wasatch fault, which shows the highest slip tendency values for the segments of the fault considered to be most active (Machette et al., 1991) [The] orientation for the principal stresses was based on recent global positioning satellite information (Martinez et al., 1998a).

Stamatakos/Chen/McCann Post Tr. 8050, at 14. According to the State, because the stress state at Skull Valley is unknown, the Staff had to assume the applicability of regional stress information from elsewhere. State Findings ¶482. The Staff reported that it used a horizontal minimum principal stress with an azimuth of 85 degrees, *citing* Martinez *et al.*, 1998 (State Exh. 184). Stamatakos/Chen/McCann Post Tr. 8050, at 14. The State contends that the cited Martinez paper (State Exh. 184) does not contain this value; rather, the Staff arrived at this value by subjectively “tuning” the regional stress field in the Wasatch Front area to get maximum slip tendency on parts of faults with known paleoseismic (prehistoric) slip like the Wasatch Fault. State Findings ¶482.

F.124 Based on the results of its tuned slip tendency analysis, the Staff argues that the East fault has a relatively low slip tendency value and is therefore less likely to slip than faults or fault segments further from the site. Stamatakos/Chen/McCann Post Tr. 8050, at 15. The State claims that this conclusion ignores the Staff’s acknowledgment of Geomatrix’s finding that, “[i]n all the alternative models and because of the evidence for surface rupture of late Quaternary deposits, the East fault is considered seismogenic and assigned a probability of activity of 1.” State Findings ¶483 (*quoting* NWRA Report at 2-17). Based on offsets of those late Quaternary deposits in the immediate vicinity of the PFS site, Geomatrix assessed for the East fault a most likely slip rate of 0.2 millimeter per year (mm/yr) — the same order of magnitude as the most likely slip rate of 0.4 mm/yr for the Stansbury Fault. *See* State Exh. 185 at Table 6-2. The State argues that the evidence of surface rupture of late Quaternary deposits by the East fault is a far more cogent indicator of the fault’s seismogenic potential and of the local stress conditions near the PFS site in Skull Valley than what the Staff guesses them to be from its hypothetical, subjectively tuned modeling. Thus, the State contends that the Staff’s interpretation of the stress state in Skull Valley would be one competing opinion in a PSHA, subject to challenge by other experts. State Findings ¶483. Further, the State believes that corresponding inferences the Staff makes from the slip tendency analysis about conservatism in Geomatrix’s assessed site-to-source distances and maximum magnitudes (Stamatakos/Chen/McCann Post Tr. 8050, at 15-16) are also arguable and not established conclusions. State Findings ¶483.

F.125 Another major line of reasoning the Staff uses to conclude the Geomatrix PSHA is conservative is a comparison to PSHA results in and around Salt Lake City, which leads the Staff to claim that Geomatrix’s PSHA may have led to an “overly conservative” hazard result by as much as 50% or more. Stamatakos/Chen/McCann Post Tr. 8050, at 13, 16-17. The State contends that an erroneous premise pervading these comparisons by the Staff is that “fault sources near Salt Lake City are larger and more seismically active than fault sources near the PFS site.” State Findings ¶485 (*quoting* Stamatakos/Chen/McCann Post Tr. 8050, at 16).

F.126 In particular, the State attacks the two basic comparisons it claims that the Staff made between Geomatrix’s PSHA results and the counterpart hazard results for sites in or near Salt Lake City. First, the State claims from the comparison that the Staff concludes that

[t]he results of the Applicant’s PSHA for Skull Valley (Geomatrix Consultants, Inc., 2001a) suggest that it is 1.5 times more likely that a ground motion of 0.5g horizontal peak ground acceleration or greater will be exceeded at the PFS site (assuming hard rock site conditions), than at Salt Lake City, based on the USGS National Earthquake Hazard Reduction Program (Frankel et al., 1997).

State Findings ¶487 (*quoting* Stamatakos/Chen/McCann Post Tr. 8050, at 16). State expert, Dr. Arabasz, however, argues in his testimony that there are significant shortcomings in this comparison by the Staff. Tr. at 9864-65 (Arabas). According to the State, the following facts are relevant to the comparison. *See* State Findings ¶487. The exact location of the Salt Lake City PSHA calculation is uncertain. *See* Tr. at 8215-16 (Stamatakos). The hazard calculation for Salt Lake City is based on the USGS NEHRP, whose hazard calculations would not be acceptable for the SAR at the PFS site. *See* Tr. at 8109-11 (Stamatakos). According to the State, the reason for the latter is that the national hazard mapping is done on a regional scale and includes only major active faults. State Findings ¶487. According to the State, Dr. Stamatakos did not know “everything the GS did in [the Salt Lake City] analysis,” but presumed that “the Wasatch fault probably controls a lot of what is in that hazard.” *Id.* (*quoting* Tr. at 8110-11 (Stamatakos)). In the Geomatrix site-specific PSHA for the PFS site, the East fault is only 0.9 kilometer from the CTB, has a mean maximum magnitude of 6.5, and is a major contributor together with the Stansbury and East Cedar Mountain faults to the total mean hazard; all three faults are within 9 kilometers of the PFS site. SER at 2-47. Given the slip rates of 0.4 mm/yr, 0.2 mm/yr, and 0.07 mm/yr for the Stansbury, East, and East Cedar Mountain faults, respectively (State Exh. 185, Table 6-2), the State contends that there is a combined slip rate of 0.67 mm/yr contributing to the annual earthquake activity rate, which is 74% of the Wasatch Fault’s slip rate of 1.1 mm/yr. Slip rates, maximum magnitudes, distances, and

near-source effects are all part of the complex interplay of parameters in the Geomatrix PSHA. The site-specific Geomatrix PSHA hazard results at the PFS site (for rock site conditions) are an integrated outcome of the seismic source characterization, just as the USGS's regional PSHS hazard results are at Salt Lake City (also for rock site conditions). The State argues that the Staff's claimed conservatism cannot be evaluated by comparing the two bottom lines. Thus, the State believes that without independently performing site-specific PSHAs for the two sites, the Staff's inference that the Geomatrix PSHA is conservative by comparison to sites in or near Salt Lake City is only speculation. State Findings ¶487.

F.127 The second comparison made by the Staff that the State attacks relates to hazard calculations at nine sites in the I-15 corridor in the Salt Lake Valley. According to the State, the Staff observes that Geomatrix's 2000-year horizontal PGA (soil hazard) is actually higher than the 2500-year ground motions (also on soil) at the I-15 sites. State Findings ¶488 (*citing* Stamatakos/Chen/McCann Post Tr. 8050, at 17). The State also claims that the Staff explicitly reviewed Geomatrix's revised ground motion modeling in 2001, which involved development of a detailed shear-wave soil profile to calculate site response, and noted: "This change in the shear-wave profile and site response model led to a significant increase in estimated ground motions at the PFS site." State Findings ¶488 (*quoting* SER at 2-41). The State contends that in fact, the 2000-year peak horizontal ground motion increased 35% from 0.528g to 0.711g. *Id.* (*quoting* SER at 2-41).

F.128 The State also argues that Dr. Stamatakos's bottom-line position is that either Geomatrix provided a very conservative seismic hazard curve or, if the hazard results are accurate, the PFS site deserves to be treated as a tectonic plate boundary site, which would justify a higher reference exceedance probability (lower MRP). *Id.* ¶491 (*citing* Tr. at 12,753-54, 12,763 (Stamatakos)). The State believes this to be a false dilemma. *Id.* ¶491.

F.129 The State concludes that the Applicant's PSHA is adequate. The State argues, however, that the Staff has not sufficiently provided evidence to support its claim that the Applicant's PSHA hazard results are conservative or overly conservative. In sum, the State insists that the evidence does not support a finding that the Staff may rely on claimed conservatisms in the Geomatrix PSHA or a 5000-year benchmark probability as rationale for the PFS 2000-year DBE exemption request. *Id.* ¶494.

F.130 We do not agree with the State's claim. Although the State points to evidence of surface rupture of late Quaternary deposits by the East fault, it did not show that the Staff was unaware of such evidence — and, indeed, the State concedes that Dr. Stamatakos explicitly recognized this factor. State Findings ¶483. Based on our review of the evidence, including the Staff's evaluation of the "evidence" referred to in the Geomatrix report, we do not share the State's view

that the Staff's slip tendency analysis should be rejected on the grounds that it is based on guesses or hypothetical modeling. Moreover, even if we were to accept the State's claims, they do not address or affect the Staff's conclusion, based on its 3D Stress slip tendency analysis, that the Geomatrix analysis is conservative insofar as it assumes that portions of the East fault near the site have the same tendency to slip as more distant portions of the East fault (whose orientation is more favorable to slip). *See* SER at 2-38 to 2-39; Stamatakos/Chen/McCann Post Tr. 8050, at 13-16.

F.131 During the hearing, although Dr. Stamatakos recognized that the data in the Geomatrix report reflect a factor of 3 difference in slip rates between the Wasatch and Stansbury faults (1.1 mm vs. 0.4 mm) — he did not retract his stated view that other data (i.e., the Martinez GPS data) show as much as a factor of 10 difference in those slip rates, as stated in the Staff's SER. Tr. at 8235-38 (Stamatakos); Stamatakos/Chen/McCann Post Tr. 8050, at 17. Even if the Wasatch slip rate is only three times greater than the Stansbury Fault's slip rate, that is still a substantial difference — which should result in a relatively greater earthquake hazard at Salt Lake City due to the Wasatch Fault as compared to the hazard at the PFS site due to the Stansbury Fault, but which is not observed in a comparison of the seismic hazard curves for the PFS site and Salt Lake City. *See* Staff Exh. JJ, at 5; Stamatakos/Chen/McCann Post Tr. 8050, at 16-17.

F.132 Further, while the State asserts that the results of two different PSHAs cannot be compared, we find no reason why a valid comparison of the resulting seismic hazard curves cannot be made, at least for purposes of examining, even on a crude basis, whether one of those analyses produced seismic hazard curve results that are palpably greater than expected. Moreover, we note that each of the hazard curves in question (for PFS, Salt Lake City, and the I-15 sites) was prepared by established, professional organizations (Geomatrix, the USGS, and Dames & Moore, respectively), and each of their PSHAs was available for review by the parties. *See* Staff Exh. JJ, at 3-5. Thus, we do not share the State's misgivings about the usefulness of Dr. Stamatakos' comparison of the seismic hazard curves produced by these three PSHA studies.

d. Comparison of the Applicant's Design Proposal with State Standards for Highways and Bridges

F.133 During the hearing, the State insisted that the 2000-year mean return period for the PFS facility does not ensure an adequate level of conservatism because design ground motion levels for certain new Utah building construction and highway bridges are more stringent. The State's conclusion was based on the observation that, for example, the International Building Code 2000 (IBC-2000) will, when in effect, require an MRP of approximately 2500 years for the DBE,

which is greater than the 2000-year MRP DBE proposed for PFS. Cornell Post Tr. 7856, at 50-51.

F.134 As we have previously discussed, all parties are in agreement that in order to determine the level of safety achieved by an applicable design one has to take a two-handed approach, addressing both the mean return period of the DBE and the conservatism embodied in the applicable design procedures and criteria. *See* Cornell Post Tr. 7856, at 53-54; Tr. at 9120-21 (Arabasz); Tr. at 12,804-05 (Bartlett). Therefore, it would be inappropriate to compare solely the 2000 mean return period DBE of the PFS facility with the higher MRP DBE of the IBC-2000 or other codes.

F.135 The design procedures and acceptance criteria of the IBC-2000 are much less conservative than those specified by the NRC SRPs. For example, a first step of the IBC-2000 design procedures and criteria is to multiply the DBE by two thirds, which at the PFS site would reduce the effective IBC-2000 DBE MRP from 2500 years to about 800 years. Cornell Post Tr. 7856, at 51-52; Tr. at 7898-7902 (Cornell). Only in the case of those “essential structures” that merit the IBC-2000 “importance factor” of 1.5 is this two-thirds reduction, in effect, recovered. Cornell Post Tr. 7856, at 51-52.

F.136 Even for those “essential structures” for which this reduction is in effect recovered, the model building codes’ design procedures and acceptance criteria are significantly less conservative than those in the SRP. The IBC-2000 and UBC model building codes permit much more liberal allowances for the benefits of post-elastic behavior than either DOE-STD-1020-94 PC-3 and PC-4 criteria, or the NRC SRPs. Cornell Post Tr. 7856, at 51-52. The net effect of the UBC design and acceptance criteria is an RR of only 2 for essential buildings and structures, which is similar to that achieved by the IBC. *Id.* at 52. By contrast, facilities designed to the NRC SRPs typically have RRs of 5 to 20 or more. These differences represent a factor of 2.5 to 10 or more in increased conservatism (as measured by RR) in the design procedures for nuclear facilities versus those in model building codes, even if the multiplier of two thirds in the IBC-2000 is ignored. *Id.* at 51-52. Thus, the PFS facility structures, even though designed using a lower MRP DBE than the starting point for determining the seismic ground motions under the IBC-2000 or UBC model building codes, would be much stronger and able to withstand greater ground motions than a structure designed to the ostensibly higher MRP DBE specified in IBC-2000.

F.137 Thus, while the MRP DBE under the IBC-2000 is 25% larger than the proposed MRP for the PFS facility, the more conservative design procedures and criteria of the ISFSIs SRP will ensure that the SSCs at the PFS facility have a mean annual probability of failure that is several times (two to eight or more) lower than buildings designed to IBC-2000 standards. Moreover, all PFS facility important-to-safety SSCs have RR factors sufficient to provide a probability of failure of 1×10^{-4} or lower, i.e., at least two times lower than

essential facilities designed to the IBC-2000. Additionally, as discussed earlier, a number of key important-to-safety SSCs in the PFS facility have great robustness and/or fractional operating periods that reduce their probabilities of failure even further. *Id.* at 52. Therefore, structures and components important to public health and safety at the PFS facility would be much less likely to fail in an earthquake than would other facilities essential for public health and safety in the event of an earthquake, such as bridges, hospitals, or fire stations.

G. Compliance with the Radiation Dose Limits

G.1 The State contends that the Board is faced with the question of whether the radiation dose limit applicable to the PFS analysis should be based on 10 C.F.R. § 72.104(a) or 10 C.F.R. § 72.106(b). According to the State, under current regulations, PFS must analyze accident dose limits from a deterministic earthquake (similar to a 10,000-year DBE) under section 72.106(b). If, in fact, the record shows that PFS has provided supportable analysis for a 10,000-year mean return period event, then the State insists that section 72.106(b) is the applicable standard. If, however, PFS is relying on analyzing releases from a 2000-year DBE to satisfy its exemption request, then by allowing PFS to use the section 72.106(b) standard, the State insists the Board would be expanding the effect of the PFS request to be exempted from 10 C.F.R. § 72.102 to a dilution of the standard in 10 C.F.R. § 72.106(b). *See* State Findings ¶ 554.

G.2 A careful review of the Commission's regulations in 10 C.F.R. Part 72, however, demonstrates that there are two sets of requirements pertaining to offsite radiological dose consequences associated with the licensing of an ISFSI. First, the following requirements, established in 10 C.F.R. § 72.104, apply to normal operations and anticipated occurrences:⁴⁶

- (a) During normal operations and anticipated occurrences, the annual dose equivalent to any real individual who is located beyond the controlled area must not exceed 0.25 mSv (25 mrem) to the whole body, 0.75 mSv (75 mrem) to the thyroid and 0.25 mSv (25 mrem) to any other critical organ as a result of exposure to:
 - (1) Planned discharges of radioactive materials, radon and its decay products excepted, to the general environment,
 - (2) Direct radiation from ISFSI or MRS operations, and
 - (3) Any other radiation from uranium fuel cycle operations within the region.

⁴⁶ "Anticipated occurrences" are defined as denoting "minor events such as upsets, leaks, and spills," in contrast to "accidents," which "are considered to have a lower probability of occurrence." *South Carolina Electric and Gas Co.* (Virgil C. Summer Nuclear Station, Unit 1), LBP-79-11, 9 NRC 471, 476 (1979).

10 C.F.R. § 72.104 (a)(1)-(3).

G.3 Second, the Commission has established the following requirements in 10 C.F.R. § 72.106(b), with respect to design basis accidents:

(b) Any individual located on or beyond the nearest boundary of the controlled area may not receive from any design basis accident the more limiting of a total effective dose equivalent of 0.05 Sv (5 rem), or the sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue (other than the lens of the eye) of 0.5 Sv (50 rem). The lens dose equivalent may not exceed 0.15 Sv (15 rem) and the shallow dose equivalent to skin or any extremity may not exceed 0.5 Sv (50 rem).

10 C.F.R. § 72.106(b).

G.4 In sum, for normal operations and anticipated occurrences at an ISFSI, the Commission has established an offsite radiological dose limit of 25 millirems to the whole body, whereas for design basis accidents a limit equal to a total effective dose equivalent of 5 rem has been established.

1. Dose Consequences Analysis Conducted by Applicant

G.5 To examine normal operational doses at the PFS facility, Holtec performed an analysis in which it determined the direct radiation dose rate at the controlled area boundary from neutron and gamma (photon) radiation emanating from the sides and top of the HI-STORM storage casks. The analysis considered the maximum PFS facility capacity of 4000 casks. The calculations were performed with the Monte Carlo radiation transport code MCNP-4A. The results of this calculation show a maximum dose rate of 5.85 mrem/yr for a 2000 h/yr occupancy time at the controlled area boundary, assuming all casks contained fuel with a burnup of 40,000 MWD/MTU and a cooling time of 10 years. These analyses demonstrated that the doses at the boundary are well within the limits deemed acceptable by the NRC in 10 C.F.R. § 72.104(a) and 10 C.F.R. § 72.106(b) for both normal operations and accident conditions. Testimony of Krishna P. Singh, Alan I. Soler, and Everett L. Redmond II on Radiological Dose Consequence Aspects of Basis 2 of Section E of Unified Contention Utah L/QQ [hereinafter Singh/Soler/Redmond] Post Tr. 12,044, at 7-8.

G.6 In addition, although it has been demonstrated that the casks will not tip over, PFS analyzed a nonmechanistic hypothetical tip-over event in accordance with applicable regulatory guidance. Singh/Soler Post Tr. 5750, at 29; NRC Staff Testimony of Michael D. Waters Concerning Radiological Dose Considerations Related to Unified Contention Utah L/QQ, Part E (Seismic Exemption) [hereinafter Waters] Post Tr. 12,215, at 7. The results of this analysis show that all stresses on the storage cask remain within the allowable values

of the HI-STORM 100 CoC, assuring the integrity of the MPC confinement boundary with large margins of safety. Singh/Soler/Redmond Post Tr. 12,044, at 6-7. Therefore, there would be no releases of radioactivity even in the event of a postulated tip-over.

G.7 Holtec qualitatively evaluated the potential radiological consequences of a hypothetical cask tip-over event in its Final SAR (FSAR) for the HI-STORM 100 and determined that the impact of the cask on the pad would only cause localized damage to the concrete and outer shell of the storage cask at the point of impact, reducing somewhat the roundness of the storage cask in the immediate area of impact. Singh/Soler/Redmond Post Tr. 12,044, at 7, 15-16.

G.8 The HI-STORM 100 cask consists of both a radial concrete shield and an outer steel shell. The concrete is fully encased in a steel structure, and four large steel ribs are located between the inner and outer shell. It is physically impossible for the concrete to be lost in the event of impact damage. A local deformation would not significantly affect the shielding performance of the storage cask, since the same mass of steel and concrete would still be present. *Id.* at 15-16. Because radiation shielding is dependent on mass rather than thickness (Tr. at 12,479 (Resnikoff)), rearrangement of the mass present in the shielding will not result in significant changes in radiation dose levels, since loss of mass in one location of the cask will be offset by an increase in mass in another location. Tr. at 12,148-50 (Soler/Redmond); Tr. at 12,244 (Waters). Additionally, the local deformations would occur at the top of the storage cask, whereas the radiation doses are greater at the middle of the cask. Tr. at 12,551-52, 12,567-68 (Soler/Redmond). Therefore, any increase in the radiological dose levels due to localized deformation of the cask would, at most, be minimal. Singh/Soler/Redmond Post Tr. 12,044, at 15-16.

G.9 Holtec also evaluated the radiological dose consequences resulting from the hypothetical tip-over of multiple casks. *Id.* at 7-12. Hypothetical multiple cask tip-overs would likely result in similar localized damage for each of the casks tipped over, with no significant aggregate effect on radiological doses at the owner-controlled area (OCA) boundary. *Id.* at 8-9, 10; Waters Post Tr. 12,215, at 9-11. The greatest potential for increase in radiological doses at the boundary would not be due to damage to the cask or the MPC, but to the possibility that the bottom of the cask, which has less radiation shielding, might face the OCA boundary. Singh/Soler/Redmond Post Tr. 12,044, at 8-9, 10; Waters Post Tr. 12,215, at 14-17; Amended State of Utah Testimony of Dr. Marvin Resnikoff Regarding Unified Contention Utah L/QQ (Seismic Exemption Dose Exposure) [hereinafter Resnikoff] Post Tr. 12,349, at 10.

G.10 Holtec evaluated the effect that 4000 tipped-over casks would have on the radiation dose at the OCA boundary, compared to the doses due to releases from the casks in their normal upright position. In the upright position, the side of the storage cask is in a direct line of sight from all equidistant locations from the cask, the top is not visible from any location, and the bottom is shielded by

the ground. In a tipped-over position, the top or bottom of the cask would be visible from some locations and not from others, while the side of the storage cask cylinder (now horizontal) would also be visible from some locations and not others. Additionally, since the storage cask would be lying on its side, a large portion of the outer radial surface of the cask would be shielded by the ground. From its evaluation of the geometry of the storage cask Holtec concluded that, overall, the decrease in dose rate from the sides of a tipped-over storage cask should more than compensate for the increase in dose rate from the top or bottom of the cask. Further, in the event of multiple casks tipping over, the orientation of the tipped-over casks would be random and the bottoms and tops of many of the casks would be shielded from the OCA boundary by other casks. Singh/Soler/Redmond Post Tr. 12,044, at 8-10.

G.11 Thus, in the event of a beyond-design-basis accident that caused the tip-over of all, or a significant portion, of the 4000 casks at the PFS site, the radiological dose levels at the OCA boundary would not be increased from the 5.85 mrem/yr for normal operations that had previously been calculated. Thus, there are approximately three orders of magnitude of margin between the expected dose rate at the OCA boundary for 4000 casks in a tipped-over condition compared to the 5-rem accident dose limit in 10 C.F.R. § 72.106(b). Singh/Soler/Redmond Post Tr. 12,044, at 10-11.

G.12 In addition, many conservatisms were included in the PFS calculation of the 5.85-mrem/yr dose at the OCA boundary. These included:

- The calculation assumed that all 4000 casks contain fuel with a burnup of 40,000 MWD/MTU and a cooling time of 10 years. This is physically impossible, since the MPCs will be delivered over many years and each additional year of cooling further reduces the radiation source term. A more realistic value of 35,000 MWD/MTU and a cooling time of 20 years has been used in other PFS analyses. These more realistic assumptions result in a greater than 50% reduction in the calculated normal doses at the site boundary, from 5.85 mrem/yr to 2.10 mrem/yr.
- The calculation assumed that the fuel assemblies inside the casks have the highest gamma and neutron radiation source term in all fuel storage locations, maximizing radiological doses.
- The calculation assumed that the fuel has been subject to a single irradiation cycle in calculating the source term. This ignores the down time during reactor operations for scheduled maintenance and refueling, which would reduce the source term by effectively increasing the cooling time.

Using more realistic assumptions would significantly reduce the calculated radiological dose levels, further decreasing the expected radiation dose consequences

of the hypothetical tip-over of all 4000 casks at the PFS facility. Singh/Soler/Redmond Post Tr. 12,044, at 11.

a. Time Spent at Boundary

G.13 The PFS site-specific analysis for radiation dose levels uses a 2000-h/yr occupancy time for calculating normal operating dose levels (conservatively based on an assumed worker at the site boundary 40 h/week for 50 weeks a year), whereas the HI-STORM 100 CoC uses 8760 h/yr to calculate the normal operating dose. *Id.* at 11-12, 13-14. The dose limits established by 10 C.F.R. § 72.104(a) apply to “any real individual who is located beyond the controlled area,” not to a hypothetical person at the OCA boundary. Thus, occupancy time for normal operating conditions is determined using a real-person standard, which takes into account the site-specific circumstances at a facility. This interpretation is endorsed by NRC regulatory guidance. *See id.* at 12. Likewise, for accident conditions, the 5-rem limit would apply to real individuals, and site-specific circumstances would similarly need to be taken into account, including any remedial measures that may be taken during extended accident conditions (e.g., shielding or moving persons away from OCA boundary). *See* Tr. at 12,072 (Redmond); Tr. at 12,266-67 (Waters).

G.14 Contrary to the PFS analysis, Dr. Resnikoff, who testified in support of the State’s claim, assumed that a person was at the fencepost 24 hr/day, which totals 8760 hr/yr. Dr. Resnikoff, notes that this change in the calculation, by itself, would increase the radiation dose at the controlled area more than fourfold. Resnikoff Post Tr. 12,349, at 6.

G.15 The State argues that the PFS assumption that an individual will be at the controlled area boundary for 2000 hours in a year is not consistent with the language in 10 C.F.R. § 72.106. The regulation refers to “[a]ny individual located on or beyond the nearest boundary of the controlled area.” 10 C.F.R. § 72.106. This stands in contrast to section 72.104, which refers to “any real individual.” 10 C.F.R. § 72.104. The State insists that the difference in the language is intentional and must be followed. The State contends that while it may be appropriate to assume, for a “real” individual, that a person does not spend 24 hours a day at the controlled area boundary, that assumption is not appropriate for “any individual.” According to the State, the term “any individual” must be assumed to include individuals who are present at the fencepost all year. State Findings ¶ 559. In fact, in the CoC for the HI-STORM 100, the State argues that the NRC Staff agreed with a comment by Dr. Resnikoff that 8760 hours should be used for estimating the dose at the site boundary. *Id.* (citing 65 Fed. Reg. 25,241, 25,245 (May 1, 2000)). As long as it is possible that some individual will live at the controlled area boundary and spend his or her days there, the State argues that

PFS must base its calculation on radiation exposure of 24 h/day, or 8760 hours. *Id.* ¶ 559.

G.16 The State claims that its position is strengthened by the fact that PFS has no way of excluding anyone from the northern part of the controlled area boundary, because it does not own the property. Moreover, the State notes that it is difficult to predict what conditions will be in 20 years — or 40 years, when PFS expects its license will terminate. *Id.* ¶ 557.

G.17 The Board agrees with the Applicant. Based on the land use surrounding the PFS facility, we find the assumed 2000-h/yr occupancy time to be adequate. Tr. at 12,066-67 (Redmond). The only individuals likely to be present at the OCA boundary would be workers, who are assumed to be present 40 h/week for 50 weeks in a year to produce an upper bound of 2000-h/yr exposure at the site boundary. Singh/Soler/Redmond Post Tr. 12,044, at 12. Furthermore, as previously explained, the criterion in 10 C.F.R. § 72.106(b) applies to accident dose rates, not to the dose rates for everyday operations.

G.18 Thus, using 2000-h/yr occupancy time is appropriate for normal operations, given the site-specific circumstances at the PFS facility. Singh/Soler/Redmond Post Tr. 12,044, at 12; Tr. at 12,066-67 (Redmond). Such an occupancy time would also be adequate for postulated accident conditions. Our findings are further strengthened by the notion that in addition to measures to limit occupancy of areas of potential radioactive contamination, remedial measures, such as the construction of an earthen berm, could easily be undertaken to assure that radiological dose levels at the boundary of the OCA do not exceed regulatory limits following a beyond-design-basis earthquake. *See* Tr. at 12,583-84 (Donnell); Tr. at 12,622-23 (Resnikoff); Tr. at 12,266-67 (Waters).

b. Tip-Over Analysis

(i) DURATION

G.19 The State contends that PFS did not make an estimate of the duration of an accident. State Findings ¶ 560. Further, the State contends that there is no evidence in the record that PFS has any contingency plan for uprighting casks if they tipped over. *Id.* Nevertheless, the State contends that PFS testified that it would be reasonable to assume that an accident lasts for 30 days. According to the State, PFS did not attempt to justify this assumption, but merely relied on a NRC regulatory guidance. *Id.*

G.20 In addition, the State points out that the NRC Staff also assumed that the accident event would last 30 days. *Id.* ¶ 561 (*citing* Tr. at 12,265-66 (Waters)). This assumption was based on NUREG-1567. “Standard Review Plan for Spent Fuel Dry Storage Facilities,” NUREG-1587 (Mar. 2000) (Staff Exh. 53). While Staff witness Waters testified that he believed 30 days was reasonable, the State

argues that there is no evidence that his opinion was based on the existence of any contingency plan or actual knowledge of how long it would take to restore the site to preaccident conditions. State Findings ¶561 (*citing* Tr. at 12,267 (Waters)). Instead, the State contends that Mr. Waters relied on what he called “fundamental principles of radiological protection” — time, distance, and shielding. State Findings (*quoting* Tr. at 12,266 (Waters)). Mr. Waters also expected people near the fencepost to have been moved away within 30 days of an accident. Tr. at 12,267 (Waters).

G.21 Furthermore, the State notes that, while it may be possible to mitigate radiation doses by installing steel plates around the periphery of the site as an interim measure, such measures do not terminate the accident. The State believes the principles expressed by Mr. Waters, of “time, distance, and shielding,” are out of place in this context, and that the Staff’s assumption of a 30-day accident is based on a fundamental misconception and misapplication of 10 C.F.R. § 72.106. State Findings ¶569. The State argues that the Staff essentially adopts the assumption that the “accident,” as the term is used in section 72.106, ends when people are removed from the area or some temporary barriers have been erected. *Id.* ¶569. However, the State believes that the regulation can only be interpreted to mean that the accident has ended when the casks are set upright and restored to their previously designed condition in which the doses they emit are within the limits of 10 C.F.R. § 72.104(a). *Id.* ¶569.

G.22 The State contends that the clear purpose of section 72.106 is to ensure that the design of a proposed ISFSI is adequate to protect against excessive radiation doses in the event of an accident. The elements of the design consist of the casks and pads themselves, and the size and configuration of the controlled area. The State argues that there is no reference in the standard to contingency measures, whether planned or ad hoc, and insists that such measures are not part of the design of the facility. *Id.* ¶570.

G.23 The State argues it would violate the principle of defense-in-depth if contingency measures may be relied on as a substitute for an adequately designed ISFSI and controlled area. The State believes that the physical design of a facility must be evaluated on its own merit against NRC standards for safe facility designs. According to the State, contingency measures constitute additional, independent steps for protecting the public in the event of an accident, not substitutes for an adequate design. Otherwise, the State argues that the design requirements of 10 C.F.R. § 72.106 could be diluted merely by listing post-accident measures that could or would be taken to mitigate doses to the public. *Id.* ¶571.

G.24 We do not agree with the State’s concerns. Even assuming a worst-case cask tip-over and loss-of-all-hydrogen-shielding event as postulated by the State, the 5-rem radiological dose limits set by 10 C.F.R. § 72.106(b) would not be exceeded within at least 36 years of a beyond-design-basis seismically induced

accident. *See* Tr. at 12,618 (Resnikoff). Thus, we find the State's attack upon the Applicant's calculations to be without merit.

(ii) MULTIPLE-CASK TIP-OVER VERSUS SINGLE-CASK TIP-OVER

G.25 According to the State, in estimating radiation doses at the site boundary in a cask tip-over event, it is necessary to make some assumptions about how the casks will fall. The State believes that the orientation of the casks, whether they have fallen onto each other, and whether they are stretched or flattened by the force of falling on each other, will have an effect on the dose that is calculated. State Findings ¶ 575.

G.26 Dr. Resnikoff performed an analysis assuming that the bottoms of a row of casks face the fencepost. He assumed this configuration because, in his opinion, it was conservative. Tr. at 12,428 (Resnikoff).

G.27 The NRC Staff performed calculations, assuming essentially the same configuration as assumed by Dr. Resnikoff. Tr. at 12,243 (Waters). Mr. Waters assumed that 50 casks would be tipped over facing a northern direction. He considered that this would be the bounding case. Tr. at 12,257 (Waters).

G.28 In that regard, the State requests that the Applicant either prepare a defensible model of the configuration of tipped-over casks, or make conservative assumptions about their configuration. Otherwise, the State argues that the Board cannot find the reasonable assurance of safety that the regulations require. State Findings ¶ 579.

G.29 We find both the predicate for the State's claim and its substance to be groundless. During the hearing, all the witnesses agreed that if a beyond-design-basis accident were to cause HI-STORM 100 storage casks at the PFS facility to tip over, the orientation of such casks would be random. Tr. at 12,428 (Resnikoff); Singh/Soler/Redmond Post Tr. 12,044, at 8-10. PFS analyzed a realistic scenario where the casks were presumed to be randomly oriented and determined that there would be no effective change in radiological dose levels from normal operating levels. Singh/Soler/Redmond Post Tr. 12,044, at 7-12.

G.30 However, even if we were to assume all eighty casks in an outside row were to tip with their bottoms perpendicular to the OCA boundary, as Dr. Resnikoff hypothesized during his testimony, the radiological dose limit of 10 C.F.R. § 72.106(b) would never be exceeded during such a tip-over event. Mr. Waters agreed with the conclusions reached by Holtec's analysis of a multiple-cask tip-over, noting that the dose rates from the sides of the casks would be diminished in a tipped-over condition and that overall "one would not expect to *see* a significant increase . . . in off-site dose rates at any point of the OCA boundary." Waters Post Tr. 12,215, at 15. In addressing a worst-case, cask tip-over hypothetical, Mr. Waters concluded that the increased dose rates under that scenario were well below the radiological dose limits of 10 C.F.R. § 72.106(b).

Waters Post Tr. 12,215, at 17. For these reasons, we find the State's concerns to be without merit.

(iii) ANGULAR VELOCITY

G.31 Based on the Altran Report, Dr. Resnikoff postulated that the Holtec analysis of cask tip-over was inadequate because, contrary to the assumptions made by Holtec, the initial angular velocity of a falling cask may be greater than zero. Resnikoff Post Tr. 12,349 at 8. However, Dr. Resnikoff has never calculated an initial angular velocity for any storage cask tip-over. Tr. at 12,403-04 (Resnikoff). Instead, Dr. Resnikoff testified that he asked “[the State’s] other experts what is the angular velocity and is zero correct, and their opinion [was] that the zero initial angular velocity could be greater than zero.” Tr. at 12,403 (Resnikoff).

G.32 There is no testimony by any State witness that supports the conclusion that an initial angular velocity greater than zero would be either realistic or more appropriate for a cask tip-over at the PFS facility. State soils expert Dr. Bartlett summarily asserted, in reference to the Holtec nonmechanistic cask tip-over analysis, that “the tipover event postulated that . . . the cask would be perched on its edge with zero angular velocity. During an earthquake, that’s not true. If we go to tip-over, we have some angular velocity.” Tr. at 12,870-71 (Bartlett). However, Dr. Bartlett admitted that he had not been involved in any calculations of cask stability or the results of a tip-over event. Tr. at 12,870 (Bartlett).

G.33 The Holtec analyses of dynamic cask behavior have shown that the behavior of the cask is characterized by tilting from the vertical, resulting in a plane of precession for a certain duration in the course of the earthquake event, resulting in an oscillatory rocking motion with limited return to the vertical position until the rocking finally ends when the earthquake subsides. Singh/Soler/Redmond Post Tr. 12,044, at 16. If the earthquake ground motions were assumed to be increased to the point at which a cask would tip over, the initiating angular velocity propelling the cask toward the ground would be quite small. *Id.* at 16-17.

G.34 Furthermore, the precessionary motion of the cask enables it to remain stable after the center of gravity of the cask is well past the “center-of-gravity-over-corner” position. As a result of this precessionary motion, the location of the cask’s center of gravity is likely to be much lower than in the static tip-over scenario (where tip-over begins as soon as the center of gravity crosses the vertical plane containing the axis of overturning rotation). The combination of a shorter distance to fall and a negligible initial angular velocity propelling the tip-over further supports the assumption of an initial angular velocity of zero, because a cask tipping away from precessionary motion is expected to have substantially less kinetic energy of collision than one tipping from a zero velocity with the

center of gravity over corner. *Id.* at 17. Thus, we find the Applicant's assumption of an initial angular velocity of zero is appropriate.

(iv) DECELERATION

G.35 Dr. Resnikoff's prefiled testimony indicated that his concern regarding the possibility of the top of the cask decelerating at a rate in excess of 45g was premised on the initial angular velocity being greater than zero. *See* Resnikoff Post Tr. 12,359, at 8. He changed his testimony at the hearing and acknowledged that damage to the cladding on fuel rods contained in the fuel assemblies within the storage cask would not be an issue unless the assemblies were subjected to an acceleration of at least 63g. Tr. at 12,409-10 (Resnikoff). Dr. Resnikoff did not know how large an initial angular velocity would be required to exceed the 63g limit, but conceded that an initial angular velocity of greater than zero would be required. Tr. at 12,410-12 (Resnikoff).

G.36 The HI-STORM 100 FSAR places a 45g limit on the deceleration for the top of the HI-STORM 100 storage cask in the event of a cask tip-over event. This is a licensing limit that does not represent the actual ability of the storage cask, the MPC, or the fuel assemblies to maintain both containment and radiation shielding. Singh/Soler/Redmond Post Tr. 12,044, at 17-18; Tr. at 12,158 (Singh). The spent fuel assemblies have design margins that allow them to withstand accelerations up to at least 63g. Singh/Soler/Redmond Post Tr. 12,044, at 17-18; Tr. at 12,158 (Singh). There has been no analysis of postulated beyond-design-basis accidents that resulted in decelerations greater than the 45g limit in the HI-STORM 100 FSAR, let alone the 63g design limit. *See* Tr. at 12,411 (Resnikoff).

G.37 The MPC also has substantial design margins beyond the 45g level. A hypothetical 25-foot end drop of a loaded canister on a hard concrete foundation resulted in a computed strain in the confinement boundary of 41% of the failure strain limits for the canister material. Singh/Soler/Redmond Post Tr. 12,044, at 18. The computed strain showed that the MPC could experience a maximum deceleration of approximately 300g without loss of confinement. Tr. at 12,075 (Singh).

G.38 Thus, exceeding the 45g deceleration limit imposed on the top of the canister in the HI-STORM 100 FSAR would not result in increased radiological dose consequences. Decelerations would have to exceed 63g before there was a concern regarding the possible effect of such decelerations on the fuel assemblies contained in the MPC. Tr. at 12,409-11 (Resnikoff). Moreover, due to the large margins of safety built into the design of the MPC, much larger decelerations than 45g would be required before the containment function of the MPC was compromised. Singh/Soler/Redmond Post Tr. 12,044, at 18.

c. *Dose Calculations*

G.39 Dr. Resnikoff's prefiled testimony contained two radiation dose calculations: an estimation of the gamma dose from the bottom of eighty storage casks, with their bottoms facing the OCA boundary (State Exh. 141), and an estimation of the neutron dose from a cask based on the amount of "water evaporated" from the concrete shielding (State Exh. 143). Beginning with amended State Exh. 141A, Dr. Resnikoff combined both scenarios — cask tip-over and loss of hydrogen shielding — to portray a total, worst-case radiological dose at the OCA boundary. The Board, however, does not agree with these calculations.

G.40 The dose exposure that Dr. Resnikoff ultimately calculated at the OCA boundary was less than 150 millirem for the first year, assuming a hypothetical person were at the OCA boundary for the entire year (which, as discussed above, is not realistic). Radioactive decay would reduce this dose exposure in subsequent years. Thus, assuming that the casks remained on the ground indefinitely with no remedial actions being taken, the 5-rem limit would not be exceeded for a person continuously stationed at the OCA boundary. Tr. at 12,619-20 (Resnikoff).

G.41 Dr. Resnikoff's neutron dose calculation, State Exh. 143, is intended to represent the "increased neutron dose due to reduced shielding" in order to estimate "the increase in dose to workers due to neutrons . . . 1 meter from the cask mid-height if all of the water evaporates from a HI-STORM cask." Resnikoff Post Tr. 12,349, at 12. In this calculation, Dr. Resnikoff assumed that there is some unspecified temperature at which no hydrogen is present in the concrete or the aggregate material contained in the concrete. Tr. at 12,420-23 (Resnikoff). Dr. Resnikoff did not try to calculate the actual amount of hydrogen loss that would take place if a HI-STORM 100 cask tipped over, nor did he have any idea how to calculate the thermal degradation of the cask's concrete over time (Dep. of Marvin Resnikoff (Oct. 29, 2001) (PFS Exh. 240) at 90-93; PFS Exh. 240 at 90-93); nor had he ever used computer programs that computed the temperature of concrete over time (*id.*). He also did not know how to estimate the reduction in shielding due to concrete heating up over time (*id.* at 93). Indeed, this was his first attempt to examine thermal degradation in concrete and quantify the loss of radiation shielding that may result. Tr. at 12,418-20 (Resnikoff).

G.42 The premise of Dr. Resnikoff's calculation of the lack of any hydrogen in the concrete due to evaporation of water is unrealistic. It is not easy to evaporate water within concrete because it is in a confined space, and as the water evaporates the air pressure increases. In turn, the increased air pressure will convert the water vapor back to liquid. Likewise, concrete does not lose its moisture content as easily as water might evaporate from a free surface. In order for large, extensive, sustained water evaporation from the concrete to occur, exposure to high temperatures for a period of months will be necessary. Moreover, it is physically impossible for cask heatup to release hydrogen contained in the

aggregate within the concrete. Singh/Soler/Redmond Post Tr. 12,044, at 26. In an actual simulation of the worst-case scenario for heat degradation of the HI-STORM 100 cask, the Staff indicated that neutron dose rates due to thermal degradation would result in a much smaller increase of computed neutron dose rates than those predicted using the unrealistic assumptions in Dr. Resnikoff's analysis. Waters Post Tr. 12,215, at 11-14. In addition to the erroneous assumptions made by Dr. Resnikoff, his neutron dose calculation was also in error because he used the wrong neutron dose from the SAR, which inflated his calculated neutron dose. Tr. at 12,607-08 (Resnikoff).

G.43 Dr. Resnikoff's gamma dose calculation at the OCA boundary was premised on the bottoms of eighty storage casks lined up in a row all facing the OCA boundary. State Exh. 141, at 3-5, 6-8. Such an arrangement is "highly unrealistic." Singh/Soler/Redmond Post Tr. 12,044, at 21.

G.44 Dr. Resnikoff made a total of nine different corrections or changes to his overall dose calculation at four different points in the proceeding. These changes are identified in the testimony of the PFS witness by Dr. Redmond as well as by Dr. Resnikoff in the amendments to his prefiled direct testimony and in oral testimony at the hearing. *See, e.g., id.* at 23; Tr. at 12,374-75, 12,428-30 (Resnikoff); State Exh. 141A).

G.45 We choose not to engage here in a detailed analysis of the impact of the various changes in Dr. Resnikoff's dose rate calculations. It suffices to indicate that the number and nature of those changes undercut confidence in the accuracy of his analyses.

G.46 An important error in Dr. Resnikoff's dose calculations is that he did not consider the effect of radioactive decay. The majority of the gamma radiation from the SNF comes from the radioactive decay of cobalt-60 and cesium-137, with cobalt-60 being the main gamma emitter for radiation emanating off the bottom of the cask, accounting for 90% of the total gamma dose calculated by Dr. Resnikoff. Tr. at 12,619-20, 12,624-25 (Resnikoff). Although the half-life of cobalt-60 is approximately 5 years, Dr. Resnikoff neglected to take radioactive decay into account when arriving at his dose estimates. Tr. at 12,617-20 (Resnikoff).

G.47 Taking into account only the radioactive decay of just the cobalt-60 and ignoring the decay of other radioisotopes will result in a total radiation dose over 50 years of 2582.1 millirem, or 2.58 rem. In fact, as Dr. Resnikoff admitted, taking into account radioactive decay, the 5-rem accident limit specified in 10 C.F.R. § 72.106(b) will not be reached (Tr. at 12,620 (Resnikoff)) no matter how long one assumes that the casks remain in a worst-case tip-over and total-loss-of-hydrogen-shielding condition, and disregarding any remedial actions that might be taken in the intervening period by PFS or others.

2. Complete Air Inlet Blockage Under HI-STORM 100 Certificate of Compliance

G.48 A thermal analysis was conducted by the Applicant to support the HI-STORM 100 CoC. Staff Exh. FF. The thermal analysis makes a very conservative assumption that no heat transfer to the surrounding air will occur. In effect, the calculation assumes that the cask not only has all its air inlet ducts completely blocked, but that it is shrouded in a ‘heavy blanket’ that prevents heat transfer. Tr. at 12,152-53 (Singh). Under these extreme conditions, the short-term temperature limit of the concrete would be reached in 33 hours. *Id.*

G.49 Due to the way the air inlets are configured, it is physically impossible for all the air inlet vents of a cask to be blocked due to a cask tip-over. Singh/Soler/Redmond Post Tr. 12,044, at 24-25. Therefore, even in a tipped-over condition, heat transfer continues to take place and the air inlet ducts continue to dissipate heat. Thus, the concrete temperature of the HI-STORM cask would be expected to remain below the short-term limit. *Id.* at 25-27. More importantly, the spent fuel canister is not expected to melt. *See* Tr. at 12,205-07 (Singh).

G.50 Even assuming all inlet vents were blocked, the bounding steady-state temperature for the concrete would be well below the 600 degrees Fahrenheit necessary for extensive water evaporation. Singh/Soler/Redmond Post Tr. at 12,044, at 25-27. Both conduction and radiation of heat will still occur from a storage cask that has all its air inlet vents blocked. Tr. at 12,300-01 (Waters). Therefore, the evaporation of water from the concrete of a tipped-over cask would be small, even if the cask remained in a tipped-over position for a period of months. Singh/Soler/Redmond Post Tr. 12,044, at 26.

G.51 Exceedance of the short-term temperature limit of the concrete does not materially affect public health and safety because it has no effect on the containment of the spent fuel within the storage cask; and there would be no significant reduction in the shielding effectiveness of the system. Tr. at 12,154-55 (Singh).

X. CONCLUSIONS OF LAW

The Licensing Board has considered all of the material presented by the parties on Contention Utah L/QQ (Geotechnical). Based upon a review of the entire evidentiary record in this proceeding and the proposed findings of fact and conclusions of law submitted by the parties, and in accordance with the views set forth in Parts I through IX above — which we believe are supported by a preponderance of the reliable, material, and probative evidence in the record — the Board has decided the matters in controversy concerning this contention and reaches the following legal conclusions in favor of the Applicant:

There is reasonable assurance the spent fuel casks would not tip over during a design basis seismic accident. *See* Findings E.5-8, E.21, E.52, E.54, E.168, E.171-74; F.62-64.

If a spent fuel storage cask were to tip over, there is reasonable assurance the spent fuel canister inside would not break or melt. *See* Findings E.9, F.65, G.6-9, G.36-38, G.49-50.

In any event, as has been previously noted by the Commission and the Board, even if the spent fuel canister were to break or melt, the absence of significant dispersive forces would mitigate the consequences of the accident. CLI-00-13, 52 NRC 23, 31 (2000). *See also* Findings F.34, F.102.

Additionally we find the Applicant has met its burden in each of the following aspects of the contention:

Section C of Contention Utah L/QQ. Pursuant to 10 C.F.R. §§ 72.102(c) and (d), the Applicant has demonstrated that the program it implemented to determine the characteristics of the soils at the site provides reasonable assurance that the soil conditions are adequate for the proposed foundation loading.

Section D of Contention Utah L/QQ. Pursuant to 10 C.F.R. § 72.122(b)(2), the Applicant has demonstrated that the design of the structures, systems, and components important to safety at the facility provides reasonable assurance that anticipated earthquake phenomena will not impair their capability to perform their intended safety functions.

Section E of Contention Utah L/QQ. Pursuant to 10 C.F.R. § 72.7, both the Applicant and the Staff have provided adequate justification to support the conclusion that the Staff's grant of the Applicant's exemption request — i.e., to use a PSHA methodology and a 2000-year design basis earthquake — was authorized by law, will not endanger life or property or the common defense and security, and is otherwise in the public interest.

For the reasons set forth herein, it is, this 22d day of May 2003, ORDERED that:

1. Contention Utah L/QQ (Geotechnical) is RESOLVED in favor of the Applicant PFS.
2. Pursuant to 10 C.F.R. § 2.760(a), this Partial Initial Decision will constitute the FINAL ACTION of the Commission within forty (40) days of this date unless a petition for review is filed in accordance with 10 C.F.R. § 2.786(b), or the Commission directs otherwise.

3. Within fifteen (15) days after service of this Partial Initial Decision (which shall be considered to have been served by regular mail for the purpose of calculating that date), any party may file a petition for review with the Commission on the grounds specified in 10 C.F.R. § 2.786(b)(4). The filing of a petition for review is mandatory in order for a party to have exhausted its administrative remedies before seeking judicial review. Within ten (10) days after service of a petition for review, any party to the proceeding may file an answer supporting or opposing Commission review. The petition for review and any answers shall conform to the requirements of 10 C.F.R. § 2.786(b)(2)-(3).

THE ATOMIC SAFETY AND
LICENSING BOARD*

Michael C. Farrar, Chairman
ADMINISTRATIVE JUDGE

Jerry R. Kline
ADMINISTRATIVE JUDGE

Peter S. Lam
ADMINISTRATIVE JUDGE

Rockville, Maryland
May 22, 2003

*Copies of this Partial Initial Decision were sent this date by Internet e-mail transmission to counsel for (1) Applicant PFS; (2) Intervenors Skull Valley Band of Goshute Indians, OGD, Confederated Tribes of the Goshute Reservation, Southern Utah Wilderness Alliance, and the State of Utah; and (3) the NRC Staff.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:

**Ivan W. Smith, Chairman
Dr. Charles N. Kelber
Dr. Peter S. Lam**

In the Matter of

**Docket No. 30-33887-CivP
(ASLBP No. 03-805-01-CivP)
(EA 01-302)**

**HIGH MOUNTAIN INSPECTION
SERVICE, INC.
(Mills, Wyoming)**

May 29, 2003

**MEMORANDUM AND ORDER
(Terminating Proceeding)**

By notice and motion dated May 15, 2003, Licensee, High Mountain Inspection Service, Inc., through its counsel, withdrew High Mountain's request for a hearing and moved that this proceeding be terminated. Counsel also reported that the NRC Staff has no objection. Accordingly, this proceeding is **TERMINATED**.

It is so **ORDERED**.

**FOR THE ATOMIC SAFETY
AND LICENSING BOARD**

**Ivan W. Smith, Chairman
ADMINISTRATIVE JUDGE**

Rockville, Maryland
May 29, 2003

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

COMMISSIONERS:

Nils J. Diaz, Chairman
Greta Joy Dicus
Edward McGaffigan, Jr.
Jeffrey S. Merrifield

In the Matter of

Docket No. 40-8027-MLA-5

SEQUOYAH FUELS CORPORATION
(Gore, Oklahoma Site)

June 13, 2003

Sequoyah Fuels Corporation applied for a materials license amendment to possess byproduct material at its site near Gore, Oklahoma. The Commission accepted the Presiding Officer's two certified questions regarding whether the decommissioning waste at the Gore site qualifies as byproduct material within the ambit of section 11e(2) of the Atomic Energy Act and set a briefing schedule.

COMMISSION STAFF REQUIREMENTS MEMORANDUM (SRM)

**RULES OF PRACTICE: CHALLENGE TO COMMISSION STAFF
REQUIREMENTS MEMORANDUM (SRM); CONTENTIONS
(CHALLENGE TO COMMISSION STAFF REQUIREMENTS
MEMORANDUM); LITIGABILITY OF ISSUES;
CONSIDERATION OF ISSUES**

A Commission Staff Requirements Memorandum (SRM) is an internal agency pronouncement. It is binding inside the Commission only. It is neither a regulation resulting from notice-and-comment rulemaking under the Administrative Procedure Act nor a Commission adjudicatory decision. It thus lacks the "force and effect of law." Hence, an SRM may be reconsidered in the context of an adjudication.

MEMORANDUM AND ORDER

This case involves the application of Sequoyah Fuels Corporation (SFC) for a materials license amendment to possess byproduct material at its site near Gore, Oklahoma. On May 1, 2003, the Presiding Officer certified two questions to the Commission: (1) should the State of Oklahoma be permitted to litigate in this proceeding whether the decommissioning waste present at the Gore site qualifies as byproduct material within the ambit of section 11e(2) of the Atomic Energy Act (AEA)¹ and (2) if so, should the State's 11e(2) claim be considered by the Presiding Officer or by the Commission.² We decide that Oklahoma may raise the section 11e(2) issue in this proceeding. We also set a briefing schedule so that we can decide the merits of the issue ourselves.

I. BACKGROUND

SFC formerly operated its Gore, Oklahoma facility to produce uranium hexafluoride from yellowcake (a uranium oxide) and to convert depleted uranium hexafluoride to uranium tetrafluoride. Various phases of SFC's operations produced radioactive waste streams. In conjunction with decommissioning planning, in 2001 SFC requested that the NRC determine if some of the waste material from the SFC yellowcake solvent extraction process could be classified as byproduct material under section 11e(2) of the Atomic Energy Act — so-called "11e(2) byproduct material."³ After analysis the NRC Staff presented its views to the Commission and identified options in SECY-02-0095. The Staff recommended that the Commission approve SFC's request. On July 25, 2002, the Commission issued a Staff Requirements Memorandum (SRM) responding to SECY-02-0095. The Commission SRM concluded that some of the waste at the SFC site could be classified as 11e(2) byproduct material. That classification had

¹ 42 U.S.C. § 2014(e)(2).

² See *Sequoyah Fuels Corp.* (Gore, Oklahoma Site), LBP-03-7, 57 NRC 287 (2003). Pursuant to 10 C.F.R. § 2.1209(d), a presiding officer has the power to certify questions to the Commission for determination.

³ "The term 'byproduct material' means (1) any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material, and (2) the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content." 42 U.S.C. § 2014(e)(2). Part (2) of the definition is at issue in this proceeding.

implications for the type of decommissioning plan necessary to remediate the Gore site and terminate SFC's license.⁴

Following the Commission's SRM, SFC requested a materials license amendment to possess 11e(2) byproduct material. After publication of notice of the amendment request and opportunity for a hearing under 10 C.F.R. Part 2, Subpart L,⁵ Citizens' Action for Safe Energy (CASE), the State of Oklahoma, the Cherokee Nation, and fifteen individuals submitted hearing requests.⁶

SFC and the NRC Staff filed responses to the petitions of CASE and the individuals but requested an extension of time to file answers to the hearing requests of the State and the Cherokee Nation while SFC, Oklahoma, and the Cherokee Nation attempted to resolve the issues without litigation. The Board granted the request,⁷ as well as a later request for an additional extension.⁸ The Cherokee Nation withdrew its hearing request on April 15, 2003. The Staff and SFC have filed oppositions to the Oklahoma hearing request and claim that none of the Petitioners has established standing or identified an area of concern germane to the proceeding.⁹ The Presiding Officer has not yet issued an order on standing or germaneness.¹⁰

⁴ A separate adjudicatory proceeding is underway with respect to SFC's proposed site decommissioning plan. Oklahoma has already established standing with respect to SFC's proposed site decommissioning plan for the Gore, Oklahoma conversion facility. *See* CLI-01-2, 53 NRC 9 (2001) (denying interlocutory review of LBP-99-46, 50 NRC 386 (1999), which granted Oklahoma's request for a hearing).

⁵ *See* 67 Fed. Reg. 69,048 (Nov. 14, 2002).

⁶ The individual petitioners are Bill Bryant, Margaret Cox, Mike Fuller, Barbara A. Geary, Richard Geary, Jacquelyn C. Longacre, Mike Marshall, Bob Nichols, James Nimmo, Carl Hoot Reynolds, Christopher T. Robinson, Billye Van Schuyver, Anthony Oliver Smith, Darla Reynolds Sparks, and Kirk F. Williams.

⁷ *See* unpublished Order (Granting Joint Motion for Extension of Time To File Answers) (Dec. 26, 2002).

⁸ *See* unpublished Memorandum and Order (Granting in Part Joint Motion for Further Extension of Time To File Responses) (Jan. 29, 2003).

⁹ *See* 10 C.F.R. § 2.1205(e) and (h). A hearing request must describe the interest of the requestor in the proceeding, how the interests may be affected by the results of the proceeding, and the requestor's areas of concern about the licensing activity that is the subject of the proceeding.

¹⁰ On the basis of its technical review, which occurs concurrently with this license amendment adjudicatory proceeding, the NRC Staff has issued the license amendment. Depending on the outcome of this adjudicatory proceeding, however, the Presiding Officer and the Commission have the authority to reverse the Staff's decision and rescind the license amendment.

II. DISCUSSION AND CONCLUSION

The Presiding Officer has stated that the viability of Oklahoma's claim rests on whether Oklahoma is precluded from "insisting . . . that the waste on the Licensee's site in question does not qualify as section 11e(2) byproduct material (in other words does not meet the definition of byproduct material set forth in that section of the AEA)." ¹¹ Because the Commission earlier approved the classification by SRM, the Presiding Officer is understandably reluctant to entertain Oklahoma's position, which "represents a challenge to a decision reached by the Commission itself." ¹² Accordingly, the Presiding Officer has certified to us the following questions:

1. Should the State of Oklahoma be permitted to raise in this pending materials license amendment proceeding the question whether the decommissioning waste present on the site of the Licensee Sequoyah Fuels Corporation qualifies as byproduct material within the ambit of section 11e(2) of the Atomic Energy Act . . . ?
2. If the answer to that question is in the affirmative, does the Commission wish to entertain Oklahoma's assertions on the issue itself or, alternatively, does it want the State's section 11e(2) claims to be considered in the first instance by this presiding officer? ¹³

For the reasons stated below, we answer the first question affirmatively. And, because resolution of the 11e(2) issue hinges on law rather than fact, and has previously been addressed by the Commission (in an SRM), the Commission will address it directly.

A Commission SRM is an internal agency pronouncement. It is binding inside the Commission only. It is neither a regulation resulting from notice-and-comment rulemaking under the Administrative Procedure Act nor a Commission adjudicatory decision. It thus lacks the "force and effect of law." ¹⁴ Hence, an SRM may be reconsidered in the context of an adjudication.

The Commission recognizes that this adjudicatory proceeding appears to be the only opportunity that Oklahoma may have to argue its position, which is contrary to that of the NRC Staff and the Licensee. Consequently, we find that Oklahoma should be permitted to raise the 11e(2) issue in this materials license amendment proceeding. Although the Commission has previously considered the 11e(2) issue in connection with an SRM, the Commission did not do so in an

¹¹ See LBP-03-7, 57 NRC at 288.

¹² See *id.* at 291.

¹³ *Id.* at 291-92.

¹⁴ See *United States v. Mead*, 533 U.S. 218 (2001); *Citizens Awareness Network, Inc. v. NRC*, 59 F.3d 284 (1st Cir. 1995).

adjudicatory setting, with the benefit of adverse parties' briefs. It is possible that review of the issue from that perspective will shed new light on it. Certainly, in view of the SRM, the Commission rather than the Presiding Officer is the right forum to consider the issue.

Accordingly, we seek briefs from Oklahoma and any other hearing Petitioners, the Licensee, and the NRC Staff on the question whether, in view of the initial processing of yellowcake at the Gore site, any portion of the SFC waste can be considered as 11e(2) byproduct material. The briefs shall not exceed 25 pages and should be filed simultaneously by July 3, 2003. Reply briefs, containing only rebuttal, shall not exceed 10 pages and should be filed simultaneously by July 18, 2003.

After considering the arguments afresh, the Commission itself will decide the 11e(2) issue. After deciding the threshold 11e(2) issue, we will return this case to the Presiding Officer for appropriate disposition.

IT IS SO ORDERED.

For the Commission¹⁵

ANNETTE L. VIETTI-COOK
Secretary of the Commission

Dated at Rockville, Maryland,
this 13th day of June 2003.

¹⁵ Commissioner Dicus was not present for the affirmation of this Order. If she had been present, she would have approved it.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:

Charles Bechhoefer, Chairman
Dr. Richard F. Cole
Ann Marshall Young

In the Matter of

Docket Nos. 50-390-CivP
50-327-CivP
50-328-CivP
50-259-CivP
50-260-CivP
50-296-CivP
(ASLBP No. 01-791-01-CivP)
(EA 99-234)

TENNESSEE VALLEY AUTHORITY
(Watts Bar Nuclear Plant, Unit 1;
Sequoyah Nuclear Plant, Units 1 and 2;
Browns Ferry Nuclear Plant,
Units 1, 2, and 3)

June 26, 2003

The Licensing Board majority upholds the position of the NRC Staff that the Licensee (TVA) violated 10 C.F.R. § 50.7 by discriminating against a former employee, in part because the employee engaged in protected (whistleblowing) activities. However, the Board majority also mitigates the \$110,000 civil penalty imposed upon TVA by the Staff to \$44,000, because the adverse action against the employee was based in part on the employee's performance, the circumstance that TVA was forced to eliminate and/or modify the duties of many employees, and because TVA did not have adequate notice that the NRC interpreted 10 C.F.R. § 50.7 as including adverse actions motivated in any part (not necessarily a substantial part) by an employee's engagement in protected activities.

DISQUALIFICATION: STANDARDS

Absent a demonstration of personal bias, a licensee would have no grounds for raising or challenging the beliefs of regulators.

REGULATIONS: INTERPRETATION (10 C.F.R. § 50.7)

Section 50.7 of 10 C.F.R. prohibits NRC licensees from taking an “adverse action” against an employee based upon the employee’s involvement in certain protected activities. The activities protected by section 50.7 closely parallel those included in section 211 of the Energy Reorganization Act of 1974 (ERA), 42 U.S.C. § 5851 (section 211).

REGULATIONS: INTERPRETATION (10 C.F.R. § 50.7)

The Commission, in its statement of considerations for 10 C.F.R. § 50.7, indicates that the section incorporates not only authority derived from section 211 but also requirements stemming from NRC’s enforcement authority under subsections 161(c) and (o) of the Atomic Energy Act (AEA) of 1954, as amended, 42 U.S.C. §§ 2011 *et seq.*, which was in effect long before the enactment of section 210 or section 211. (As set forth by the Secretary of Labor, section 211 of the ERA was formerly designated section 210, but was redesignated pursuant to section 2902(b) of the Comprehensive National Energy Policy Act of 1992, Pub. L. No. 102-486, 106 Stat. 2776, which amended the ERA effective October 24, 1992. *Zinn v. University of Missouri*, Nos. 93-ERA-34 and 93 ERA-36, 1996 DOL Sec. Labor LEXIS 8, at *1 n.1.

REGULATIONS: INTERPRETATION (10 C.F.R. § 50.7)

Department of Labor interpretations of section 211 of the ERA are not statutorily binding upon the NRC but may be taken as guidance only.

REGULATIONS: INTERPRETATION (10 C.F.R. § 50.7)

Based on its derivation from AEA standards, the seriousness of a section 50.7 violation is taken into account only in the penalty assessed. If discrimination is established, the NRC is entitled to impose some sort of remedy, irrespective of any benefits or lack thereof provided to an employee. The Staff may properly interpret section 50.7 as including any degree of discrimination for protected activities and as permitting consideration of whether an employee’s engagement in protected activities in any degree contributed toward an adverse personnel action, even though not the primary or even a substantial basis for the action.

Thus, in interpreting 10 C.F.R. § 50.7 as being derived both from the AEA and from section 211 of the ERA, the principle stemming from section 211, to the effect that “[r]elief may not be ordered [to the employee] . . . if the employer demonstrates by clear and convincing evidence that it would have taken the same unfavorable personnel action in the absence of the complainant’s protected activity” (*citing* 42 U.S.C. § 5851(b)(3)(D)), is not applicable to the threshold issue of whether an employer has violated section 50.7 but only to the follow-on consideration of whether the employee is entitled to some relief.

REGULATIONS: INTERPRETATION (10 C.F.R. § 50.7)

Under DOL interpretations of section 211, in dual-motive cases, the temporal proximity of the protected activities and the adverse action may be designated as the sole basis for discrimination only when separated by a month or two. Under the AEA enforcement authority, particularly where additional bases for the discrimination have been demonstrated, the strict time limitations are not applicable. Thus, where section 50.7 is derived both from section 211 of the ERA and from the AEA, the strict ERA limitations need not be applied.

REGULATIONS: INTERPRETATION (10 C.F.R. § 50.7)

Protected activities include not only the discovery, raising, reporting, and/or documentation of such issues but also participation in their resolution. *Zinn v. Univ. of Missouri*, 1996 DOL Sec. Labor LEXIS 8.

REGULATIONS: INTERPRETATION (10 C.F.R. § 50.7)

There are four elements that the Staff must establish to demonstrate that there has been a violation of section 50.7 by a licensee. Specifically, the Staff must demonstrate, first, that the employee engaged in one or more protected activities; second, that members of management were aware of the protected activity; third, that the employee was subject to an adverse action; and fourth, that the adverse action was premised at least in part on retaliation for such activities.

REGULATIONS: INTERPRETATION (10 C.F.R. § 50.7)

An employee is the subject of an adverse action, as contemplated under section 50.7, even if given the option to be transferred to a services organization to seek other employment as well as an option to resign with enhanced severance benefits. *See TVA v. Secretary of Labor (Curtis Overall, Intervenor)*, 59 Fed. Appx. 732 (6th Cir. 2003).

ENERGY REORGANIZATION ACT: SCOPE OF NRC ACTIVITIES

The NRC is authorized under both the Atomic Energy Act and section 211 of the Energy Reorganization Act to take action against licensees for whistleblower retaliation claims.

ENFORCEMENT ACTIONS: LEGAL BASIS

Violations by a licensee of either section 211 of the Energy Reorganization Act or of the Atomic Energy Act enforcement provisions are subject to civil penalties under section 234 of the Atomic Energy Act.

REGULATIONS: INTERPRETATION (10 C.F.R. § 50.7)

The appropriate standard of proof applicable to a section 50.7 case is whether the Staff can prove by a preponderance of the evidence that the complainant's protected activity was a contributing factor in an adverse action.

EVIDENCE: INFERENCES

Circumstantial evidence of discrimination may be used to establish, by a preponderance of the evidence, that discrimination took place in a 10 C.F.R. § 50.7 case.

TECHNICAL ISSUES DISCUSSED

The following technical issues are discussed: Protected Activities, Radiation Monitor Set Points, Post-Accident Sampling System (PASS) Analyses, Diesel Generator Fuel Oil Storage Tanks, and Data Trending.

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INITIAL DECISION

Pending before us is a proceeding in which the Tennessee Valley Authority (TVA or Licensee) is challenging a civil penalty of \$110,000 imposed on it by the NRC Staff (Staff). The civil penalty was premised upon an alleged violation by TVA of 10 C.F.R. § 50.7, *Employee protection*, based on TVA's assertedly having not selected Mr. Gary Fiser, a former TVA employee, to a competitive position in 1996 due, at least in part, to Mr. Fiser's having engaged in protected ("whistleblowing") activities.

For reasons set forth below, the majority of the Licensing Board (Administrative Judges Bechhoefer and Cole) finds that the Staff has demonstrated, by a preponderance of the evidence, that Mr. Fiser's nonselection was motivated to some degree as retaliation for engaging in protected activities — including his having filed two complaints of discrimination before the Department of Labor (DOL) concerning his treatment at TVA for attempting to raise nuclear safety issues (albeit in a manner not conforming to the prescribed internal procedures for raising such safety concerns), and his contacting (along with two other TVA employees) a U.S. Senator concerning TVA employees' raising safety issues. (As we shall explain, copies of the letter to the U.S. Senator were also sent to NRC officials, so as to constitute a whistleblowing complaint before the NRC.) We therefore conclude that a violation of 10 C.F.R. § 50.7 has occurred and that the civil penalty should be sustained in part.

We are, however, mitigating the amount of the civil penalty imposed. In determining the civil penalty, the Staff properly relied on policies and procedures set forth in the NRC's Enforcement Policy, NUREG-1600, "General Statement of Policy and Procedure for NRC Enforcement Actions" (rev. 3), 64 Fed. Reg. 61,142 (Nov. 9, 1999) (*see* Staff Exh. 170).¹ NUREG-1600 itself provides for mitigation of civil penalties in certain circumstances. *See, e.g.*, 64 Fed. Reg. at 61,144, 61,154-55, 61,156, 61,157.

Briefly, our reasons for mitigation are as follows. First, TVA had what appeared to it as seemingly significant performance-oriented reasons that apparently played a large part (although not the sole part) in its nonselection of Mr. Fiser for the position he was seeking. As set forth in greater detail below, his nonselection came about in the context of a massive 1996 reorganization in which, because it was changing from a construction mode for several reactors to an operating

¹ A list of exhibits entered into evidence, as well as those offered but not accepted into evidence, is attached as Appendix A (not published) to this Decision. Exhibits are referenced according to the sponsoring party, i.e., Joint Exh., TVA Exh., and Staff Exh. Some exhibits were admitted in a redacted form, eliminating home addresses, dates of birth, and social security numbers of named employees. Those exhibits are referenced in Appendix A as "redacted."

mode for all of its reactors, TVA was forced to eliminate and/or modify the duties of many — indeed, thousands — of employees. *See, e.g.*, [TVA's] Posthearing Proposed Findings of Fact and Conclusions of Law (Dec. 20, 2002) [hereinafter TVA FOF], ¶¶ 2.12-2.14. Mr. Fiser was one of those employees.

Additionally, as the Nuclear Energy Institute (NEI) observes in a brief filed *amicus curiae* (Brief *Amicus Curiae* of the Nuclear Energy Institute (Mar. 1, 2002) [hereinafter NEI Brief] at 23 & n.14), TVA appears not to have been provided adequate notice (at least at the time of the nonselection of Mr. Fiser in 1996) of NRC's interpretation of section 50.7 as including adverse actions motivated in any part (not necessarily a substantial part) by an employee's engagement in protected activities. Accordingly, although TVA's actions with respect to Mr. Fiser were not entirely appropriate, we are nonetheless reducing the civil penalty imposed by the Staff from \$110,000 to \$44,000.

A. Procedural Background

On February 7, 2000, the NRC Staff issued to TVA a Notice of Violation and Proposed Imposition of Civil Penalty (NOV) in the amount of \$110,000. The NOV was premised upon TVA's nonselection of Mr. Fiser to a competitive position due, in part, to Mr. Fiser's having engaged in "protected activity," as proscribed by section 50.7. *See* Joint Exh. 47. According to the Staff, Mr. Fiser in 1993 filed a discrimination complaint with the DOL in which he alleged that TVA had discriminated against him, in part for raising nuclear safety concerns related to his activities as Chemistry and Environmental Superintendent at the Sequoyah Nuclear Plant. The complaint, *inter alia*, listed three separate technical activities with respect to which Mr. Fiser claimed discrimination. *See* Staff Exh. 34, Letter from Gary Fiser to Carol Merchant, DOL (Sept. 23, 1993).

In 1996, Mr. Fiser filed another discrimination complaint with the DOL in which he asserted that TVA's posting of the job he was seeking (incident to a Reduction in Force (RIF)) likewise discriminated against him. *See* Staff Exh. 37, Letter from Gary Fiser to Carol Merchant, DOL (June 25, 1996). In that letter, Mr. Fiser, *inter alia*, claimed disparate treatment vis-à-vis at least one other employee who retained his position.

TVA responded to the NOV by letters dated January 22, 2001, and March 9, 2001. In its January 22, 2001 response, TVA denied the violation and protested the proposed civil penalty. It claimed that both the reorganization of TVA in 1996, which eliminated the position of Chemistry and Environmental Protection Program Manager, Operations Support, and the selection of individuals to fill new positions, were made solely for legitimate business reasons and not in any part taken as retaliation for Mr. Fiser's engagement in protected activities. *See* Letter from Thomas McGrath to Luis Reyes, Region II Administrator (Jan. 22, 2001); Letter from John A. Scalice to Dr. Frank Congel, Office of Enforcement

(Mar. 9, 2001). (TVA, although denying the significance of the alleged protected activities, as well as the extent of Mr. Fiser's participation in those activities, concedes that Mr. Fiser's 1993 and 1996 complaints to DOL, as well as a letter he (and two others) wrote to Senator James Sasser, with copies to two NRC officials, were in themselves protected activities (*see* [TVA's] Prehearing Brief (Mar. 1, 2002) at 11; TVA FOF ¶4.4; [TVA's] Reply to the Staff's Findings of Fact and Conclusions of Law (Mar. 7, 2003) at 95 [hereinafter TVA Reply FOF]). TVA deems the protected activities in which it concedes Mr. Fiser engaged — presumably the two DOL complaints and the Sasser letter — to be “insignificant.” TVA Reply FOF at 95. The Board hereby rejects that characterization — any employee's participation in a protected activity is in our view a significant matter.

In its supplementary response to the NOV, dated March 9, 2001, TVA referenced comments submitted to the NRC Discrimination Task Force by a former member of NRC's Office of Enforcement (OE), to the effect that NRC has lowered the threshold for taking enforcement action for discrimination. It claimed that NRC's policy fails properly to consider a licensee's position that adverse actions taken against employees were done for “legitimate business reasons.” TVA points to the former OE staff member as being involved in the escalated enforcement action (civil penalty) proposed in this proceeding.²

Subsequently, the NRC Staff rejected TVA's explanations and, on May 4, 2001, issued an Order Imposing Civil Monetary Penalty. 66 Fed. Reg. 27,166 (May 16, 2001); *see* Joint Exh. 53, Letter from William F. Kane to Mr. J.A. Scalice (May 4, 2001). On June 1, 2001, TVA filed a timely appeal and request for an enforcement hearing.³ On June 26, 2001, this Licensing Board (consisting of Judge Charles Bechhoefer, as Chairman, and Judges Richard F. Cole and Ann Marshall Young, as members) was established to preside over this proceeding. 66 Fed. Reg. 34,961 (July 2, 2001). By Memorandum and Order (Granting Request for Hearing and Scheduling Telephone Prehearing Conference), dated June 28, 2001, this Board granted TVA's hearing request and scheduled the first of what ultimately would be five telephone prehearing conferences. On the same day, June 28, 2001, the Board issued a Notice of Hearing. 66 Fed. Reg. 35,467 (July 5, 2001).

²At the outset, we note that, absent a demonstration of personal bias, a licensee would have no grounds for raising or challenging the beliefs of regulators (including the members of this Licensing Board). That being so, we must reject TVA's supplemental response irrespective of the accuracy of the allegations. We will, of course, address whether the Staff's enforcement action in this proceeding adequately reflects the allowance for legitimate business reasons as justification in whole or in part for an adverse employment action against an employee.

³Letter from Mark J. Burzynski, Manager, Nuclear Licensing, TVA, to Secretary, NRC, titled “TVA — Request for an Enforcement Hearing” (June 1, 2001).

Telephone prehearing conferences were conducted on July 19, 2001, November 14, 2001, January 9, 2002, February 5, 2002, and April 9, 2002.⁴ In addition, a telephone status conference was conducted on July 8, 2002. During those conferences, the Board, *inter alia*, outlined requirements and established schedules for discovery, for filing of summary disposition motions,⁵ for requesting subpoenas, for filing proposed witness and exhibit lists,⁶ for filing motions *in limine*, and for hearing dates. Discovery formally commenced on July 19, 2001 (*see* Aug. 1, 2001 Order at 2-3), and extended until January 22, 2002 (*see* Jan. 30, 2002 Order). A Notice of Evidentiary Hearing was issued on March 25, 2002, setting forth the initial dates and location for the evidentiary hearing. *See* 67 Fed. Reg. 15,252 (Mar. 29, 2002).

Evidentiary hearing sessions were held in Chattanooga, Tennessee, on April 23, 24, 25, 26, and 30, 2002; May 1, 2, 3, 6, 7, 8, and 9, 2002; June 11, 12, 13, 14, 17, 18, 19, and 20, 2002; and in Rockville, Maryland, on September 9, 10, 11, 12, and 13, 2002. The evidentiary record was closed on October 24, 2002. *See* Memorandum and Order (Rejection of Late-Filed Exhibit; Closing of Evidentiary Record; Transcript Corrections; Schedules for Proposed Findings of Fact and Conclusions of Law), Oct. 24, 2002 (unpublished) [hereinafter Oct. 24, 2002 Order]. As requested by both parties and approved by the Board (*see id.* at 6-7, *but see* note 8 *infra*), proposed findings of fact and conclusions of law

⁴ *See* Prehearing Conference Order (Telephone Conference, 7/19/01), dated August 1, 2001 (unpublished) [hereinafter Aug. 1, 2001 Order]; Second Prehearing Conference Order (Telephone Conference, November 14, 2001), Nov. 28, 2001 (unpublished); Third Prehearing Conference Order (Telephone Conference, January 9, 2002), Jan. 30, 2002 (unpublished) [hereinafter Jan. 30, 2002 Order]; Fourth Prehearing Conference Order (Telephone Conference, February 5, 2002), Feb. 13, 2002 (unpublished); and Fifth Prehearing Conference Order (Confirming Matters Addressed at April 9, 2002 Telephone Conference), Apr. 17, 2002 (unpublished) [hereinafter Apr. 17, 2002 Order].

⁵ TVA filed a Motion for Summary Decision on February 1, 2002. The Staff filed its response to TVA's Motion for Summary Decision on February 20, 2002. TVA filed a reply in support of its Motion for Summary Decision on March 1, 2002 (to which the Staff objected). By Memorandum and Order dated March 21, 2002, the Licensing Board permitted the filing of TVA's reply but denied the Motion for Summary Decision. LBP-02-10, 55 NRC 236 (2002). The Board determined that the Staff was relying upon several independent bases for its position and that a genuine dispute of material fact existed, warranting an evidentiary hearing.

⁶ TVA and the Staff each filed proposed witness and exhibit lists on March 29, 2002. The Staff filed a supplemental witness list on April 9, 2002. A listing of witnesses who testified in this proceeding appears in Appendix B (unpublished) to this Decision. TVA filed supplemental exhibit lists on April 2, 2002, April 4, 2002, April 18, 2002, May 28, 2002, and August 22, 2002. The NRC Staff filed supplemental exhibit lists on April 15, 2002, and September 6, 2002, and a revised document list on September 9, 2002.

were filed simultaneously by both parties on December 20, 2002,⁷ and responsive findings and conclusions were filed simultaneously on March 7, 2003.⁸

B. Governing Legal Principles

The civil penalty imposed by the Staff that TVA is challenging is premised on an alleged violation by TVA of 10 C.F.R. § 50.7, *Employee protection*. That section, *inter alia*, prohibits NRC licensees, such as TVA, from taking an “adverse action” against an employee, such as Mr. Fiser, based upon his involvement in certain protected activities that include, but are not limited to:

[§ 50.7(a)(1)](i) Providing the Commission or his or her employer information about alleged violations of either of the statutes named in paragraph (a) introductory text of this section⁹ or possible violations of requirements imposed under either of those statutes;

(ii) Refusing to engage in any practice made unlawful under either of the statutes named in paragraph (a) introductory text or under these requirements if the employee has identified the alleged illegality to the employer;

(iii) Requesting the Commission to institute action against his or her employer for the administration or enforcement of these requirements;

⁷ NRC Staff’s Findings of Fact and Conclusions of Law Concerning [TVA’s] Violation of 10 C.F.R. 50.7 (Dec. 20, 2002) [hereinafter Staff FOF]; TVA FOF. Each of these filings was presented in both hard copy and electronic (e-mail) form. Citations in this opinion to those documents will reference the pages and/or paragraph numbers as they appear in the hard-copy forms. Further, on January 21, 2003, the Staff refiled certain pages of its proposed findings in order to correct typographic errors in certain transcript citations appearing on those pages.

⁸ NRC Staff’s Response to [TVA’s] Posthearing Proposed Findings of Fact and Conclusions of Law (Mar. 7, 2003) [hereinafter Staff RESP FOF]; TVA Reply FOF. The Licensing Board initially had scheduled responsive findings to be filed on February 28, 2003, *see* Oct. 24, 2002 Order at 6, but on February 20, 2003, the Board granted TVA’s unopposed motion (*see* [TVA’s] Unopposed Motion for an extension of time (Feb. 20, 2003)) to extend the time for filing of responses for both parties to March 7, 2003. Both parties timely met that deadline.

On March 14, 2003, the NRC Staff forwarded to the Board and parties a copy of an opinion of the United States Court of Appeals for the Sixth Circuit, dated March 6, 2003, which affirmed a Department of Labor ruling on which the Staff had relied both in its Staff FOF and its Staff RESP FOF. *TVA v. Secretary of Labor (Curtis Overall, Intervenor)*, 59 Fed. Appx. 732 (6th Cir. 2003). The Staff advised that it only became aware of this decision after it had filed its Staff RESP FOF on March 7, 2003. Although an unpublished decision, given the fact that TVA, as a party to that proceeding as well as this one, became aware of the Sixth Circuit opinion, we hereby accept the Staff’s March 14, 2003 filing as a supplement to its Staff RESP FOF.

⁹ Those statutes are (1) the Energy Reorganization Act (ERA) of 1974, as amended; and (2) the Atomic Energy Act (AEA) of 1954, as amended.

(iv) Testifying in any Commission proceeding, or before Congress, or at any Federal or State proceeding regarding any provision (or proposed provision) of either of the statutes named in paragraph (a) introductory text[;]

(v) Assisting or participating in, or is about to assist or participate in, these activities.

The section goes on to provide remedies for purported violations:

(b) Any employee who believes that he or she has been discharged or otherwise discriminated against by any person for engaging in protected activities specified in paragraph (a)(1) of this section may seek a remedy for the discharge or discrimination through an administrative proceeding in the [DOL]. The administrative proceeding must be initiated within 180 days after an alleged violation occurs. The employee may do this by filing a complaint alleging the violation with the [DOL]. . . . The [DOL] may order reinstatement, back pay, and compensatory damages.

(c) A violation of paragraph (a) . . . of this section by a Commission licensee . . . may be grounds for —

. . . .

(2) Imposition of a civil penalty on the licensee

. . . .

(d) Actions taken by an employer, or others, which adversely affect an employee may be predicated upon nondiscriminatory grounds. The prohibition applies when the adverse action occurs because the employee has engaged in protected activities. An employee's engagement in protected activities does not automatically render him or her immune from discharge or discipline for legitimate reasons or from adverse action dictated by nonprohibited considerations.

. . . .

(f) No agreement affecting the compensation, terms, conditions, or privileges of employment, including an agreement to settle a complaint filed by an employee with the [DOL] pursuant to section 211 of the Energy Reorganization Act of 1974, as amended, may contain any provision which would prohibit, restrict, or otherwise discourage an employee from participating in protected activity as defined in paragraph (a)(1) of this section including, but not limited to, providing information to the NRC or to his or her employer on potential violations or other matters within NRC's regulatory responsibilities.

10 C.F.R. § 50.7 (2002). The foregoing protected activities closely parallel those included in section 211 of the Energy Reorganization Act of 1974, 42 U.S.C. § 5851 (section 211). The remedy sought by the Staff for the purported violation is that authorized by 10 C.F.R. § 50.7(c)(2), calculated in accordance with the NRC's Enforcement Policy, NUREG-1600 (*see* Staff Exh. 170).

In determining the proper scope and coverage of this provision, as well as its applicability to actions taken (or not taken) by TVA with respect to Mr. Fiser, we

are guided by the legal analyses submitted by TVA and the Staff, respectively.¹⁰ In addition, we granted the March 1, 2002 motion of NEI to file a brief in support of TVA's challenge to the civil penalty in this case as *amicus curiae*.¹¹ NEI filed its brief on March 1, 2002.¹² NEI's participation in this proceeding has been limited to legal interpretation; it has not participated in the development of any factual material (although, in its brief, it has assumed that certain facts sought to be established by TVA are in fact true.) We have considered NEI's analyses, as well as TVA's and the Staff's, in reaching our legal conclusions herein.

The parties differ markedly on the appropriate interpretation of the above-cited provisions of 10 C.F.R. § 50.7, particularly as they may impact the NOV and the Order Imposing Civil Monetary Penalty in this proceeding. The Commission itself, in its statement of considerations for 10 C.F.R. § 50.7, indicates that the section incorporates not only authority derived from section 211 but also requirements stemming from NRC's enforcement authority under subsections 161(c) and (o) of the Atomic Energy Act (AEA) of 1954, as amended, 42 U.S.C. §§ 2011 *et seq.* See Whistle Blower Protection for Employees of NRC-Licensed Activities, 58 Fed. Reg. 52,406, 52,410 (Oct. 8, 1993). TVA and NEI, however, portray section 50.7 as constituting — indeed, as being limited to — NRC's embodiment of section 211. According to TVA, precedent developed under section 211 (or its predecessor, section 210¹³) “is particularly persuasive as to the legal standards applicable in this section 50.7 proceeding.” TVA FOF ¶ 13.2. Further, according to TVA, “[w]here, as in Section 211, Congress has entrusted the administration of a remedial scheme to an agency (DOL) for addressing employment discrimination, another federal agency (NRC) has no authority to extend that scheme by providing new remedies or imposing new burdens on the regulated parties.” TVA FOF ¶ 13.4.

TVA and NEI claim that the section 211 standard is to be applied in a uniform manner by the NRC and the DOL. Referencing Supreme Court decisions applying Title VII of the Civil Rights Act of 1964, they assert that the “comprehensive character of the remedial scheme expressly fashioned by Congress strongly

¹⁰ See TVA FOF, *passim*, particularly ¶ 13.10; TVA Reply FOF, *passim*, particularly pp. 92-131; Staff FOF ¶¶ 2.6-2.9, 3.1-3.13; Staff RESP FOF ¶¶ 2.1-2.6, 2.27, 3.1-3.18.

¹¹ See Apr. 17, 2002 Order at 1 (Tr. 203). Transcripts of various prehearing conferences, as well as the evidentiary hearing, are numbered consecutively. The evidentiary hearing commenced on April 23, 2002. Tr. 262.

¹² This brief was filed in both hard copy and electronic (e-mail) form. Citations in this opinion to this brief will reference the hard-copy pages.

¹³ As set forth by the Secretary of Labor, section 211 of the ERA was formerly designated section 210, but was redesignated pursuant to section 2902(b) of the Comprehensive National Energy Policy Act of 1992, Pub. L. No. 102-486, 106 Stat. 2776, which amended the ERA effective October 24, 1992. *Zinn v. University of Missouri*, Nos. 93-ERA-34 and 93-ERA-36, 1996 DOL Sec. Labor LEXIS 8, at *1 n.1.

evidences an intent' that the scheme not be modified by the addition of new rights or remedies.'" TVA FOF ¶13.4 (citing *Northwest Airlines v. Transportation Workers Union*, 451 U.S. 77, 93-94 (1981)). They characterize the NRC Staff's enforcement of 10 C.F.R. § 50.7 as departing from the legal standard "mandated by Congress under Section 211.'" NEI Brief at 2.

For its part, the Staff acknowledges that the standard it is using for determining whether a violation of section 50.7 has taken place differs in some respects from the section 211 and DOL standards. The Staff standard takes into account not only requirements imposed by section 211 and DOL regulations and interpretations but also requirements stemming from NRC's enforcement authority under subsections 161(c) and (o) of the Atomic Energy Act of 1954, as amended, 42 U.S.C. §§ 2011 *et seq.* The Staff observes that the AEA enforcement authority with respect to at least some protected activities was in effect long before the enactment of section 210 or 211 and was not superseded or limited by the subsequent enactment of those sections. Indeed, during the congressional debate on section 210 (which later became section 211), Senator Hart, Manager of the legislation in the Senate, stated:

[The] new section 210 . . . is not intended to in any way abridge the [NRC's] current authority to investigate an alleged discrimination and take appropriate action against a licensee-employer, such as a civil penalty

124 Cong. Rec. S15,318 (daily ed. Sept. 18, 1978). *See* Staff FOF ¶3.3.

Thus, the AEA provided the Commission with authority to take action against a licensee (as in this proceeding) but it did not include a personal remedy for an employee subjected to discrimination. *Union Electric Co.* (Callaway Plant, Units 1 and 2), ALAB-527, 9 NRC 126, 138, 144 (1979). Section 210 (later, section 211) filled that gap. *See* Staff FOF ¶3.3; *but see* NEI Brief at 9.

After reviewing the positions of both parties (as well as that of NEI, which parallels TVA's position), we conclude that the DOL interpretations of section 211 are not statutorily binding upon the NRC but, as pointed out by the Staff, may be taken as guidance only. *See* Staff FOF ¶3.10; NRC Staff's Response to [TVA's] Motion for Summary Decision (Feb. 20, 2002) at 28; *see also* Tr. 14 (Prehearing Conference, July 19, 2001). Further, as a result of our view of the derivation of the standards for interpreting 10 C.F.R. § 50.7, we reject TVA's claim that the Staff (through its reliance upon standards other than DOL standards) has found discrimination where none in fact exists.

What difference does the use of differing standards have on the proceeding before us? The parties have pointed to essentially two significant differences. First, and most important, in a dual-motive case such as this one (where an adverse action may have been premised both on the employer's legitimate reasons as well as on the employee's protected activities), is the degree to which protected

activities must be involved to be deemed a contributing factor in the adverse action.

TVA and NEI assert that the Staff is departing from a statutorily mandated interpretation by permitting discrimination to be considered when it is merely a contributing factor, although not the primary or even a substantial reason, for a discharge or other adverse personnel action. Looked at from another point of view, TVA and NEI decry the NRC's standard for showing that a legitimate reason for a personnel action was not merely a pretext to cover up discriminatory conduct: i.e., that the legitimate reason must constitute the *sole* basis for the adverse action. TVA would have us adopt the standard under section 211 and DOL regulations to the effect that an adverse action must be directly or substantially premised upon an employee's participation in protected activities to constitute discrimination under 10 C.F.R. § 50.7. Further, TVA and NEI would require the Staff to employ probative evidence, not merely inference drawn from circumstantial evidence, to demonstrate that a legitimate reason for an adverse action was merely a pretext for discrimination. *See* TVA FOF ¶ 1.11, at 9; NEI Brief at 16.

We conclude that, under the interpretation of 10 C.F.R. § 50.7 as being derived both from the AEA and from section 211, the principle asserted by TVA and NEI in this instance (*see* NEI Brief at 20), stemming from section 211 alone, to the effect that “[r]elief may not be ordered [to the employee] . . . if the employer demonstrates by clear and convincing evidence that it would have taken the same unfavorable personnel action in the absence of the complainant's protected activity” (*citing* 42 U.S.C. § 5851(b)(3)(D)), is not applicable to the threshold issue of whether an employer has violated section 50.7 but only to the follow-on consideration of whether the employee is entitled to some relief. That question is not before us in this proceeding — the NRC Staff is not here seeking to provide any relief to Mr. Fiser for his alleged discharge. Here, the sole question at issue is whether TVA violated 10 C.F.R. § 50.7 by basing to any degree its failure to retain Mr. Fiser as an employee on his involvement in one or more protected activities.

Construction of 10 C.F.R. § 50.7, to prohibit any discriminatory conduct, even though not necessarily a substantial part of a reason for an adverse personnel action, is consistent with NRC's traditional manner of construing its enforcement authority. Under NUREG-1600, the NRC enforcement policy in effect at the time of issuance of the NOV in this proceeding (64 Fed. Reg. at 61,164-65; *see* Staff Exh. 170), violations of 10 C.F.R. § 50.7 are categorized into four severity levels. The higher the severity level, the more severe the penalty.

Thus, under Supplement VII — Miscellaneous Matters, where violations of 10 C.F.R. § 50.7 are grouped, Severity Level I (the most serious) includes “[a]ction by senior corporate management in violation of 10 CFR 50.7 or similar regulations against an employee.” 64 Fed. Reg. at 61,164. Severity Level II includes “[a]n action by plant management or mid-level management in violation of 10 CFR

50.7 or similar regulations against an employee.’’ *Id.* at 61,165. (Severity Level II also includes “[t]he failure of licensee management to take effective action in correcting a hostile work environment.’’ *Id.*) Severity Level III includes “[a]n action by first-line supervision or other low-level management in violation of 10 CFR 50.7 or similar regulations against an employee.’’ *Id.* And, finally, Severity Level IV includes “[d]iscrimination cases which, in themselves, do not warrant a Severity Level III categorization.’’ *Id.*

What is significant is that *any* instances of discrimination are condemned, no matter how minor or serious. TVA’s statement that the “protected activities in which [Mr. Fiser] did engage were insignificant” (TVA Reply FOF at 95) is thus inconsistent with the requirements of 10 C.F.R. § 50.7 and must be rejected. The seriousness of the violation is to be taken into account only in the penalty assessed.

In that connection, as further explained under Part F of this Decision (“Civil Penalty”), differing base-level penalties are set forth in NUREG-1600 for each severity level, with the NRC afforded discretion to escalate or mitigate the prescribed penalties, as appropriate. Freeing an employer from liability for discrimination if it can demonstrate that it would have taken the same discharge action for legitimate, nondiscriminatory reasons, as permitted under section 211 and as sought by TVA, is thus inconsistent with NRC’s traditional manner of enforcing its own AEA regulations. We accordingly reject that approach. If discrimination is established, the NRC is entitled to impose some sort of remedy, irrespective of any benefits or lack thereof provided to an employee.

The other significant manner in which section 211 standards differ from those under section 50.7 (at least insofar as is pertinent to this proceeding) is in the use of temporal proximity as a basis for an adverse action. TVA and NEI claim that the Staff has exaggerated the importance of temporal proximity to support a finding of discrimination, so that the sufficiency of its evidence does not meet the preponderance-of-the-evidence standard. In that regard, TVA and NEI (by inference) refer to a statement in the February 7, 2000 letter transmitting the Order Imposing Civil Monetary Penalty to TVA that mentions the “temporal proximity between the appointment of [McGrath and McArthur] as Fiser’s supervisors and his non-selection in July 1996” as evidence of discrimination. *See* Joint Exh. 47; February 7, 2000 Letter from NRC to TVA at 3. TVA claims that temporal proximity may only be judged with respect to the time between the protected activity and the nonselection (more than 3 years, assuming the 1993 DOL complaint constitutes the protected activity); that the time would not be suspended during periods when Mr. Fiser had different nondiscriminatory supervisors; and, in any event, that temporal proximity is applicable only when

the two events (protected activity and adverse action) are separated by no more than a month or two. TVA FOF ¶¶ 14.5, 14.6; NEI Brief at 16-18.¹⁴

For its part, the Staff argues that it is not primarily relying on temporal proximity to prove its claims of discrimination, that temporal proximity is not mentioned in the NOV or Civil Penalty Order as a basis for discrimination, and that its mention of temporal proximity in the February 7, 2000 transmittal letter only serves to establish that the discharge action bore some relationship to Mr. Fiser's filing of the DOL complaints and to the appointments of Dr. McArthur and Mr. McGrath as his supervisors. *See* Staff FOF ¶¶ 2.153-2.155. The Staff adds that "[t]he letter is merely a cover letter transmitting the NOV and proposed Civil Penalty to TVA, and is not part of the NOV." Staff RESP FOF ¶ 2.7. We agree and, accordingly, reject TVA's attempt (TVA FOF ¶ 14.6) to incorporate the cover-letter comments as part of the NOV.

Further, as we held earlier, the cases that require only a short term (1 or 2 months, according to TVA¹⁵) to establish temporal proximity do so when temporal proximity is the sole basis for the alleged claim of discrimination — clearly not the case here. Indeed, even if the Staff may be deemed to be relying here on temporal proximity, the Staff is relying on several other independent bases to prove discrimination. *See* Memorandum and Order (Denying Motion for Summary Disposition), LBP-02-10, 55 NRC 236, 241-42 (2002). And, to reiterate, temporal proximity was used by the Staff only in a contextual sense, to demonstrate that the nonselection was premised to some degree on Mr. Fiser's filing of the DOL complaints and the appointments of Mr. McGrath and Dr. McArthur as Mr. Fiser's supervisors. The DOL itself has approved use of temporal proximity in the same context as may have been used by the Staff here. *See Zinn v. Univ. of Missouri*, 1996 DOL Sec. Labor LEXIS 8, at *3, 4.¹⁶

¹⁴NEI states that the temporal-proximity reference appears in the NOV, but it then quotes from the transmittal letter. *See* NEI Brief at 16: "The NOV states that the 'temporal proximity . . .'" (*citing* NOV at 3). The referenced statement does not appear in the NOV but, rather, the cover letter transmitting the NOV. *See* Joint Exh. 47 (*cf.* Cover Letter at 3, with attached NOV.) As the Staff observes, "[t]he issues relevant to this proceeding are those raised in the NOV itself, not those raised in a [cover] letter by the Staff." Staff RESP FOF ¶ 2.7.

¹⁵*See* TVA FOF ¶¶ 14.4-14.8.

¹⁶The Staff's use of temporal proximity in this proceeding is comparable to the Secretary of Labor's use of that factor in *Zinn v. Univ. of Missouri*, *supra*. As the Secretary of Labor observed,

[t]he ALJ also properly concluded that the temporal proximity between Zinn's protected activity, beginning in August 1992 and continuing through the time of the University's refusal in February 1993 to initiate formal consideration of Zinn for promotion . . . , which is the adverse action at issue here, was adequate to support an inference of a causal link between the protected activity and the University's adverse action.

1996 DOL Sec. Labor LEXIS 8, at *10.

TVA and NEI go on to describe the process in a discrimination complaint in the following way (as to which the Staff does not seem to disagree):

Once the employee has made out a *prima facie* case and the employer has articulated legitimate non-discriminatory reasons for its employment decision, the ultimate burden rests with the employee (here the NRC Staff) to prove by a preponderance of the evidence that the employer's proffered reasons were pretextual and that discrimination was a contributing factor in that decision.

NEI Brief at 4; *see also* TVA FOF ¶ 13.09; Staff FOF ¶ 3.17. Thus, as pointed out in a special Commission-sponsored "Report of Review, Millstone Units 1, 2, and 3," prepared by the Millstone Independent Review Team [MIRT], United States Nuclear Regulatory Commission, dated March 12, 1999 [hereinafter "MIRT Report"], there are four elements for review in discrimination cases:

1. Did the employee engage in protected activity?
2. Was the employer aware of the protected activity?
3. Was an adverse action taken against the employee?
4. Was the adverse action taken because of the protected activity?

Id. at 3-4.

In sum, we conclude that the Staff may properly interpret 10 C.F.R. § 50.7 as including any degree of discrimination for protected activities and as permitting consideration of whether an employee's engagement in protected activities in any degree contributed toward an adverse personnel action, even though not the primary or even a substantial basis for the action. We proceed now to the facts developed in this proceeding, to determine whether the Staff has demonstrated that, at least in part, Mr. Fiser was not selected for a continuing position with TVA because he engaged in protected activities. In that connection, however, TVA does not even attempt to show that Mr. Fiser's protected activities did not play a significant role in his nonselection but, rather, denies that Mr. Fiser's engagement in protected activities played *any* part in its decision not to retain Mr. Fiser as its employee.

C. Findings of Fact

1. Employment History

Mr. Gary Fiser first was employed by TVA in September 1987, as a Corporate Chemistry Program Manager, following service from 1973-1987 in various advancing positions in the Chemistry Department at Arkansas Nuclear One. Tr.

989-91 (Fiser); *see* TVA Exh. 24 at HH000030-HH000031. In approximately April 1988, he assumed duties as a Chemistry Superintendent at TVA's Sequoyah Nuclear Plant. Tr. 991-93 (Fiser); *see* TVA Exh. 24 at HH000030. During this service, the title of the position was changed to Chemistry and Environmental Superintendent. Tr. 1005 (Fiser); *see* Joint Exh. 31, Staff Exh. 44. Mr. Fiser's initial supervisor in this position was Mr. Ron Fortenberry. Tr. 992 (Fiser). Shortly thereafter, Mr. Fortenberry was replaced as Mr. Fiser's supervisor by Mr. Steve Smith, the Sequoyah Plant Manager. Tr. 993 (Fiser). Under both titles of the position, beginning in 1989, Mr. Fiser's supervisor was Mr. Bill Lagergren, Operations Manager at Sequoyah. Tr. 999-1000, 1006 (Fiser).

On January 6, 1989, Mr. Fiser received a performance evaluation with respect to his position as Sequoyah Chemistry Superintendent. *See* Joint Exh. 30. The evaluation was signed by Mr. Steve J. Smith, the Sequoyah Plant Manager, and rated Mr. Fiser's overall performance as "adequate." In most areas, Mr. Fiser was rated as "adequate," although in several he was rated as a "solid" performer (one step higher than "adequate"). With respect to his strengths, the report stated that Mr. Fiser "has a strong technical understanding of the chemistry area; additionally he has considerable experience in this area." Joint Exh. 30, § 4. With respect to areas of needed improvement, Mr. Smith commented that "Mr. Fiser must become more aggressive in the performance of his duties." *Id.* Mr. Fiser disagreed with this evaluation because, in his view, it had been based upon a poor evaluation by INPO that had been largely completed prior to Mr. Fiser's becoming Sequoyah Chemistry Superintendent. Tr. 2438 (Fiser).

Mr. Fiser's next performance appraisal was signed by Mr. Bill Lagergren on September 18, 1989. He commented that "Mr. Fiser's performance for FY88 was adequate and improved to solid performance through the first three quarters of FY89." *See* Joint Exh. 31. The evaluation noted continuing "weaknesses in aggressiveness and communication skills." *Id.* It added that "[f]ollowing specific discussions and coaching in these areas, I have noted improvements, although not to the degree I would have expected." *Id.*

Mr. Fiser's appraisal for the fiscal year ending September 30, 1990, was also signed by Mr. Lagergren, on November 7, 1990. *See* Staff Exh. 44. He was rated "high" in all areas. *Id.* at 3, 3a. The appraisal stated that "Gary's management performance has been very good. He can succeed into a corporate chemistry management position. Would need to gain detailed systems knowledge to go further at plant but has the ability to do so." *Id.* at 1.

In April or May 1991, Mr. Fiser was rotated to the position of Outage Manager for Unit 1, Cycle 5, and Unit 2, Cycle 5. *See* Staff Exh. 45; Tr. 2272-73 (Fiser). He claims that, in that position, he retained no further responsibilities with respect to Chemistry and Environmental Superintendent. Tr. 1008, 2275 (Fiser).

Mr. Fiser's appraisal for FY 1991, signed by Mr. Lagergren on September 30, 1991, covered both Mr. Fiser's service as Chemistry and Environmental Superin-

tendent and his service as Outage Manager. *See* Joint Exh. 32. He was rated highly with respect to chemistry duties: “Very organized and has potential to perform at a higher management level than Chemistry Superintendent. Will rotate to Outage Manager position for U1C5 and U2C5 outages to observe leadership skills outside of his area of expertise.” *Id.* at 1. With respect to Outage Management, however, the appraisal included a caveat: “Is having difficulty operating independently outside the chemistry area. Is not using the authority of his position as an Outage Manager effectively. Will be given feedback and performance will be monitored during the outage.” *Id.*

In January 1992, Mr. Fiser returned to his position as Sequoyah Chemistry and Environmental Superintendent, under a new supervisor, Mr. Pat Lydon. Tr. 1015, 2273 (Fiser). According to Mr. Fiser, during his absence in Outage Management from the Spring of 1991 to January 1992, several problems had arisen in the chemistry program. His rotation to Outage Management was cut short (covering only one of the two outages that he had been expected to manage, that of Unit 1, Cycle 5) when he was called back to Chemistry by Mr. Lagergren to help resolve some of the problems that had arisen in his absence, as to which inquiries had been made by the Nuclear Safety Review Board (NSRB).¹⁷ Tr. 1015, 1017 (Fiser); Joint Exh. 27 at 2. Apparently the NSRB had been advised by Bill Jocher, the Corporate Chemistry Manager, that the Chemistry group at Sequoyah was “out of control.” Tr. 2591 (Fiser). The problems facing the Chemistry group at that time included an alleged failure to generate many of the chemistry trending plots. Tr. 1015-16 (Fiser).

From March 1992 to November 1992, Mr. Fiser was rotated from his position as Chemistry and Environmental Superintendent at Sequoyah to the position of Acting Corporate Chemistry Manager, in the corporate office at TVA headquarters. Tr. 2273-74 (Fiser). This rotation was intended to last for a year (Tr. 1028 (Fiser); *see* Joint Exh. 43), after which Mr. Fiser was supposed to return to Sequoyah (Tr. 1032 (Fiser)).

The Staff asserts that the NSRB Manager, Mr. Thomas McGrath, recommended to the Sequoyah plant management that Mr. Fiser should be removed from Sequoyah. *See* Staff RESP FOF ¶ 2.88. Mr. McGrath denies that claim. Tr. 918-19 (McGrath). However, evidence contained in tape-recorded conversations as

¹⁷ In accord with the facilities’ technical specifications, TVA has established separate NSRBs for its three operating facilities, Browns Ferry, Sequoyah, and Watts Bar. Their primary function is the safety oversight of the plants’ operations. Tr. 385, 386 (McGrath). The NSRB for each facility typically meets quarterly for 2 days, with a briefing by plant managers on emerging issues and subcommittee meetings on the first day, and a full board meeting with discussion of action items on the second day. Tr. 387-89 (McGrath). Mr. McGrath served as Chairman of the NSRBs for all three facilities, beginning in 1989 and ending in 1997. Tr. 376, 379, 380 (McGrath). Mr. McGrath served in several positions at the same time he was NSRB manager, except that in 1995 (through 1997) his sole position was as NSRB manager. Tr. 381 (McGrath).

corroborated by the statement by Dr. McArthur to the TVA OIG that Mr. McGrath wanted Mr. Fiser removed from his Sequoyah Chemistry Superintendent position is more credible than Mr. McGrath's categorical denial. *See* Joint Exh. 27, Staff Exh. 168, Joint Exh. 24. As the Staff points out, "[i]t is unlikely that McGrath would admit to something which evidences discriminatory intent on his part when he is accused of discrimination." Staff RESP FOF ¶2.88. The Board hereby finds that Mr. Fiser's removal from Sequoyah Chemistry in 1992 was motivated at least in part by Mr. McGrath's objections.

At the time of Mr. Fiser's rotation to the Corporate Chemistry Department, the Corporate Chemistry Manager (Bill Jocher) was rotated to Sequoyah. Tr. 1025, 2630 (Fiser). In his Corporate Chemistry assignment, Mr. Fiser's supervisor was Dr. Wilson C. McArthur. Tr. 1025,1039 (Fiser); Tr. 1414 (McArthur); Joint Exh. 33.

Mr. Fiser was not uniformly successful in performing his Corporate Chemistry assignment. His employee appraisal for the fiscal year ending September 30, 1992 (Joint Exh. 33), executed by Dr. McArthur and approved by Dan R. Keuter, the "next higher manager," reached an overall rating of "adequate" (out of a possible high or low for each activity) and indicated many substantial accomplishments, both in his service at Sequoyah and in his subsequent service (beginning in March 1992) as Corporate Chemistry Manager. Among other matters, with respect to Sequoyah the appraisal states that "[t]here have been no Chemistry related findings by INPO [Institute of Nuclear Power Operations] for SQN. THIS IS A RECORD FOR SQN." Joint Exh. 33 at 1 (capitals in original). There is also one seemingly negative comment, pertaining to Mr. Fiser's service as Corporate Chemistry Manager:

Gary has attempted to manage the Chemistry Group under the cloud of the previous manager's strong influence. This has been a difficult task. Efforts to bring this group into full cooperation has been slow and the technical leadership needs attention. This has been a difficult experience by an individual that has performed well in some other efforts (U1C5 Outage Management Team at SQN).

Id. at 2.

Furthermore, at approximately the same time as that appraisal (Sept. 4, 1992), Dr. McArthur was advised by Dan Keuter that, notwithstanding Dr. McArthur's high rating of Mr. Fiser's performance, Mr. Fiser was to get no pay enhancement for the forthcoming fiscal year. Tr. 1042 (Fiser).¹⁸ Mr. Fiser explained that he

¹⁸Dr. McArthur explained that TVA had annual increases of small amounts (2% or 3%) plus annual pay increases or bonuses tied to performance, paid in addition to the small annual increase. Tr. 1417-18 (McArthur). It was the pay increases or bonuses that Mr. Keuter is said to have wished to deny to Mr. Fiser.

had been told by Dr. McArthur that Dan Keuter was blaming Mr. Fiser for all the various chemistry problems that had arisen at Sequoyah. Tr. 1048 (Fiser). On November 16, 1992, Mr. Fiser learned from Dr. McArthur that Rob Beecken, Sequoyah Plant Manager, and Jack Wilson, Sequoyah Vice-President, did not want Mr. Fiser to return to Sequoyah. Tr. 1091, 2617 (Fiser); Joint Exh. 27 at 6.¹⁹

Effective November 23, 1992, Mr. Fiser was demoted from Acting Corporate Chemistry Manager to a position of Acting Program Manager in the Corporate Chemistry organization. Tr. 1420 (McArthur); Tr. 1096, 2274 (Fiser); Staff Exh. 90. Mr. Fiser was first advised of this demotion in early November 1992, by his then-supervisor, Dr. McArthur. Tr. 1047 (Fiser). According to Mr. Fiser, the demotion was directed by Joe Bynum, then a Vice President in the nuclear power organization. Tr. 1047 (Fiser).

In April 1993, shortly after his demotion to Program Manager in the Corporate Chemistry organization, Mr. Fiser received a “surplus” notice (i.e., a predecessor to a Reduction in Force (RIF) notice), from the position of Sequoyah Chemistry and Environmental Superintendent, transferring him to the employee transition program, where employees facing “surplus” notices were transferred so that they could seek other employment at TVA or elsewhere. Tr. 1097, 1100 (Fiser); *see* Joint Exh. 59. While in the employee transition program in July 1993, Mr. Fiser interviewed for several jobs at TVA, including the Sequoyah Chemistry Manager position that he had occupied previously. Tr. 1102-04 (Fiser). During this period, Dr. McArthur offered to help Mr. Fiser secure a position at TVA and elsewhere, and for that reason was considered an ally by Mr. Fiser. Tr. 1120-21 (Fiser).

Mr. Fiser claims that he was offered the Sequoyah Chemistry Manager position in July 1993 by Charles Kent and Ken Powers but that the offer was withdrawn shortly thereafter after Charles Kent discussed the matter with Dr. McArthur (who discussed it with Joe Bynum and Dan Keuter²⁰). Tr. 1105-09, 1111, 2342-43, 2346 (Fiser). Mr. Fiser recalled that he was informed by personnel in the employee transition program that the Sequoyah Chemistry job was “blocked at the highest level.” Tr. 1112 (Fiser). According to Mr. Fiser, although he previously had viewed Dr. McArthur as an “ally,” he lost confidence in Dr. McArthur when he became aware that Dr. McArthur had “torpedoed” the Sequoyah Chemistry offer, telling Charles Kent that corporate management did not think highly of Mr. Fiser’s managerial skills and past performance. Tr. 2342-47 (Fiser). As stated by Mr. Fiser, “this man [Dr. McArthur] can look you right in the face and tell you one thing, and do another.” Tr. 2347 (Fiser).

¹⁹Mr. Fiser was so advised by Mr. Wilson on November 21, 1992, and by Mr. Beecken on December 9, 1992. *See* Tr. 1092 (Fiser).

²⁰Mr. Fiser claimed that both Joe Bynum and Dan Keuter had previously been involved in his removal from Sequoyah Chemistry.

The Licensing Board here notes its agreement with the characterization, as the Staff observes, that “McArthur would tell an employee one thing, and then do the opposite behind his back.” Staff FOF ¶ 2.199. We find that the conflict between Dr. McArthur’s early position as an “ally” of Mr. Fiser (including his offer to help Mr. Fiser seek alternate TVA employment) and his later action preventing Mr. Fiser from being hired as Sequoyah Chemistry Manager while in the employee transition program adversely affects Dr. McArthur’s credibility as a witness. (*See also infra* p. 577.)

Several months later, when he had not found another TVA job, Mr. Fiser received a notice RIFing him from the Sequoyah Chemistry position. *See* Joint Exh. 60. Mr. Fiser was not then occupying that position, however, nor did he return to it thereafter. Tr. 2274 (Fiser). (In fact, following his service in Outage Management, Mr. Fiser only served as Sequoyah Chemistry and Environmental Superintendent for a few weeks, in January-February 1992 (*id.*)). In view of these circumstances, and as part of the settlement of Mr. Fiser’s 1993 DOL complaint (*see infra* pp. 576-77), the “surplus” and “RIF” notices were subsequently withdrawn. Tr. 3357, 3359, 3363 (Reynolds); *see* Staff Exh. 110 at 3.

On August 16, 1993, Mr. Fiser and two other TVA employees (Mr. W.F. Jocher and Dr. D.R. Matthews) jointly wrote a letter to U.S. Senator James Sasser of Tennessee, stating that there was a “repressive management structure” within TVA’s nuclear power agency that, in fact, made senior managers “fearful of using the corrective action process.” *See* Staff Exh. 29 at 1 (CB000130). The letter went on to state that adherence to an “unwritten rule, ‘don’t report or document safety related problems, especially those requiring capital dollars to fix,’ ensures longevity at TVA.” *Id.* It further documents that Mr. Jocher, a manager with 28 years in the industry, had been coerced to resign; that Mr. Fiser had been demoted and surplused after 20 years in the industry; and that Dr. Matthews, an employee at Watts Bar, had been demoted after 20 years in the industry. *Id.* The letter provides examples of asserted safety-related problems that each of the three employees had been attempting to correct. The letter advises that Mr. Jocher and Dr. Matthews had each filed DOL complaints concerning TVA’s handling of safety questions and that Mr. Fiser was planning to do so in the near future.²¹ Copies of this letter were forwarded to NRC officials. Staff Exh. 29 at 7 (CB000136).

In our view, this letter in itself constitutes another “protected activity” in which Mr. Fiser participated. *See* 10 C.F.R. §§ 50.7(a)(1)(i) and (iv).²² TVA and

²¹ Mr. Fiser’s DOL complaint, referenced earlier in this Decision at p. 559, was filed on September 23, 1993. *See* Staff Exh. 34.

²² TVA criticizes the Staff for relying on the Sasser letter during the hearing, when it had not been referenced in Mr. Fiser’s 1993 or 1996 DOL complaints (Staff Exhs. 34 and 37), or in the September

(Continued)

the Staff do not dispute this characterization (TVA FOF ¶ 17.2, TVA Reply FOF at 95, Staff RESP FOF ¶¶ 2.76-2.77) and we so hold.

Some of the problems that were assertedly identified or raised by Mr. Fiser, and included in the letter to Sen. Sasser, were (1) “PASS equipment availability and design problems which limit use of the equipment and contribute to job knowledge problems in this area” (Staff Exh. 29 at 4 (CB000133)); (2) problems with the emergency diesel generator 7-day storage tank; (3) a recirculation system that rendered the emergency diesel generator “inoperable” and placed both units at Sequoyah on a Limited Condition of Operation (LCO) (*id.*); (4) process chemistry equipment availability being unacceptably low (many times 50% or less); (5) money budgeted to implement a comprehensive raw cooling water treatment program to preclude corrosion and biological fouling of safety-related equipment was “cut from the budget year after year” (*id.*); and (6) the inability of chemistry technicians to draw a reactor coolant sample from PASS during an accident in under 3 hours, for the purpose of assessing reactor vessel and fuel conditions.²³

The letter also stated, with respect to problems on which Mr. Jocher had been working, that he “identified to NSRB a material false statement made to NRC.” Staff Exh. 29 at 3 (CB000132). The letter further states that “[a]dditional material false statements may have recently been made by TVA in response to Mr. Jocher’s allegation.” *Id.*

Mr. McGrath, who was then NSRB Chairman, testified in this proceeding that he never knew about the “material false statement” allegation. “[N]o one ever brought an issue up to NSRB about TVA having made a material false statement.” Tr. 416 (McGrath). He added that that would have been a “big issue.” He also testified that he was unaware of the Sasser letter until the discovery phase of this proceeding (in November 2001). Tr. 415-17 (McGrath). The Licensing Board believes that Mr. McGrath’s testimony in this regard, particularly with respect to the advice the NSRB is said to have received concerning a material false statement, along with his denial of contacting management at Sequoyah seeking Mr. Fiser’s removal following the trending incident (*see supra* pp. 571-72), reflects adversely on his credibility.

1999 letter notifying TVA of an apparent violation (Joint Exh. 47), or listed as a protected activity in the September 2001 responses to TVA’s first set of interrogatories (TVA Exh. 113 at 1-4). TVA noted that the Sasser letter was first described as a protected activity in a January 24, 2002 response to TVA interrogatories. *See* TVA FOF ¶ 4.30. Prior to the evidentiary hearing, therefore, TVA had notice of the Staff’s reliance on the Sasser letter.

²³The letter indicated that the Sequoyah Site Vice President, Mr. Jack L. Wilson, sought a more flexible time limit but that the 3-hour limit was set forth in then-current NRC Regulatory Guide 0737 and was supported by representatives of NRC’s Office of Nuclear Reactor Regulation (NRR). The Board hereby notes that Regulatory Guides are not regulations but provide guidance as to practices that will be deemed acceptable to the NRC Staff.

On September 23, 1993, Mr. Fiser filed a complaint with the DOL regarding his RIF and termination notice from TVA. *See* Staff Exh. 34. As part of this complaint, Mr. Fiser identified a number of safety concerns (some of which had also been included in the letter to Sen. Sasser) where, according to Mr. Fiser, TVA management took steps to interfere with their proper resolution.

Specifically, Mr. Fiser in his 1993 DOL complaint (1) set forth, in detail, a problem that had occurred with respect to radiation monitor set points, asserting that Rob Beecken, then Sequoyah Plant Manager, was angry with him because the problem with the radiation monitor set points had been reported and documented through a Significant Corrective Action Report (SCAR) (*id.* at AJ000135); (2) identified the filter change-out scenario as one where TVA management (in particular, Mr. Beecken) had problems because of its occurrence and documentation; (3) identified a dispute over NRC's 3-hour requirement for conducting PASS analyses; and (4) claimed that in July 1993, while he was in the employee transition program, he had been offered the job of Chemistry Manager at Sequoyah by Charles Kent, Sequoyah RadChem Manager, but that this offer fell through after protests by TVA upper management. Further, in his 1993 DOL complaint, Mr. Fiser noted that the Chemistry Manager position from which he had been surplusd had not actually been eliminated but had simply been recreated with a different title. *See* Staff Exh. 34 at AJ000135. Mr. Fiser also stated that the Sequoyah RadChem Manager, Charles Kent, offered him the Chemistry Manager position in July 1993, but that this offer was later withdrawn because he had a "target" on his back. *Id.* at AJ000138.

In support of his 1993 DOL complaint, Mr. Fiser had tape-recorded — "surreptitiously," according to TVA (*see* TVA FOF at 32 n.10) — a number of conversations with his co-workers, including supervisors. *See* Staff Exhs. 168, 169, 178, 179; TVA Exh. 148. These tape recordings commenced in about November 1992, and were undertaken by Mr. Fiser because he "began to suspect something was awry." Tr. 1050 (Fiser). He later would transcribe some of the recorded conversations, preparing a document entitled "Sequence of Events" (*see* Joint Exh. 27) that was based on the tapes, notes from his Day Planner, and his memory. Mr. Fiser later used this "Sequence of Events" in support of his 1993 DOL complaint. Tr. 1051-52 (Fiser).

In April 1994, TVA and Mr. Fiser reached a settlement agreement with respect to Mr. Fiser's 1993 DOL complaint. *See* Joint Exh. 34. As a result, the RIF notice was withdrawn and Mr. Fiser was placed in a PG-8 position of Corporate Chemistry Program Manager, Technical Support. Ronald Grover

was his immediate supervisor and Dr. McArthur his second-line supervisor. Tr. 1820-21 (Grover), Tr. 2290 (Fiser).²⁴

After settlement of the 1993 DOL complaint, Dr. McArthur advised Ronald Grover, Mr. Fiser's new supervisor, that Mr. Fiser had begun taping conversations with his colleagues. Tr. 1850 (Grover). Mr. Grover felt that Dr. McArthur was attempting to influence negatively his perception of Mr. Fiser (Tr. 1853 (Grover)), but Dr. McArthur explained that he simply wished to make Mr. Grover aware of the tapes (Tr. 1586 (McArthur)). In any event, Mr. Grover stated to Dr. McArthur that he (Grover) was not concerned with past incidents but preferred to form his own opinion of Mr. Fiser based upon performance in his new position. Tr. 1851 (Grover).

It is unclear what effect, if any, the taping played in Mr. Fiser's continuing employment with TVA. Dr. McArthur at one point stated that he did not feel uncomfortable and was not concerned about having his conversations taped by a co-worker. Tr. 1462, 1682 (McArthur). But at another point he also testified to the contrary, that he found the taping very offensive, and that he could tell when Mr. Fiser was trying to tape conversations with him. Tr. 1586 (McArthur). Dr. McArthur also discussed Mr. Fiser's taping with the site RadChem managers. Tr. 1850-51 (Grover). Further, Mr. Grover testified that, on one occasion, he had asked Mr. Fiser to attend on his (Mr. Grover's) behalf a peer team meeting of the RadChem managers (Tr. 1855 (Grover), Tr. 2311 (Fiser)) and that, during the meeting, Mr. Fiser was asked to leave because the peer team would be discussing sensitive matters and did not wish to do so in Mr. Fiser's presence (Tr. 2313 (Fiser)). Dr. McArthur later told Mr. Grover that the RadChem managers felt uncomfortable about discussing sensitive matters in Mr. Fiser's presence because of the taping practices. Tr. 1856-57 (Grover).

With regard to Dr. McArthur's testimony concerning the taping, we note that Dr. McArthur, in response to Staff questioning, appears not to have been disturbed about the practice but that, in response to TVA cross examination, found it to be offensive. We agree with the Staff that Dr. McArthur's "ability to state different opinions based upon who is asking the question" adversely affects his credibility as a witness. *See* Staff FOF ¶2.200.

In 1994, the Corporate Chemistry Program Manager position that Mr. Fiser was occupying as a result of the 1993 DOL settlement agreement was itself the subject of a reorganization. The Corporate Chemistry and Environmental organizations were combined into one organization under one manager. *See* TVA FOF ¶5.1, Staff FOF ¶2.50. At that time, Dr. McArthur became RadCon Manager, a PG-11 position. Tr. 3794 (Boyles).

²⁴ As part of the agreement, Mr. Fiser's PG-8 salary was retroactive to October 4, 1993, and he was reimbursed certain expenses attributable to his DOL complaint. Joint Exh. 34 at 2.

In that reorganization, Mr. Fiser was given a surplus notice and required to compete for a new position. TVA acknowledges that, if Mr. Fiser were not selected for a new position, he would have been transferred to TVA Services. TVA FOF ¶5.2. Mr. Fiser in fact was selected for one of several PG-8 positions (same grade as his earlier position), that of Chemistry and Environmental Protection Senior Program Manager. Tr. 2290, 2303-04 (Fiser); Staff Exh. 43. Ronald Grover was the selecting official for the Chemistry and Environmental Protection Program Manager positions. Tr. 2302 (Fiser), Tr. 3588 (Grover). Thus, in the fall of 1994, Mr. Fiser left the position designated in the settlement (which position was then eliminated) and entered into a new position. Whether such transfer was “voluntary,” as claimed by TVA (TVA FOF ¶5.3), is questionable. At best it was a palliative choice by Mr. Fiser of taking the position or being RIFed (i.e., discharged).²⁵

At the time of the 1994 reorganization, the intent was for the chemists and environmental specialists to cross train and learn the functions of the other specialization so that each could be proficient in both fields. Tr. 1827-28 (Grover). The four employees selected for these PG-8 positions were Mr. Fiser, Mr. Sam Harvey, and Dr. E.S. Chandrasekaran (“Dr. Chandra”), all chemistry specialists, and Mr. David Sorrelle, an environmental specialist. Tr. 1830.²⁶ The intent for those employees to become functionally proficient in both areas through exercise of duties in both areas was not effectually realized, however, inasmuch as the three chemists continued to perform 95-99% chemistry-related duties in their new positions. Tr. 1885-86 (Grover), Tr. 2311 (Fiser), Tr. 5036 (Harvey).

In his performance evaluations for Fiscal Years 1994 and 1995, Mr. Fiser performed satisfactorily in his respective positions of Chemistry Program Manager and Senior Chemistry and Environmental Specialist, both under the supervision of Ronald Grover. *See* Staff Exhs. 46 (Performance Review and Development Plan, 10/1/93 to 9/30/94) and 47 (Performance Review and Development Plan, 10/1/94 to 9/30/95). For Fiscal Year 1994, Mr. Fiser exceeded expectations in eight of the behavioral areas on which he was rated, and met expectations in three areas. He received no lower ratings, and his overall evaluation was “meets” expectations. Staff Exh. 46. In Fiscal Year 1995, Mr. Fiser exceeded expectations

²⁵ TVA points out that, despite similarities between the 1993, 1994, and 1996 reorganizations, Mr. Fiser opted not to file a DOL complaint in 1994. TVA FOF ¶5.6. As the Staff points out, however, the circumstances surrounding each of these reorganizations were different. Staff RESP FOF ¶2.95. In particular, in 1994, Mr. Fiser was not dissatisfied with the position to which he was transferred, whereas in 1993 and 1996 he was RIFed. We accordingly find that the differences in the three reorganizations make it eminently reasonable for Mr. Fiser to have elected not to file a DOL complaint in 1994.

²⁶ A fifth employee, Mr. Jim Mantoath, was selected for a lower-level PG-7 position in that reorganization. Tr. 1830-31 (Grover).

in six areas and met expectations in six areas. He received no lower evaluations in any area, and his overall evaluation again was “meets” expectations. Staff Exh. 47. Neither Dr. McArthur nor Thomas McGrath, then Chairman of the Nuclear Safety Review Board (NSRB),²⁷ had any input into the foregoing performance evaluations. Tr. 2311 (Fiser).

In October 1995, Thomas McGrath became Acting General Manager of Operations Support, Mr. Fiser’s second-level supervisor. Tr. 429 (McGrath). At the time, Mr. Grover remained Mr. Fiser’s direct supervisor. In early 1996, Mr. McGrath informed the managers directly reporting to him — including both Mr. Grover and Dr. McArthur — that the Operations Support Group that he headed would be undergoing another reorganization. Tr. 436 (McGrath). The staff reductions accompanying this reorganization could have been spread over 4 years — indeed, the target for the first year (FY 1997) was a minimum budgetary saving of 17%. Tr. 433-34 (McGrath). (By FY 2001, the target was a budgetary reduction of about 40% (Tr. 434 (McGrath), Tr. 1861 (Grover)). For his part, Mr. Grover recommended that no incumbents lose their jobs during the first year but that an already-vacant position (the Corporate RadChem Manager) be eliminated. Tr. 1862 (Grover). Mr. McGrath’s position prevailed. He directed Mr. Grover to prepare a plan that eliminated all but two Chemistry Manager positions. Tr. 1860 (Grover). The Operations Support organization thus underwent approximately a 40% budget reduction the first year (FY 1997).

The two surviving Chemistry Manager positions were a PWR Chemistry Program Manager position and a Boiling Water Reactor (BWR) Chemistry Manager position. Tr. 453 (McGrath), Tr. 1699 (McArthur), Tr. 1863 (Grover). On June 17, 1996, Mr. McGrath announced the creation of these positions and also that they would be advertised. Tr. 2339 (Fiser). He further announced that Dr. McArthur had been selected (without advertising) as the RadChem Manager, the selecting official for the new Chemistry Program Manager positions. Tr. 2339-40 (Fiser). Reacting to the decisions to select Dr. McArthur (without advertising) as RadChem Manager, and to advertise the PWR Chemistry Program Manager position that Mr. Fiser was seeking to fill, Mr. Fiser on June 25, 1996, filed an additional DOL complaint. *See* Staff Exh. 37. Five weeks later, Mr. Fiser was not selected for the PWR Program Manager position. *See* Joint Exh. 20 at GG000022. As described in further detail below, this nonselection of Mr. Fiser, as well as the nonadvertised selection of Dr. McArthur for a position higher in grade from that he officially held earlier, although purportedly carried out under prescribed TVA procedures, was fraught with sufficient errors to raise a reasonable inference that

²⁷ Mr. McGrath became Chairman of the NSRB in late 1989, although he continued to serve in other positions simultaneously. Tr. 376 (McGrath). He remained Chairman of the NSRB until 1997. Tr. 380 (McGrath).

the nonselection was motivated by extraneous reasons, such as the employee's involvement in protected activities.

As a result, Mr. Fiser was given the option of transferring for the remainder of the fiscal year to TVA Services (an option that has been deemed to be an adverse action under section 211 of the ERA, *see Overall v. TVA*, Nos. 97-ERA-50, 97 ERA-53, 2001 DOL Ad. Rev. Bd. LEXIS 31 (ARB Apr. 30, 2001), *aff'd sub nom. TVA v. Sec'y of Labor*, 59 Fed. Appx. 732 (6th Cir. 2003)) or resigning his TVA employment, including payment of a generous severance package that TVA was then offering. Joint Exh. 28. Mr. Fiser opted to resign, to avoid the risk that, if transferred to TVA Services and not offered a suitable job, he would risk losing the salary and severance pay that attended a resignation at that time. Tr. 2374 (Fiser).

2. Nature of Protected Activities

As set forth earlier, in order to demonstrate discrimination on the part of TVA, the Staff must demonstrate that Mr. Fiser engaged in one or more protected activities, that TVA was aware of those activities, and that Mr. Fiser suffered an adverse action for engaging in such activities. That the Staff has succeeded in demonstrating Mr. Fiser's engagement in protected activities is in fact conceded by TVA, which has acknowledged that Mr. Fiser's filing of the 1993 DOL complaint, as well as the 1993 Sasser letter, and the 1996 DOL complaint, themselves constituted protected activities. The Board agrees with and adopts that conclusion.

Moreover, one or both of the TVA management officials involved in the adverse action against Mr. Fiser clearly had contemporaneous knowledge of Mr. Fiser's 1993 DOL complaint and the 1993 Sasser letter, as well as the 1996 DOL complaint. Dr. McArthur in particular knew of all these activities. *See* Staff Exh. 31 (Sasser letter), Joint Exh. 24 (1993 DOL complaint), Tr. 1647 (McArthur) (1996 DOL complaint). Mr. McGrath knew of the 1996 DOL complaint and, at the time of the SRB interviews, and prior to the decision concerning the PWR RadChem Manager position, also had knowledge of the 1993 DOL complaint. Tr. 730 (McGrath).

TVA denies, however, that any of the specific safety matters set forth in the DOL complaints or the Sasser letter constitute protected activities on the part of Mr. Fiser. *See* TVA FOF ¶¶4.7, 4.9; TVA Reply FOF at 95, 98. TVA asserts that Mr. Fiser did not "discover, raise, report, or document" any of those specific issues. TVA FOF ¶4.9. For its part, the Staff claims that protected activities include not only the discovery, raising, reporting, and/or documentation of such issues but also participation in their resolution. Staff RESP FOF ¶2.66 (citing *Zinn v. Univ. of Missouri*, Nos. 93-ERA-34, 93 ERA-36, 1996 DOL Sec. Labor LEXIS 8 (1996)). Specifically, *Zinn* makes it clear that protected activities are

not limited to those initially raised, documented, or identified by the complainant. The factual situation in *Zinn* is analogous to that before us in this proceeding. Accordingly, we regard the Staff's definition of protected activity, which is in accord with the *Zinn* decision, as more persuasive than TVA's restricted definition and, accordingly, we adopt the Staff's position. Thus, to the extent Mr. Fiser was actively involved in the resolution of a safety-related issue, the Board regards him as being engaged in a protected activity, whether or not he formally discovered, raised, reported, or documented such issue.

a. General Considerations: Hostile Work Environment

Before turning to the specific protected activities in which Mr. Fiser claims to have been involved, we address the Staff's assertion that TVA, in general, fosters a work environment hostile toward whistleblowers that discourages workers from attempting to develop or assert or document any protected activities. *See* Staff FOF ¶¶ 3.125-3.130; Staff RESP FOF ¶¶ 2.17-2.19. That claim appears to the Board to be well founded.

In that respect, Ms. Tresha Landers, an engineering intern who was a co-worker of both Mr. Fiser and Mr. Sam Harvey, testified that people at TVA would talk about workers who filed complaints and thereafter were "out the door," or interns who "had a problem" were subsequently not hired. Tr. 2050-51 (Landers). Mr. Sam Harvey, a witness presented by TVA itself, stated that, prior to 1997, he feared retaliation if he raised issues regarding harassment and intimidation. Tr. 5054-55, 5057 (Harvey). He testified that he had not earlier raised some of the issues in his November 27, 1997 memorandum because he feared retaliation from his supervisors, including Dr. Wilson McArthur. Tr. 5058 (Harvey). And Dr. McArthur himself, in a recorded conversation between himself and Mr. Fiser, acknowledged that TVA has a work environment that is hostile to those who find and document problems or file complaints. *See* Joint Exh. 27 at 71. Specifically with respect to Mr. Fiser, Mr. Fiser advised Dr. McArthur of his plan to file a DOL complaint concerning his RIF from Sequoyah Chemistry (see discussion *supra* p. 576) and was warned by Dr. McArthur against taking such action because people "don't want somebody that is a troublemaker A lot of companies will not hire you if you have a legal history." Joint Exh. 27 at 80.

Supplementing these statements by various witnesses was that by Mr. Patrick M. Lydon, a former TVA employee, who advised the TVA OIG that he had resigned because he was "disgusted with senior executive management." TVA Exh. 122, OIG Interview of Lydon, at 3. Mr. Lydon reportedly stated that TVA was "the most abusive place" he had ever worked. *Id.* Mr. Lydon apparently commented that Messrs. Bynum and Beecken would "fire people for effect." *Id.* (For his part, Mr. Beecken denied knowing the basis for Mr. Lydon's statement. Tr. 4835 (Beecken).)

TVA counters these “hostile environment” arguments by advancing platitudinous assurances both that it is committed to nuclear safety and that it is TVA policy to protect employees from retaliation for raising nuclear safety concerns. To illustrate its commitment to nuclear safety, TVA asserts (TVA FOF ¶2.3) that it has adopted, as one of its basic Principles and Practices, a Commitment to Nuclear Safety. Tr. 881 (McGrath); *see* TVA Exh. 65. TVA further asserts that it has also adopted, as a lower-tier document, a policy entitled TVA Communications Practice 5, *Expressing Concerns and Differing Views*, which expressly states that employees “found guilty of acts of reprisal, such as acts of intimidation, harassment or discrimination, against an employee because the employee expressed a differing view is subject to disciplinary action, up to and including termination.” Tr. 590-91 (McGrath); *see* TVA Exh. 66.

TVA goes on to claim that its establishment of NSRBs at Sequoyah, Watts Bar, and Browns Ferry “is inconsistent with retaliating against an employee for raising nuclear safety concerns.” TVA FOF ¶2.5. It adds that NSRBs are not in the plant chain of command and neither issue orders about plant operations nor make personnel decisions. TVA FOF ¶2.7. As the Staff observes, however, the NSRBs are mandated by the plants’ licenses, i.e., as a technical specification. Through this technical specification, the NRC itself both required that NSRBs be established and set forth a number of the NSRBs’ duties. *See* Staff RESP FOF ¶2.19 (*citing* Mr. McGrath at Tr. 592); *see also* Tr. 379-80 (McGrath). Thus, according to the Staff, the creation of NSRBs should not be viewed as a voluntary commitment by TVA to enhance safety. Staff RESP FOF ¶2.19.

Beyond that, the Staff observes that there is no evidence to indicate that TVA has actually imposed any meaningful disciplinary action on those (if any) who are found guilty of whistleblower retaliation. *Id.* ¶2.18. Mr. McGrath was not aware of any. Tr. 883 (McGrath). For these reasons, the Board gives little weight to TVA’s testimony (*see* TVA FOF ¶¶2.3-2.7) that attempts to disprove the Staff’s claim that TVA fosters a work atmosphere that is hostile to whistleblowers.

b. Specific Protected Activities

Although the Staff is not relying only on Mr. Fiser’s participation in any technical protected activities — its primary reliance is on the letters to DOL or to Sen. Sasser that are conceded by TVA to be protected activities — we nonetheless view those technical activities as necessary adjuncts to the Staff’s theory. Active participation in at least one of these issues lends substantive significance to the DOL complaints and the Sasser letter which, in themselves, admittedly constitute protected activities. In other words, active participation would remove any inference that Mr. Fiser was merely “working the system” to attain personal advantages. We thus turn *seriatim* to a consideration of each of the asserted protected issues, and Mr. Fiser’s role with respect to such issues.

(i) RADIATION MONITOR SET POINTS

The radmonitor set-points issue was the first of the specific issues referenced in the 1993 DOL complaint. The issue was first identified to TVA by NRC through an IE bulletin in 1982, prior to Mr. Fiser's employment by TVA. Tr. 1129, 2641 (Fiser). The bulletin indicated that TVA should account for vacuum (or negative pressure) in a noble gas chamber. Tr. 2641-42 (Fiser).

After Mr. Fiser was hired by TVA in 1987, and assigned to Sequoyah Chemistry in 1988, he inquired (based on his earlier experience with Arkansas Power & Light Company) whether TVA had taken the bulletin into account and was told that it was "not a problem." Tr. 2642-43 (Fiser). A SCAR (Significant Corrective Action Report) delineating the problem and the necessary corrective actions was not prepared or issued until Mr. Fiser had left Sequoyah Chemistry. Tr. 2643 (Fiser). But Mr. Fiser claims that, while at Sequoyah Chemistry, he "certainly had a part to play" in identifying the problem (Tr. 1136 (Fiser)) because he "started the questioning process about the way . . . the issue was resolved." *Id.* "I started the initial investigation" into the problem (Tr. 2644 (Fiser)) by questioning Don Amos, the chemical engineer on the Chemistry staff who worked for Mr. Fiser and had helped answer (albeit incorrectly) the IE Notice in 1982 (Tr. 2647 (Fiser)). Indeed, as part of the TVA Office of Inspector General (OIG) investigation of Mr. Fiser's 1993 DOL complaint, Mr. Fiser indicated to the OIG representative that Don Amos had acknowledged that he had given the "wrong information" to Mr. Fiser about the radiation monitor set points. Staff Exh. 35 at AJ000115.

Mr. Fiser further testified that the radiation monitor set-points issue was one of the contributing factors to Rob Beecken's (Sequoyah Plant Manager) displeasure with him (Tr. 1129-30 (Fiser)). Indeed, based on a conversation held with Mr. Beecken on December 9, 1992, Mr. Fiser claimed it is one of the reasons Mr. Beecken did not want him to return to Sequoyah following his scheduled 1-year rotation to Corporate Chemistry (Tr. 1129-30, 2638-39 (Fiser)).

During his testimony, Mr. Beecken testified that he was dissatisfied with Mr. Fiser for not having resolved the issue satisfactorily during his (Fiser's) tenure as Chemistry Manager. Tr. 4810 (Beecken). Mr. Fiser apparently advised Mr. Beecken during their December 9, 1992 conversation that he (Fiser) tried to resolve the issue by talking with Engineering about the problem and was told by Engineering that it was correct. Tr. 4811 (Beecken). According to Mr. Beecken, Mr. Fiser stated that "I talked to Engineering and they told me it was correct. But I tried. I raised the issue [with Engineering] 13 times. I tried." *Id.* But, according to Mr. Beecken, "it didn't happen." Mr. Beecken advised Mr. Fiser that "that's the type of issue that needs to be escalated, moved upwards in the chain of command so that they can interdict and correct those types of problems." *Id.* Mr. Beecken would have escalated this issue to the OPS Manager or Plant Manager. Tr. 4812 (Beecken). And he criticized Mr. Fiser for not preparing a

corrective action document (like the SCAR that was prepared after Mr. Fiser left). *Id.* Mr. Beecken added that Mr. Fiser was not responsible for identifying the issue but that he (Fiser) had not dispositioned it properly. Tr. 4814-15 (Beecken).

TVA claims that Mr. Fiser did not identify, document, or otherwise raise the issue about the radmonitor set points. TVA FOF ¶¶4.12-4.13. And it “strongly disputes” that this matter, *inter alia*, describes any protected activity in which Mr. Fiser engaged. TVA FOF ¶4.7.

The Board agrees that Mr. Fiser did not initially raise the issue before TVA. Nor did he sign the corrective action document (SCAR) that closed the issue. That document was prepared and signed by the technician who had given incorrect information about the issue to Mr. Fiser. But Mr. Fiser also did not let the issue die. He suspected that the issue had not been resolved properly, and he participated in the discussion of salient parts of the issue that eventually led TVA to undertake corrective action. Moreover, he was criticized by management for not having resolved the issue satisfactorily. Mr. Fiser thus may be regarded as at least peripherally raising the issue and preparing TVA for its proper resolution. Furthermore, the criticism that Mr. Fiser did not act properly to resolve the issue does not mean that Mr. Fiser did not participate in its resolution, only that in TVA’s view he participated inadequately. This participation is enough for us to conclude that Mr. Fiser was sufficiently engaged in the first of the protected activities that he incorporated into his 1993 DOL letter to warrant his association with such activity, and we do so here.

(ii) FILTER CHANGE-OUT SCENARIO

With respect to the second issue in the 1993 DOL letter — the filter change-out scenario — TVA claims that Mr. Fiser did not identify, document, or otherwise raise this issue. TVA FOF ¶¶4.14-4.15. The record reflects that the problem occurred and was documented in July 1991, during the period when Mr. Fiser was assigned to Outage Management. Tr. 2678 (Fiser). An employee in Sequoyah Chemistry (not Mr. Fiser) discovered that containment radiation monitor valves had not been properly aligned after sampling activities. Staff Exh. 34 at AJOOO136. Thereafter, a SCAR was prepared and placed into the corrective action system. However, Mr. Fiser did not instruct anyone to report this issue. Tr. 2671, 2672 (Fiser). In fact, he conceded that the instructions he claimed to have given were generic instructions given to everyone at the plant. Tr. 2682-83 (Fiser). Mr. Beecken allegedly would have preferred that the problem be resolved without reporting it. But the record fails to demonstrate that Mr. Fiser was anything more than an observer or that he played any part in raising, settling, or reporting this issue (except to DOL) or in resolving the problem. (The record also fails to reflect whether the person who raised and documented the problem was disciplined for doing so.) The issue accordingly does not appear to qualify

as a protected activity in which Mr. Fiser actively participated, and we decline to consider it as such.

(iii) PASS ANALYSES

The third of the issues listed in the 1993 DOL complaint (as well as being identified in the letter to Sen. Sasser) was a dispute over NRC's 3-hour requirement for conducting Post Accident Sampling System (PASS) analyses. According to the Staff (Staff FOF ¶ 2.115), Mr. Fiser and Mr. Jocher (working together) determined that personnel at the Sequoyah plant could not meet this 3-hour requirement, whereas site Vice President Jack Wilson differed in the interpretation of the requirement. Further, after NRC confirmed, upon inquiry from Mr. Jocher, that the regulatory interpretation by Mr. Fiser and Mr. Jocher was correct, TVA conducted tests that confirmed that Sequoyah personnel indeed lacked the ability to meet this requirement. *See* Staff Exh. 34 at AJ000136.

TVA asserts that Mr. Fiser did not identify, document, or otherwise raise the PASS issue. TVA FOF ¶¶ 4.16-4.19. It claims that the NSRB, not Mr. Fiser, initially raised the question whether Sequoyah personnel could meet the PASS requirements. Tr. 890 (McGrath). According to TVA, the NSRB (at least, its Radiation and Chemistry Subcommittee) first identified the question at its May 22-23, 1991 meeting, where it questioned whether PASS training of TVA employees recognized time/exposure constraints and recommended more realistic training. *See* Joint Exh. 1, NSRB Minutes of Meeting No. 132 (May 22-23, 1991) at CC000087-88; Tr. 607 (McGrath). The subcommittee recommended:

Include proficiency parameters in training to ensure original design criteria can be met in accordance with NUREG-0737. Ensure that the above is performed in the same anti-c's/respiratory protection anticipated for post-accident sampling conditions (A132-6).

Joint Exh. 1 at CC000088. At that time, Mr. Fiser was not in charge of Sequoyah Chemistry but, rather, had been rotated to Outage Management. *See supra* p. 570.

With respect to a subsequent NSRB meeting on August 21-22, 1991, the minutes reflect that "Post-Accident Sampling System training concerns have not been addressed and this action item remains open (A132-6)." Joint Exh. 2 at CC000092. At that time, Mr. Fiser was still in Outage Management — indeed, he was not responsible for Sequoyah Chemistry for any period between the initial NSRB directive on the subject and this one.

The PASS problem was considered again by the NSRB at its meeting on November 20-21, 1991. The minutes for that meeting state:

Post-Accident Sampling Training (A132-6)

The NSRB was concerned that training on the post-accident sampling system did not recognize the time or radiation exposure constraints that exist when collecting and analyzing samples. The NSRB reviewed the site response on this item and discussed it with the Site and Corporate Chemistry managers. It was found that Corporate Chemistry did not agree with the site response, and it remained questionable whether the sampling time requirements specified in the procedure could be met. The NSRB also pointed out that Corporate Chemistry should have been involved earlier with the site in addressing this concern. This item remains open.

Joint Exh. 3 at CC000095. As indicated above, Mr. Fiser was still in Outage Management at the time of the November 20-21 NSRB meeting, and had been assigned to Outage Management at all times between this meeting and the prior meeting on August 21-22, 1991.

According to TVA, when the NSRB met on February 19-20, 1992, it was dissatisfied that the issue had still not been resolved by Sequoyah Chemistry. (Mr. Fiser had rejoined Sequoyah Chemistry in January 1992.) There had not, however, been any formal directive for Sequoyah Chemistry to resolve the issue — indeed, only a subcommittee recommendation. The NSRB at its February 19-20, 1992 meeting thus set up an “action item” that would remain open until all shifts could demonstrate that they could meet the requirements. Tr. 677-78 (McGrath); *see* Joint Exh. 4 at CC000105. Mr. McGrath was NSRB Chairman at that time. Mr. Fiser was with Sequoyah Chemistry for only a week or two of that period, after which he was transferred to Acting Corporate Chemistry Manager in early March 1992.

Putting together the pieces of this puzzle, we infer that, during this brief period, Mr. Fiser (and Mr. Jocher) had their disagreement with Jack Wilson over the applicability of the PASS requirement, and that Mr. Jocher (working with Mr. Fiser), contacted the NRC during this period, getting confirmation that the requirement was in effect. Mr. Fiser and Mr. Jocher at this time also discussed the required PASS testing program and began preparation of appropriate questions. Mr. Fiser was transferred, however, before any of the tests could be administered. Mr. Jocher thus administered the tests and executed the required SCAR on the problem.

We conclude that, under these circumstances, Mr. Fiser was involved and participated to some extent in resolving the PASS question and thus was entitled to be treated as participating in a protected activity. Further, we note that Mr. McGrath, as Chairman of the NSRB, expressed his dissatisfaction with Sequoyah Chemistry, and specifically Mr. Fiser, for not having resolved the question earlier (notwithstanding Mr. Fiser’s limited opportunity to do so). Tr. 677-78 (McGrath). We cannot tell from the record whether Mr. McGrath’s dissatisfaction was motivated by his perception of a performance deficiency on the part of Mr.

Fiser or, instead, by Mr. Fiser's having uncovered a safety issue that Mr. McGrath did not wish to have attributed to the Sequoyah Chemistry organization.

(iv) DIESEL GENERATOR FUEL OIL STORAGE TANK ISSUE

Another safety problem that Mr. Fiser claims to have identified related to the 7-day diesel fuel tanks at Sequoyah. The Staff relies particularly on this problem as demonstrating that Mr. Fiser raised or substantially participated in protected activities but was disciplined or retaliated against for doing so. Staff FOF ¶¶ 2.94-2.98.

Mr. Fiser claims to have "found this working with my people" and to have "reported it, filled out the SCAR, . . . and we fixed the problem." Tr. 1146 (Fiser). This problem was not included among those set forth in Mr. Fiser's 1993 DOL complaint, but it was mentioned in the letter to Sen. Sasser as one of the problems with which Gary Fiser was involved:

Problems with the emergency diesel generator seven day storage tank recirculation system. This finding rendered the emergency diesel generators inoperable and placed both units at Sequoyah in a Limiting Condition of Operation.

Staff Exh. 29 at 4.

The Staff described the problem as follows (Staff FOF ¶ 2.94):

On August 15, 1989, the four emergency diesel generators at [Sequoyah] were declared inoperable because the diesel generator fuel oil had not been sampled in accordance with [Sequoyah's] Technical Specifications [which incorporated ASTM standards]. TVA Exh. 126 at FI000006. This resulted in SQN entering a Limiting Condition for Operation [LCO] under which SQN had 24 hours to complete the required sampling or to shut down the plant.

See TVA Exh. 126; Tr. 4884 (Burzynski). The mistake related to a chemistry procedure for sampling which, according to the Staff, had been written improperly upon the initial licensing of Sequoyah. Staff FOF ¶ 2.94; *see* Tr. 4897 (Burzynski).

TVA, through Mr. Mark Burzynski, the site Licensing Manager at Sequoyah from 1986 through the close of 1989 (*see* Tr. 4863 (Burzynski) and TVA Exh. 139), acknowledged the seriousness of the diesel generator fuel storage tank issue. Tr. 4884 (Burzynski). And TVA did not dispute that Mr. Fiser performed work with respect to resolving the problem — in fact, he was directed to look into the problem and write a CAQ (Condition Adverse to Quality). *See* TVA Exh. 146. But TVA claimed that the issue was not "identified, raised, or documented" by Mr. Fiser and, accordingly, that the issue should not be considered a protected activity on the part of Mr. Fiser. TVA FOF ¶ 4.37.

As reflected in the record of this proceeding, the issue was an operating experience item emanating from an event occurring on April 26, 1989, at the Waterford 3 plant (TVA Exh. 146 at FI000248) that was brought to TVA's attention by INPO on August 8, 1989. Tr. 4866, 4869 (Burzynski). On August 14, 1989, T.W. Overlid, TVA's Manager, Nuclear Experience Review (NER), transmitted the item for action or information to the NER Supervisor at the Sequoyah and Watts Bar facilities, respectively. TVA Exh. 145, NER 89-3491 (OE). On the same day, the Sequoyah NER Supervisor sent a CAQ request to the Chemistry Department, where a CAQ was initiated that same day (August 14, 1989) by Don Amos. TVA Exh. 146. The TVA Final Event Report (FER), which recorded both the circumstances giving rise to the problem and the manner in which the question was resolved, was signed by Gary Fiser, as Event Manager, on August 23, 1989. TVA Exh. 147. The investigative team included Don Adams, as the Event Manager, and Don Amos, Wayne Reid, and Vernon Shanks, as Investigators. *Id.* at FI000262.

A portion of the FER titled "Sequence of Events" reflects that, on August 10, 1989, the problem had actually been brought to the attention of the Chemistry Department, which had been given 10 days to respond to NER 89-3491. *Id.* at FI000259. The report goes on to state that "[a]t this time chemistry personnel believed that the design *allowed recirculation* of the tanks, and that the NER *did not apply* to Sequoyah." *Id.* (emphasis added). During that evaluation, the Chemistry Department was headed by Mr. Fiser, but the CAQ report (TVA Exh. 146) indicates that Don Amos offered that very evaluation of the item:

Based on the above sampling and analysis results of all diesel fuel oil on site, the diesel generators are considered operable, and this is considered to be a representative sampling process for the oil in the 7 day tanks. /s/ Don Amos, 8/10/89.

TVA Exh. 146 at FI000249.

There is no indication whether, prior to Mr. Amos rendering that determination, Mr. Fiser had in fact been consulted. Further documentation in the FER indicates that, on August 11, 1989, the day following the Chemistry Department's initial evaluation, the Supervisor, NER, assigned responsibility for this item to G.L. Fiser, for "immediate attention." TVA Exh. 147, Attachment 1, NER Evaluation Form at FI000313. The incident investigation team assigned to evaluate and document the chemistry personnel's earlier conclusion of nonapplicability, which included Don Amos but not Mr. Fiser (TVA Exh. 147 at FI000262), determined, as of August 14, 1989, that

each 7-day storage tank was designed with four horizontal cylindrical tanks, side-by-side, approximately 85' long and 6' diameter. These tanks are connected to each

other at each end on the top and bottom by a 12" section of pipe. The recirculation was inadequate in that only a portion of the two center tanks were affected.

Id. at FI000259. The FER was signed by Gary Fiser, as Event Manager, on August 23, 1989 (*id.* at FI000258), but there is no indication whether Mr. Fiser in fact developed the above-cited description of the tanks. Mr. Fiser did not in fact sign the SCAR for this issue. TVA Exh. 146.

In sum, Mr. Fiser did not technically initiate this issue, nor did he sign the SCAR that documented it. But he obviously participated in its resolution. Moreover, Dr. McArthur became aware of this problem in 1993, when he was assigned to investigate several problems raised in the letter to Sen. Sasser (including the PASS problem). *See* Staff Exh. 31 at BG000288. For these reasons, we are treating this issue as a protected activity in which Mr. Fiser was involved.

Mr. Fiser testified that he was threatened with disciplinary action for his role in not identifying this issue earlier. Tr. 1147 (Fiser). The FER for this issue (TVA Exh. 147) identifies two potential root causes for the issue arising, both concerning the time frames during which the issue should have been recognized: (1) review *during design* did not consider sampling; and (2) inadequate review of system design *during procedure evaluation*. Mr. Fiser, of course, was not a part of the initial design review, inasmuch as he was not employed at Sequoyah during such review. TVA management — particularly Mr. Burzynski, the Sequoyah Plant Manager — attempted to attribute to Mr. Fiser the responsibility for the failure to detect the problem during surveillance instruction (SI) review prior to Sequoyah's restart in 1988. But Mr. Fiser also was not the superintendent of Sequoyah Chemistry during that SI review, which was carried out prior to Sequoyah's restart. Tr. 4926 (Burzynski). In short, TVA's attempt to portray Mr. Fiser as responsible for the adverse effects of this activity and to blame him for those adverse effects may have been an attempt to discipline Mr. Fiser for involvement in this protected activity.

(v) DATA TRENDING

The Staff claims that data trending was another protected activity in which Mr. Fiser was involved. Data trending involved the production of histogram plots for different contaminants, and different chemical control analysis on various plant systems, which were produced for the operations department and other plant groups. Tr. 4719 (Ritchie). During the period when Mr. Fiser was on rotation to Outage Management from his position as Sequoyah Chemistry Superintendent, the computers used to generate trend plots became inoperable, and trend plots were not generated for a period of time. Tr. 1016 (Fiser). At the November 1991 NSRB meeting, at which both Dr. McArthur and Mr. McGrath were present, Tom Peterson, an NSRB member, and Mr. McGrath, the NSRB Chairman, demanded

that Mr. Fiser, who was in attendance at that NSRB meeting, draft a procedure that would require the Chemistry program to generate all of the trend plots every day, including weekends and holidays. *See* Tr. 1018-19 (Fiser), Tr. 1687-88 (McArthur), Tr. 4721 (Ritchie).

At that time, except when disabled by computer malfunction, the Chemistry program was generating the trends about which the NSRB was concerned 4 days per week, and was also trending the data collected over weekends. Tr. 1024 (Fiser). Mr. Fiser advised Mr. Peterson and Mr. McGrath that he could not comply with a daily-trending requirement for a number of reasons. First, and most important, he explained that if the computer were to break again, then, if the trending were required by a procedure, the Chemistry program would be in violation of the procedure and potentially subject to enforcement action by NRC as a result. Tr. 1020 (Fiser). Second, Mr. Fiser explained that incorporating the trending into a procedure would require tremendous overtime by the chemistry technicians who performed the trending, overtime for which Mr. Fiser lacked approval. Tr. 1021 (Fiser). Finally, Mr. Fiser expressed concern about a potential procedural violation emanating from the proposed trending procedure because Sequoyah had recently had problems with procedural violations, for which a corrective action document would have to be prepared and NRC eventually informed. Tr. 1022-24 (Fiser). Mr. Fiser assured the NSRB members that the Chemistry program would continue to generate trends and that, once the Chemistry Upgrade Program (CUP) was approved, he would be able to comply with the requested daily trending requirement. He had requested the NSRB to assist him in getting the CUP approved. Tr. 2473, 4358 (Fiser).

According to Mr. Rob Ritchie, who also was present for that NSRB meeting, the NSRB did not listen to what Mr. Fiser had told it about trending. Tr. 4721 (Ritchie). The NSRB never followed up with Mr. Fiser regarding the trending issue, and the Sequoyah Chemistry program (following Mr. Fiser's return in January 1992) continued to generate trend plots, albeit not on a daily basis. Tr. 1023-24 (Fiser). When Mr. Charles Kent assumed responsibility for the Sequoyah RadChem organization in early 1993, the Chemistry organization was still generating trend plots. Tr. 3217 (Kent). As indicated earlier (*supra* p. 571), after Mr. Fiser's return to Sequoyah Chemistry in January 1992, he was transferred a few weeks later, in March 1992, to Corporate Chemistry.

TVA treats the data-trending question as a nonissue. It explicitly asserts that trending was not a key issue at the November 1991 NSRB meeting. TVA FOF ¶4.25. It cites the proposition that issues of major importance are designated by the NSRB as "action items" and that minutes of the November 1991 NSRB meeting reflect that data trending was not among the "action items" considered. *See* Joint Exh. 3. Notwithstanding TVA's attempt to minimize the significance of the issue of data trending, however, the minutes of the November 20-21 meeting of the NSRB reflect otherwise: They state that, under the "key" item designated

as “Site Chemistry Program,” a problem that, if not promptly corrected, “could impact plant chemistry control” was that “required data trend analyses were not being performed.” *Id.* at CC000093.

That data trending in the Chemistry program continued to remain a problem worthy of note at future NSRB meetings is reflected in minutes of the February 19-20, 1992 meeting where, both in the Executive Summary and in the report of the meeting, again under the key item designated as “Site Chemistry Program,” program deficiencies as to which effective corrective action was called for included “trending analyses.” *See* Joint Exh. 4 at CC000101, CC000102.

Further, TVA argues that a refusal to perform data trending constitutes a failure to perform job responsibilities, which is not a protected activity. As the Staff observes, Mr. Fiser never refused to perform data trending but, rather, only refused to institute a procedure requiring daily trending. Staff RESP FOF ¶ 2.72. Further, data trending was not one of Mr. Fiser’s formal job responsibilities but, rather, only a recommendation from the NSRB. And although Mr. Fiser refused or declined to initiate a procedure requiring the daily performance of data trending, as requested by the NSRB, he did so for what he regarded as safety-related reasons, i.e., the likely regulatory infractions that could result from such a procedure. For these reasons, although Mr. Fiser did not technically raise this issue — the NSRB did so — we consider Mr. Fiser’s involvement in the data-trending issue as another protected activity in which he was involved. We so find.

We also note, however, that the proceduralized daily data trending itself could have implications enhancing plant safety. TVA itself describes data trending as productive of “information helpful to safely operate a nuclear plant.” TVA FOF ¶ 4.29. These pro-safety implications of proceduralized data trending lessen the weight we accord to Mr. Fiser’s participation in this protected activity.

One further comment about the data-trending issue is in order. Mr. McGrath repeatedly denied that chemistry data trending was an important or significant issue discussed at the November 1991 peer team meeting (which preceded the NSRB meeting). Tr. 395, 400 (McGrath). He recalled that the issue had been discussed but added that there was “no meeting that I was in where data trending *was a big issue with me.*” Tr. 395 (McGrath) (emphasis added). Finally, he testified that no one from the NSRB demanded that Mr. Fiser institute a daily trending procedure. Tr. 400, 661 (McGrath).

The foregoing opinion expressed by Mr. McGrath is undercut by the testimony of others who attended the NSRB meeting, including Mr. Fiser, Mr. Ritchie, and Dr. McArthur, all of whom indicated that data trending was a significant issue and that members of the NSRB requested that Mr. Fiser institute a trending procedure. Tr. 1018 (Fiser), Tr. 1400 (McArthur), Tr. 4722 (Ritchie). The NSRB minutes of the November 1991 meeting identified above also reflect that data trending was a key issue, albeit not an “action item.” That being so, Mr. McGrath’s testimony on this issue does not comport with either the testimony of other observers or the

documentary records mentioned above. We judge that such testimony seriously undercuts the credibility of Mr. McGrath as a witness (as claimed by the Staff at Staff FOF ¶¶ 2.193-2.196).

3. Termination of Mr. Fiser's Employment by TVA

The termination of Mr. Fiser's employment by TVA eventuated from the 1996 reorganization of TVA Nuclear. As explained by TVA, during the summer of 1995, both units at Sequoyah and two units at Browns Ferry had been restarted, and the initial startup of Watts Bar was imminent. Thus, TVA was moving away from being an organization focused on construction and restart to an organization operating five reactors. See TVA FOF ¶ 6.1. In addition, at that time, there was an effort to improve efficiency and to use information from NEI as a benchmark to achieve an effective and competitive organization. *Id.* "Throughout the industry, utilities were downsizing." Tr. 1474 (McArthur). With respect to Nuclear Operations Support, the 1996 reorganization eliminated more than thirty positions. Tr. 4009 (Boyles). Twenty positions were recreated at the same time. Compare TVA Exh. 56 (jobs that were eliminated) with TVA Exh. 55 (jobs created at that time). The Board agrees with TVA that, overall, this reorganization was motivated by legitimate business reasons and was not *per se* intended to discriminate against any individual, including Mr. Fiser.

The details by which this reorganization was carried out, however, raise considerable doubts as to their motivation concerning Mr. Fiser. With respect to the Corporate Operations Support organization, in which Mr. Fiser was serving in 1996, the reorganization was carried out under the supervision of Mr. McGrath, who in October 1995 became the Acting General Manager of Operations Support.²⁸ Tr. 429-30, 754 (McGrath); Tr. 1475 (McArthur).

In the winter of 1995 or early spring of 1996, however, prior to the reorganization, there appeared to be a position with Sequoyah Chemistry that Mr. Harvey had sought to occupy. Tr. 4976-77, 5036-37 (Harvey). Charles Kent, Plant Manager at Sequoyah, admitted that he had a vacancy in the Chemistry organization that had been vacated by an individual who left TVA to work with another utility. Tr. 3080, 3092-93 (Kent). Prior to the hearing, Mr. Kent made similar statements to three different organizations. See Staff Exh. 70 at 1 (TVA OIG); Staff Exh. 72 at 2 (DOL investigator); Staff Exh. 73 at 14 (NRC OI). Later in his testimony, however, Mr. Kent appears to have changed his position by denying that there was any such position on his organizational chart. Tr.

²⁸Mr. McGrath never became the permanent Manager of Operations Support. He remained as Acting General Manager until the position was eliminated as part of a 1997 reorganization. Tr. 443 (McGrath).

3132 (Kent). In the Board's view, this seeming change in opinion undercuts the credibility of Mr. Kent's testimony. In any event, Mr. McGrath blocked Mr. Harvey's direct transfer to Sequoyah, thus setting the stage for Mr. Harvey's selection during the reorganization for the PWR Reactor Chemistry position and Mr. Fiser's resultant dismissal.

The reorganization involved a 5-year reduction plan, with an overall goal of a 40% reduction. Tr. 433-34 (McGrath); *see* TVA FOF ¶ 6.2, Staff FOF ¶ 2.75. The proposed 40% reduction could have been achieved incrementally (with about a 17% reduction the first fiscal year), or it could have been imposed at the outset, with the entire reduction in the first fiscal year. Mr. Grover testified that, at the beginning of the reorganization, Mr. McGrath instructed those reporting to him to cut a minimum of 17% in the first year, with the 40% to be achieved over 5 years. At the outset of the reorganization, there were five permanent positions in the organization, with one being vacant. Tr. 1859 (Grover). Mr. McGrath apparently expressed the desire to do everything he could to help everybody keep their jobs. Tr. 1865 (Grover). Mr. Grover actually proposed a plan to this effect, which did not require any incumbent to lose his or her position within the first year, eliminating the vacant position from budget calculations. Tr. 1860-62 (Grover); Tr. 1477 (McArthur).

Mr. McGrath reacted to that (and other) proposals by then proposing and adopting a plan making deeper cuts the first year in the Chemistry program, limiting the two remaining technician positions to one PWR position and one BWR position, requiring one of the incumbents to lose his position (Tr. 1862, 2199 (Grover)), and promoting Dr. McArthur to a higher-grade supervisory position. He explained that in a reorganization it was better for management to be clear to employees about what was going to happen and then to proceed, instead of stretching out reductions over several years. Tr. 439-40 (McGrath), Tr. 1476 (McArthur).

The reorganization was initially announced to Operations Support personnel following a June 17, 1996 "all hands" meeting at which Mr. McGrath announced a reorganization would take place and that Dr. Wilson McArthur would be the RadChem Manager. Tr. 1481 (McArthur). Mr. McGrath also advised Dr. McArthur that he (Dr. McArthur) would not have to compete for this position. Of the three remaining employees in those positions, only two would be retained (the PWR and BWR positions described above).

a. Governing Procedures

Procedurally, in a situation where four existing positions were to be transferred to three remaining positions, the RIF procedures prescribed by OPM would be used. TVA presented two policies that govern selections in its nuclear organization, the Personnel Manual Instruction and BP-102, "Management and

Specialist Selection Process.’’ See Joint Exhs. 63 and 65. These policies implement the relevant OPM regulations relating to RIFs, which are found in 5 C.F.R. Part 351. Tr. 5376 (Fogleman).

The primary criteria used under these procedures (not counting an allowance for veterans preference) are job interchangeability and length of service. All of the existing positions were PG-8 positions, except the RadCon Manager position occupied by Dr. McArthur, which was PG-11. Tr. 3772 (Boyles). No position description had been created for the RadCon Manager position in which Dr. McArthur was serving at the time of the 1996 reorganization. However, the last position description of record for Dr. McArthur was the PG-8 position of Manager of Technical Programs, which Dr. McArthur had occupied following the 1994 reorganization. None of these incumbents appears to have had prior military service. See TVA Exh. 24 at HH000030-HH000031(Fiser); Tr. 1382-86 (McArthur); TVA Exh. 24 at HH000012-HH000013 (Harvey) and *id.* at HH000017-HH000018 (Dr. E.S. Chandrasekaran (Chandra)). Mr. Fiser had a greater length of service with TVA (1987-1996) than did the others who were candidates for the surviving positions, i.e., Dr. McArthur (1990-1996), Sam Harvey (1991-1996), and Dr. Chandra (1991-1996).

Mr. Fiser thus would have had seniority on the retention register, assuming RIF procedures had been used. Accordingly, using the strict RIF policies and procedures, Mr. Fiser should have been selected for one of the remaining positions.

If the existing and surviving positions are not mutually interchangeable (as claimed by TVA, see TVA FOF ¶¶ 7.0-7.6), then procedures applicable to newly created positions are followed. According to TVA, under federal regulations as applied by TVA, the incumbents of existing positions did not have retention standing for the new, noninterchangeable positions, which would have to be advertised to allow employees to apply and compete for the jobs. TVA FOF ¶ 7.0. We note, however, that Mr. McGrath insisted upon rewriting the existing position descriptions to create new, noninterchangeable positions notwithstanding the virtually identical duties of the existing and new positions.²⁹

²⁹ Mr. Ben Easley, a former HR officer with TVA, testified that, in a RIF situation, positions were different if their duties differed by more than 35%. Tr. 1201, 1285 (Easley). Mr. Ronald Grover, former TVA Corporate Chemistry Manager, testified that positions were different for RIF purposes if their duties differed by more than 15-20%. Tr. 1824, 1884-85 (Grover). Mr. James Edwin Boyles, who in June 1996 was serving as Manager of Human Resources in the corporate TVA organization (Tr. 3738 (Boyles)), and was Mr. Easley’s supervisor, testified that, in comparing positions in a RIF situation, TVA looks to whether a “preponderance of the duties” remains the same. Tr. 3744-45 (Boyles). Although the preexisting positions included environmental responsibilities and the new positions did not, the environmental responsibilities amounted to less than 5% of the duties of the position. Tr. 1885-86 (Grover). Deletion of those duties from the new positions did not, therefore,

(Continued)

b. Differing Procedures (and Disparate Treatment) Applied to Dr. McArthur

As noted earlier, TVA did not apply these governing procedures with respect to Dr. McArthur. Instead, TVA assigned Dr. McArthur (without competition) to the position of RadChem Manager. As explained by Mr. McGrath, TVA had a policy of recognizing an employee's rights to a position where, in a prior reorganization, his position had been discontinued but, later, was recreated. In other words, TVA would recognize the rights of the incumbent of the previous eliminated job to the new position. Tr. 487 (McGrath).

The Department of Human Relations (HR) had initially advised Mr. McGrath that the RadChem Manager position, like others in the new organization, would have to be posted or advertised. Tr. 481-82 (McGrath). At some point thereafter, Dr. McArthur raised with Mr. McGrath the question whether he (McArthur) should be required to compete for the RadChem Manager position, in view of the circumstance that he (McArthur) previously (following the 1994 reorganization) had held the position of Manager of Technical Programs. Dr. McArthur regarded the duties of Manager of Technical Programs and RadChem Manager as nearly identical. Tr. 481-82 (McGrath).

Accordingly, Mr. McGrath referred the question to HR, which responded that Dr. McArthur had "rights" to the new position. Tr. 483 (McGrath). Its reasoning, however, was not that assumed by Mr. McGrath. Rather, HR apparently reasoned that, following the 1994 reorganization, Dr. McArthur was never issued a position description for the job he was then occupying — a technical error by HR itself — and therefore should be considered as still occupying the position of Manager of Technical Programs. Tr. 489 (McGrath). In any event, as part of the 1996 reorganization, Dr. McArthur was appointed to the RadChem Manager position.

The Staff asserts that TVA's treatment of Dr. McArthur in this reorganization represented disparate treatment from that offered to Mr. Fiser. *See* Staff FOF ¶¶ 3.48-3.58. In contrast, TVA treats Dr. McArthur's situation as essentially unique and denies disparity on the ground that Mr. Fiser was treated like the vast majority of TVA employees. TVA FOF ¶¶ 8.0-8.11.

Whether or not Dr. McArthur's treatment was impermissibly disparate from that offered Mr. Fiser, it was certainly different. Because Dr. McArthur apparently, through an error by HR, was not formally issued a position description following the 1994 reorganization, he was considered as occupying a lower-level position which was his latest position description of record. In contrast, Mr. Fiser, who

amount to a significant enough change to constitute those new positions as newly created positions subject to competition. As noted by Mr. Grover, the position descriptions for the new PWR and BWR program manager positions did not change the functions that the Chemistry program managers had been performing on a day-to-day basis. Tr. 1883 (Grover).

was forced to leave the position that was the basis of his settlement of the 1993 DOL complaint as a result of the 1994 reorganization, was not considered to have rights to the PWR Chemistry Manager job that he was seeking in 1996, even though the vast majority of the duties encompassed by that job were the same as those he performed following the DOL settlement. As set forth by the Staff, “the fact that every other position except McArthur’s RadChem Manager position was posted for competition supports the Staff’s argument that TVA made an end run around OPM RIF regulations in order to control who would be retained in a reorganization.” Staff RESP FOF ¶2.126. Based on the foregoing, we regard Dr. McArthur as one of the “favored few” that TVA wished to designate for a particular remaining position and, to achieve that result, gave him disparate treatment vis-à-vis that accorded to the majority of TVA employees.

c. Biased Treatment of Mr. Fiser in Remainder of Reorganization

As carried out by TVA, the 1996 reorganization required filling two positions through competition, the PWR and BWR Chemistry management positions. Following Dr. McArthur’s selection for the RadChem Manager position, there were three remaining employees who met the minimum qualifications for, and sought to fill, one or either of the Chemistry Manager positions — Mr. Fiser, Mr. Harvey, and Dr. Chandra. Joint Exh. 21 at GG000212; Tr. 1498-99 (McArthur). (Mr. Harvey and Dr. Chandra each was in fact a candidate for both positions, and Dr. Chandra was chosen for the BWR position, for which Mr. Fiser had not been a candidate.) Dr. McArthur, by virtue of his promotion to RadChem Manager, became the selecting official for the two Chemistry Manager positions. Tr. 1493 (McArthur); Tr. 1910 (Grover); Tr. 2916, 2988 (Corey); Joint Exh. 21 at GG000212.

With respect to the PWR position, the selection process included posting of the position, initial evaluation of the qualifications of applicants, conduct of interviews by the Selection Review Board (SRB) of applicants who possessed at least the minimum qualifications for the position, and final selection. When Mr. Fiser learned that the PWR Chemistry Manager position was to be posted, he quickly filed his 1996 DOL complaint. His theory was that the position should not have been posted, for a reason comparable to the reason Mr. McGrath referred Dr. McArthur’s inquiry to HR: that the position Mr. Fiser earlier occupied as a result of the 1993 DOL settlement had been reorganized out of existence in 1994 and that, under his understanding of TVA policy, he should have been regarded as having “rights” to the new position, comparable to Dr. McArthur’s having been afforded rights to the RadChem Manager’s position. On that basis, Mr. Fiser filed his 1996 DOL complaint on June 25, 1996, prior to TVA’s selection of an incumbent to occupy the PWR Chemistry Manager position. *See* Staff Exh. 37.

The SRB for the Chemistry Manager positions (as well as certain other positions for which interviews were conducted the same day) was selected by Dr. McArthur and approved by both Tom McGrath and the HR department. Tr. 1494 (McArthur), Tr. 2916 (Corey). Initially, Dr. McArthur sought to establish an SRB consisting of the incumbent Chemistry and Environmental Protection Program Managers from three sites — Jack Cox from Watts Bar, Charles Kent from Sequoyah, and John Corey from Browns Ferry. *Id.* The proposal to use the site RadChem Managers as the SRB was intended to have the managers to whom the candidates had been and would be providing support rate the candidates. Tr. 2916 (Corey). Each of these individuals was a person with whom one of the prospective Chemistry Managers was or had been working closely in recent years — Jack Cox, with Mr. Fiser; Charles Kent, with Sam Harvey; and John Corey, with Dr. Chandra.

On the morning of the SRB meeting, however, Jack Cox advised Dr. McArthur that he had a conflict with respect to the particular time frame proposed for the SRB questions. Tr. 2874 (Corey), Tr. 3152 (Kent). Dr. McArthur responded by selecting another individual. After considering several from Watts Bar who were not available, Dr. McArthur selected Heywood R. (Rick) Rogers, the Maintenance Support Manager in Nuclear Operations Support at Sequoyah. Tr. 1495 (McArthur), Tr. 5166-67 (Rogers).³⁰ TVA presented a long list of Mr. Roger's qualifications to serve on the SRB. *See* TVA FOF ¶¶9.24-9.26. Dr. McArthur explained that, although Mr. Rogers had not recently worked with Mr. Fiser, he had been exposed to Mr. Fiser's work some years earlier, when Mr. Fiser was serving as Chemistry Manager at Sequoyah. Tr. 1497 (McArthur). (Mr. Rogers was not, however, a part of the RadChem organization, either at that time or more recently. Tr. 2883 (Corey).). Dr. McArthur added that he "thought it was a very fair board." Tr. 1497 (McArthur).

However, the Licensing Board concurs with the Staff conclusion that the SRB was "stacked against Fiser in that the RadChem Manager most familiar with his recent work [Mr. Cox] was not included in the process, whereas the RadChem Managers most familiar with Harvey and Dr. Chandra's recent work were on the SRB." Staff FOF ¶2.137. Indeed, one of the SRB members, Mr. Kent, the manager from Sequoyah, had made an effort, shortly before the 1996 reorganization, to have Mr. Harvey transferred to Sequoyah because he had performed well at Sequoyah and had good secondary chemistry experience. Tr. 3106, 3137 (Kent). Such a transfer appears to have been blocked by Mr. McGrath, allegedly on the ground that Mr. Harvey could not be transferred to a vacant position without posting it for competition. Tr. 3137-38 (Kent).

³⁰Dr. McArthur did not consider rescheduling the SRB meeting to accommodate Jack Cox's schedule because "we were trying to get the selections made" and "it just holds up the organization — reorganization." Tr. 1496 (McArthur).

Three candidates for the PWR Chemistry Manager's job, Messrs. Fiser and Harvey and Dr. Chandra, met the minimum qualifications for the job and were interviewed. Tr. 1498-99 (McArthur); Joint Exh. 23 at GG000620. The questions propounded by the SRB to each of the candidates for a particular position (e.g., PWR Chemistry Manager) were identical. The SRB for the PWR Chemistry Manager position asked each candidate the same eight questions, chosen by the SRB from a group of sixteen questions drafted by Dr. McArthur, together with one additional question drafted by Charles Kent (Tr. 2880, 2899 (Corey)) and added by the SRB on its own. Tr. 1499 (McArthur); Joint Exh. 23 at GG000655. (Similarly, the SRB for the BWR Chemistry Manager position — the same individuals as for the PWR position — asked each candidate the same six questions, chosen by the SRB from the same group of questions drafted by Dr. McArthur for both the PWR and BWR positions; the SRB did not add a question on its own with respect to the BWR position. See Joint Exh. 21 at GG000265 (questions asked Dr. Chandra).)

Not only was the SRB, in its personnel, stacked against Mr. Fiser (as described above), but the particular questions propounded to each candidate for the PWR Chemistry Manager position also focused on the expertise of Mr. Harvey rather than that of Mr. Fiser. Thus, the position description for the PWR Chemistry Manager position called for a candidate who was knowledgeable in the areas of both primary chemistry and secondary chemistry. Tr. 1914 (Grover).³¹ Similarly, the position description for the BWR Chemistry Manager position likewise called for both of those areas of expertise, with emphasis on primary chemistry.³² Primary chemistry concerns “the reactor part of the facility.” Tr. 1477 (McArthur). On the other hand, secondary chemistry concerns “the steam generation portion, the steam generators [and the] pressurizers. . . .” *Id.* The questions asked by the SRB related both to managerial skills and technical skills. Tr. 2859 (Corey), Tr. 3145 (Kent). But none of the questions relating to technical skills was explicitly directed at problems arising with respect to primary chemistry, which was Mr.

³¹ The position description for the Chemistry Program Manager (PWR) called for a candidate to be responsible for providing “technical and programmatic expertise for implementation of the [TVA Nuclear] chemistry program at individual sites” [in particular, Sequoyah and Watts Bar, both PWRs]. Such responsibilities would cover both primary and secondary chemistry problems. In addition, a candidate was to “[f]unction as the [TVA Nuclear] senior technical expert to the sites in the areas of PWR Secondary chemistry control.” TVA Exh. 55 at BF001339 (position description of Sam Harvey).

³² The position description for the Chemistry Program Manager (BWR) position included responsibility for “Primary Chemistry Program & Count Room Support for all [TVA Nuclear] sites.” Specifically, the occupant was to function as the TVA Nuclear “senior technical expert to the sites in the areas of BWR chemistry control, *PWR Primary Chemistry*, laboratory QA/QC, radioactive effluents, and failed fuel action plans.” TVA Exh. 55 at BF001272 (position description of Dr. Chandra) (emphasis added).

Fiser's area of greater expertise. They all focused on secondary chemistry (Mr. Harvey's area of expertise) or, generally, managerial expertise. Stated another way, the questions themselves predetermined which of the candidates would likely achieve the better scores.

But in terms of problems that were then extant, there were some in each area of chemistry that the new PWR manager would have to be able to address. According to Dr. McArthur, the biggest problem that the Chemistry Program Manager would have to deal with at that time was on the secondary side, dealing with steam generators. Tr. 1623 (McArthur). But attention also would have to be paid to the primary side, particularly corrosion problems. Tr. 1623-24 (McArthur), Tr. 2929 (Corey). Fuel failures were also a primary chemistry concern at that time. Tr. 2976 (Corey). As acknowledged by Mr. Corey, a member of the SRB, "a primary concern with nuclear safety is containing the radioactivity. And that's a primary chemistry issue." Tr. 2937 (Corey).

TVA offers two bases for the lack of primary-chemistry questions in the examination for the PWR Program Manager position. First, that the incumbent of the PWR Chemistry Program Manager was not supposed to be the primary chemistry expert for any of TVA's sites, that instead the BWR Program Manager position included responsibility for primary chemistry at all TVA sites. TVA FOF ¶¶ 9.29-9.30. And second, that the questions were fair and it was reasonable to expect the selectee for the PWR Chemistry Manager position to know the answers to the technical questions about secondary chemistry. TVA FOF ¶ 9.30. TVA adds that many of the general questions could be answered based on a background of either primary or secondary chemistry.

The Licensing Board rejects these explanations. As spelled out above, the lack of explicit primary-chemistry questions on the PWR examination fails to recognize the extent of primary-chemistry questions that the PWR Manager would be called upon to address. (Parenthetically, the BWR Chemistry Manager examination likewise failed to include explicit questions relating to primary chemistry. *See* Joint Exh. 21 at GG000249-GG000250.) Finally, the circumstance that certain general questions could be answered from either a primary or a secondary chemistry background does nothing to undercut the overall bias of the questions in favor of persons with a background in secondary chemistry.

The Staff asserts (Staff FOF ¶¶ 2.186-2.187), and TVA apparently does not dispute (TVA Reply FOF at 52-53), that at least two of the three members of the SRB (Messrs. Kent and Corey), as well as Dr. McArthur, the selecting official, were aware that, prior to the SRB examination for the PWR Chemistry Program Manager position, Mr. Fiser had filed DOL complaints, the most recent based on Dr. McArthur's posting of the position. Indeed, they were so informed by Mr. Kent, one of the SRB members, approximately 30 minutes before the SRB's examination of Mr. Fiser. Tr. 2879 (Corey); Tr. 3154, 3230 (Kent).

The Staff also claims that Sam Harvey was preselected for the PWR Program Manager position. Staff FOF ¶¶ 2.158-2.163. Here, however, the evidence is mixed. First, Mr. McGrath is said to have refused to transfer Sam Harvey to the Sequoyah site because he wanted to keep Mr. Harvey's expertise in Corporate Chemistry. Tr. 3615, 3619 (Grover); Tr. 3318 (Voeller). Mr. Harvey is also said to have confided by telephone, on June 3, 1996 (prior to Mr. Fiser's and Mr. Harvey's SRB interviews on July 18, 1996), with Dave Voeller, then the Superintendent of Maintenance at Watts Bar (Tr. 3304 (Voeller)), that he (Harvey) would be working more closely with him (Voeller) in the future. Tr. 3316 (Voeller). That would be the case if Mr. Harvey were selected for the PWR Corporate Chemistry position (Watts Bar was a PWR). Mr. Harvey further was said to have stated that he was not being released to be transferred to Sequoyah because he would be the one retained in Corporate Chemistry. Tr. 3318 (Voeller). Sam Harvey is also said to have stated during the telephone conversation that the SRB interviews would be conducted to "keep it legal" and that "Gary [Fiser] would be the odd man out." Tr. 3319, 3322 (Voeller).³³

On the other hand, Sam Harvey related the telephone conversation somewhat differently. He said that he told Dave Voeller that he "would either be working with him [Voeller] closer, which I would look forward to, or possibly not at all." Tr. 4978 (Harvey). Mr. Harvey also related a second conversation with Mr. Voeller in which Mr. Harvey clarified the portion of the first conversation indicating that he (Harvey) might not be working with Mr. Voeller. In any event, Mr. Harvey explained that, "if the selection process was equal, all things being equal that based on my technical abilities and what I had delivered over time would come to the forefront in the selection process." Tr. 4982 (Harvey).

The Board is not entirely persuaded that Sam Harvey's telephone conversations with Dave Voeller prior to the SRB interviews indicate that Sam Harvey was preselected for the Corporate PWR Chemistry Manager position. Nor do they indicate that Sam Harvey was not preselected. They do appear to reflect Sam Harvey's confidence that he had superior qualifications for the job than did Mr. Fiser. The Board expresses no opinion on this subject, although noting that Mr. Harvey had significant technical qualifications, particularly with respect to secondary chemistry. The Board believes, however, that the membership on the SRB, together with questions propounded by the SRB emphasizing secondary rather than primary chemistry issues, and the circumstance that Dr. McArthur was the selecting official, did in effect virtually assure that Sam Harvey rather than Gary Fiser would be selected for the PWR Chemistry Manager position.

³³ Mr. Voeller advised both Mr. Grover and Mr. Fiser of his telephone conversation with Sam Harvey. Tr. 3320-21 (Voeller). *See also* Joint Exh. 36.

In fact, Mr. Harvey received a higher cumulative score (235.7 points) than Mr. Fiser (180.8 points) or Dr. Chandra (235.5 points) before the SRB. Joint Exh. 22 at GG000420, GG000439, and GG000456. Mr. Harvey was selected by Dr. McArthur as PWR Corporate Chemistry Manager. *Id.* at GG000399.³⁴ Mr. Fiser was given the option of transferring to the TVA Services staff, effective October 1, 1996 (where he could remain and search for another position throughout Fiscal Year 1997) or to resign by close of business September 30, 1996, with severance pay together with a lump-sum payment of salary throughout Fiscal Years 1996 and 1997 (ending September 30, 1997), and a lump-sum payment for unused annual leave. *See* Joint Exh. 28. Mr. Fiser reasoned that, if he transferred to TVA Services and thereafter was offered an unsatisfactory TVA position (e.g., at a lower salary, although amounting to at least 80% of his current salary), he would be forced to accept such position or resign at that time, without the benefit of the one-time lump-sum payment. Tr. 2370-71 (Fiser). Accordingly, Mr. Fiser elected to resign, effective September 5, 1996. Tr. 2369 (Fiser); *see* Joint Exh. 29.

D. Licensing Board Analysis of Facts

As noted earlier in this Decision, there are four elements that the Staff must establish to demonstrate that there has been a violation of 10 C.F.R. § 50.7 by TVA. Specifically, the Staff must demonstrate, first, that Mr. Fiser engaged in one or more protected activities; second, that members of TVA management were aware of the protected activity; third, that he was subject to an adverse action; and fourth, that the adverse action was premised at least in part on retaliation for such activities.

In the first place, it is clear to us that, as set forth earlier in this Decision, Mr. Fiser was involved throughout his career with TVA in a number of “protected activities,” as contemplated by 10 C.F.R. § 50.7. Among other matters, he filed two discrimination complaints with the DOL and also joined in a letter to Sen. Sasser (with copies to NRC personnel) complaining about TVA’s activities that tended to discourage employees from raising such issues. In addition, we find that Mr. Fiser engaged to some extent in several technical protected activities (certain of which were referenced in the 1993 DOL complaint and the Sasser letter), although in some instances only marginally so. Specifically, of the five protected activities described *supra* pp. 582 through 592 of this Decision, we find that Mr.

³⁴In this selection document, Dr. McArthur refers to Dr. Chandra as the first-ranked applicant for both the PWR and BWR positions. That was incorrect with respect to the PWR position — Mr. Harvey was in fact the first-ranked candidate for the PWR position, and he was selected for that position. Dr. Chandra was selected for the BWR position. Joint Exh. 22 at GG000398.

Fiser was sufficiently involved in four of those activities to warrant classification of his actions as “protected activities.” *See* pp. 584, 586, 589, and 591.

Second, as noted earlier, members of TVA management also were knowledgeable about Mr. Fiser’s participation in such activities. Dr. McArthur, in particular, was knowledgeable about the two DOL complaints and the Sasser letter, as well as several of the technical protected activities. Mr. McGrath was knowledgeable about several of the technical protected activities, as well as the 1996 DOL complaint.

Third, Mr. Fiser was also the subject of an adverse action, as contemplated under 10 C.F.R. § 50.7. Although he was given the option to be transferred to TVA Services, that option, as well as the resignation option he actually chose, has likewise been deemed to be an adverse action under the Whistleblower statute (section 211). *See TVA v. U.S. Secretary of Labor (Curtis Overall, Intervenor)*, 59 Fed. Appx. 732 (6th Cir. 2003). TVA’s claim to the contrary (TVA FOF ¶¶ 10.0-10.5) is hereby rejected.

Fourth, the crucial part of the “protected activity” violation is the nexus between the adverse action and discriminatory intent. There is no direct testimony that TVA’s dismissal of Mr. Fiser was based, in whole or in part, on retaliation for Mr. Fiser’s involvement in protected activities. Nor would any such “smoking gun” be likely to be available in any proceeding of this type. As set forth in a special report to the Commission on allegations of discrimination with respect to Millstone Power Plant, Units 1, 2, and 3:

Although all four of the items described³⁵ above are necessary to make out a case of discrimination under section 50.7, the fourth item [Was the adverse action taken because of the protected activity?] is the most problematic, both generally and in the cases we were asked to review. *This is because it is rare that this crucial element can be established by so-called “smoking gun” evidence, i.e., evidence that irrefutably shows the adverse action was pretextual.* (The clearest example of such evidence would be an admission by the official of the employer who was directly responsible for the adverse action that he or she took that action against the employee because the employee engaged in protected activity.)

Instead, what usually is available from an investigation into a section 50.7 discrimination allegation is testimony and documentary information, often conflicting, that provides circumstantial evidence of whether an adverse action was taken because an employee engaged in protected activity. Circumstantial evidence is “evidence that tends to prove a fact by proving other events or circumstances which afford a basis for a reasonable inference of the occurrence of the fact in issue.” Webster’s New Collegiate Dictionary 203 (1975). . . . In the context of a discrimination case, relying on circumstantial evidence means that the requisite factual finding that

³⁵The four items are set forth *supra* at p. 569 of this Decision.

adverse action was taken because of the protected activity would be the product of a reasonable inference drawn from other proven events or circumstances in the case.

MIRT Report at 4-5 (emphasis added).³⁶ Administrative Judge Alan S. Rosenthal, in a Separate Statement to the MIRT report, drew essentially the same conclusion:

Unsurprisingly, the difficult assessment concerned the fourth element: whether the required nexus existed between the protected activity and the adverse action. In approaching that question in each case, there was a recognition of the obvious: the fruits of the OI investigation [in the cases under review] would not include any acknowledgment of licensee wrongdoing or, in all likelihood, anything that might constitute direct evidence either in support or in refutation of the alleged's claim. Thus, the determination respecting whether the licensee's proffered explanation for the adverse action was genuine, or instead in whole or in part pretextual, would necessarily hinge upon the drawing of inferences from evidentiary disclosures that might well be in substantial conflict.

Separate Statement to MIRT Report of Administrative Judge Alan S. Rosenthal at 2. Indeed, the Supreme Court has sanctioned the drawing of inferences of causation based on circumstantial evidence, consisting of numerous circumstances that give rise to an inference of unlawful discrimination. *McDonnell Douglas Corp. v. Green*, 411 U.S. 792 (1973).

Such circumstances are present here. They include (1) the disparate treatment accorded to Dr. McArthur and Mr. Fiser in the 1996 reorganization; (2) the membership makeup of the SRB that was biased in favor of candidates other than Mr. Fiser, particularly Sam Harvey; (3) the propounding of technical questions by the SRB that lacked any focus on primary chemistry, Mr. Fiser's specialty, but included several focused on secondary chemistry, Mr. Harvey's specialty; (4) the virtual preselection of Mr. Harvey by virtue of the personnel makeup of the SRB and the questions asked by the SRB; (5) the statement by Charles Kent, prior to the SRB interview, to John Corey, another SRB member, and Dr. McArthur, the selecting official, of Mr. Fiser's history of filing DOL complaints; (6) the temporal proximity of Mr. Fiser's nonselection and certain of his protected activities, particularly the 1996 DOL complaint; (7) the attempted RIF of Mr. Fiser in 1994 from a position he was not then occupying and which was not in fact being eliminated; (8) the rewriting of position descriptions in 1996 so as to

³⁶The MIRT Report adds: "In so describing what is often the central supporting material in discrimination cases, it should not be supposed that because the information is circumstantial, the cases are somehow rooted in weak or deficient evidence. . . . Indeed, such evidence, often the result of a painstaking exercise in drawing inferences (or more specifically reasonable inferences) based on the factual circumstances that are presented, can be as convincing as the 'smoking gun.'" MIRT Report at 5.

avoid using standard RIF procedures that would have given Mr. Fiser a preferred position to be retained; and finally (9) the expressed warning by Dr. McArthur to Mr. Fiser (in 1993) to the effect that he should not file a DOL complaint because people “don’t want somebody that is a trouble maker.” *See* Joint Exh. 27 at 80.

The plethora of career-damaging situations and circumstances to which Mr. Fiser was subjected during the last several years of his career at TVA, described in the record of this proceeding, go well beyond unfortunate circumstances and/or chance. Given these circumstances, as well as the criticisms by management officials of Mr. Fiser’s participation in several of the technical protected activities (such as the PASS controversy and the diesel generator fuel oil tank issue), and reflecting the lack of credibility that attends certain portions of the testimony of Mr. McGrath, Dr. McArthur, and Mr. Charles Kent (all as outlined earlier in this Decision), we conclude that the sum total of these many inferential adverse actions present a pattern of discrimination that was likely orchestrated by persons in authority at TVA to terminate Mr. Fiser’s career. It is our view that Mr. Fiser’s engagement in protected activities played at least some role in the adverse action taken against him. That being so, TVA has discriminated against Mr. Fiser in violation of 10 C.F.R. § 50.7.

In that connection, we note that, throughout this proceeding, TVA has attempted to expand the arena of nonprotected activities and to contract the scope of protected activities. TVA has done so in two ways: (1) by its legal construction of 10 C.F.R. § 50.7 as covering only discrimination identified by section 211 of the ERA and as excluding discrimination precluded by the AEA; and (2) by narrowly defining what constitutes a protected activity. As described earlier, we have essentially rejected both avenues of TVA’s approach.

TVA (and NEI) regard the strict approach to discrimination adopted by the Staff as counterproductive. “A finding of discrimination based on the facts of the present case would have a very real potential for a chilling effect on management — an effect that would be contrary to nuclear safety.” TVA FOF ¶ 16.6; *see also* NEI Brief at 24-25.

We agree that the Staff is adopting a stiff standard for construing 10 C.F.R. § 50.7. We also agree that the Staff is broadly construing the scope of activities covered by that section. But we disagree with TVA that the Staff’s approach would have a deleterious effect on nuclear safety. TVA is essentially saying that a little discrimination is permissible if it enhances the ability of managers to operate their facilities efficiently.

As the Staff has pointed out, relevant evidence of discrimination should not be ignored “simply because it might impact how nuclear managers conduct their business.” Staff RESP FOF ¶ 3.16. Further, we fail to see “how encouraging nuclear managers to conduct personnel processes in a fair and impartial manner would have a detrimental effect upon the nuclear industry. To the contrary,

ensuring whistle blowers are protected from retaliation for raising concerns promotes nuclear safety.’’ *Id.*

E. Conclusions of Law

1. The NRC is authorized under both the Atomic Energy Act and section 211 of the Energy Reorganization Act to take action against licensees for whistleblower retaliation claims.

2. Violations by a licensee of either section 211 of the ERA or of the Atomic Energy Act enforcement provisions are subject to civil penalties under section 234 of the Atomic Energy Act.

3. The appropriate standard of proof applicable to a 10 C.F.R. § 50.7 case is whether the Staff can prove by a preponderance of the evidence that the complainant’s protected activity was a contributing factor in an adverse action.

4. Circumstantial evidence of discrimination may be used to establish, by a preponderance of the evidence, that discrimination took place.

F. Civil Penalty

Having found that TVA violated 10 C.F.R. § 50.7 by failing to select Mr. Fiser for a continuing position during the 1996 reorganization, the Staff utilized NRC’s Enforcement Policy, NUREG-1600, 64 Fed. Reg. 61,142 (Nov. 9, 1999) [hereinafter “NUREG-1600”] to determine the civil penalty it would impose. Tr. 282 (Luehman); *see* Staff Exh. 170.³⁷ The supplements to NUREG-1600 are used to determine the severity level of a violation, and the particular severity level depends for the most part on the management level of the discriminating official. Tr. 283, 285 (Luehman). The Staff characterized the violation by TVA as Severity Level II (*see* NOV, Joint Exh. 47), based on the activities of Mr. McGrath and Dr. McArthur as “plant management or mid-level management” set forth in Supplement 7 to NUREG-1600. (TVA stipulated that Mr. McGrath and Dr. McArthur were senior-level management at TVA. Tr. 301 (Luehman).)

Once the severity level of a violation is ascertained, the Enforcement Policy calculates the amount of a civil penalty in accord with Tables 1A and 1B of that policy. Table 1A sets forth base civil penalties based on the type of licensee, its size, and ability to pay. Under that table, the base civil penalty for TVA is \$110,000. Table 1B is then used to adjust the civil penalty based on severity level of the violation. The base civil penalty for a Severity Level II violation by a

³⁷ As set forth in NUREG-1600, “this is a policy statement and not a regulation. The Commission may deviate from this statement of policy as appropriate under the circumstances of a particular case.” NUREG-1600, 64 Fed. Reg. at 61,145.

licensee such as TVA is \$88,000 (80% of a Severity Level I violation). Tr. 286, 287, 303 (Luehman); *see also* NUREG-1600, 64 Fed. Reg. at 61,150.

Following determination of a base civil penalty for a particular violation, NUREG-1600 authorizes adjustment of the penalty based on factors such as (a) previous escalated enforcement action (regardless of activity area) during the past two years or two inspections, whichever is longer; (b) whether the licensee should be given credit for actions related to identification; (c) the promptness and comprehensiveness of corrective actions; and (d) whether, “in view of all the circumstances, the matter in question requires the exercise of discretion.” NUREG-1600, 64 Fed. Reg. at 61,151. A flowchart together with descriptive instructions as to the exercise of discretion appears on page 61,151. *Id.*; Tr. 287-88 (Luehman). Based on these factors, the base civil penalty may be escalated or mitigated as a matter of discretion. One of the factors on which mitigation may be selected is “the clarity of the requirement [for which a violation has been found].” NUREG-1600, 64 Fed. Reg. at 61,157. NUREG-1600 also includes the caveat that, “*absent the exercise of discretion,*” the outcome of the assessment process for each violation or problem “is limited to . . . no civil penalty, a base civil penalty, or a base civil penalty escalated by 100%.” *Id.* at 61,151 (emphasis added).

In ascertaining that the civil penalty in this case should be \$110,000, the Staff started with the base of \$88,000. It determined that the protected activities of Mr. Fiser, including the two DOL complaints, the letter to Senator Sasser, and the technical activities that have been found to be protected activities on the part of Mr. Fiser, together with TVA’s discouragement of whistleblowing activities, are of sufficient significance to warrant escalation of the base penalty by 100% (leading to a potential penalty of \$176,000). The Staff declined to mitigate the penalty for actions by TVA related to identification — indeed, TVA still does not acknowledge that any violation occurred. Nor did the Staff feel that corrective actions by TVA warranted mitigation. Based on the statutory maximum civil penalty of \$110,000, the Staff imposed a civil penalty of that amount. The Licensing Board finds that the NRC Staff appropriately applied the guidance in NUREG-1600 in imposing the civil penalty of \$110,000.

NUREG-1600 permits adjustments of the civil penalties imposed based on discretion by the NRC. This discretion may be exercised by the NRC Staff or, in a proceeding such as this, by the Atomic Safety and Licensing Board designated to rule on appeals of the civil penalty. 10 C.F.R. § 2.205(f). In this proceeding, the Licensing Board believes that a violation of 10 C.F.R. § 50.7 has occurred. But the failure to retain Mr. Fiser appears to have been premised at least to some degree on TVA’s view of Mr. Fiser’s work history. Indeed, his protected activities appear to have played a minor role in his failure to be retained. That is sufficient under 10 C.F.R. § 50.7 (although perhaps not so under section 211). But a manipulation of personnel regulations also appears to have played some

role in that result, inasmuch as, if standard RIF procedures had been utilized, Mr. Fiser would have been retained.

Based on all these circumstances, and particularly the small role that protected activities may have played in leading to the adverse action against Mr. Fiser, we believe that the base civil penalty of \$88,000 should not have been escalated and that the \$110,000 civil penalty should instead be mitigated to \$44,000 (one-half the base penalty). This is based in large part on TVA's misunderstanding that, unlike under section 211, an adverse action premised on violation of the AEA may be based not only where a significant portion thereof is premised on a substantial contribution of the protected activities (as under section 211) but also where only a small part is premised on an employee's participation in protected activities.

In reaching this decision, the Licensing Board has considered all the evidence submitted by the parties and the entire record of this proceeding. That record consists of the Commission's Notice of Violation and Proposed Imposition of Civil Penalty (NOV), the Commission's Order Imposing Civil Monetary Penalty, the pleadings filed by both parties (TVA and the NRC Staff) and by the Nuclear Energy Institute, as *amicus curiae*, the oral testimony adduced on the record and the exhibits received into evidence, and the proposed findings of fact and conclusions of law submitted by each of the parties. To the extent they are accepted in whole or in part, such proposed findings and conclusions are reflected by the Board's discussion of the issues and findings set forth above. All issues, arguments, or proposed findings presented by the parties, but not addressed in this Decision, have been found to be without merit or unnecessary to this Decision.

G. Order

Based on the foregoing opinion, including findings of fact, conclusions of law, and the entire record, it is, this 26th day of June 2003, ORDERED:

1. The Order Imposing Civil Monetary Penalty, dated May 4, 2001, and published at 66 Fed. Reg. 27,166 (May 16, 2001) is hereby *sustained*, except that the civil monetary penalty of \$110,000 set forth therein is hereby reduced to \$44,000, for reasons set forth in this opinion. The Tennessee Valley Authority shall pay the \$44,000 civil penalty within 30 days of the date of this Initial Decision, in accordance with NUREG/BR-0254. In addition, at the time of making the payment, the Licensee shall submit a statement indicating when and by what method payment was made, to the Director, Office of Enforcement, U.S. Nuclear Regulatory Commission, One White Flint North, 11555 Rockville Pike, Rockville, MD 20852-2738. (A copy of this statement should also be furnished to the Licensing Board.)

2. This Initial Decision is effective immediately and, in accordance with 10 C.F.R. § 2.760 of the Commission's Rules of Practice, shall become the final action of the Commission forty (40) days from the date of its issuance, unless any

party petitions the Commission for review in accordance with 10 C.F.R. § 2.786 or the Commission takes review *sua sponte*. See 10 C.F.R. § 2.786.

3. Within fifteen (15) days after service of this Decision, any party may seek review of this Decision by filing a petition for review by the Commission on the grounds specified in 10 C.F.R. § 2.786(b)(4). The filing of the petition for review is mandatory for TVA to exhaust its administrative remedies before seeking judicial review. 10 C.F.R. § 2.786(b)(2).

4. Any petition for review shall be no longer than ten (10) pages and shall contain the information set forth in 10 C.F.R. § 2.786(b)(2). Any other party may, within ten (10) days after service of a petition for review, file an answer supporting or opposing Commission review. Such an answer shall be no longer than ten (10) pages and, to the extent appropriate, should concisely address the matters in 10 C.F.R. § 2.786(b)(2). A petitioning party shall have no right to reply, except as permitted by the Commission.

5. Attached to this Initial Decision are the following Appendices:

- APPENDIX A: List of Exhibits (unpublished).
- APPENDIX B: List of Witnesses (unpublished).
- APPENDIX C: Transcript Corrections (unpublished).
- APPENDIX D: List of Acronyms and Abbreviations (unpublished).

THE ATOMIC SAFETY AND
LICENSING BOARD

Charles Bechhoefer, Chairman
ADMINISTRATIVE JUDGE

Dr. Richard F. Cole
ADMINISTRATIVE JUDGE

[Copies of this Initial Decision, along with the Separate Opinion of Administrative Judge Young, and Appendices to the Decision, have been transmitted this date by e-mail to counsel for each of the parties.]

[Appendices A, B, C, and D have been omitted from this publication but are available in ADAMS (ML031770503) for public inspection at the Commission's Public Document Room located at One White Flint North, 11555 Rockville Pike, Rockville, MD.]

Separate Opinion of Administrative Judge Ann Marshall Young, Concurring in Part and Dissenting in Part

I concur with my colleagues, with regard to the four-part test described *supra* p. 569, that parts 1 through 3 — involving whether the employee engaged in protected activity, whether the employer was aware of the protected activity, and whether an adverse action was taken against the employee — are met in this case. The central question in this proceeding is, and the outcome turns on, whether “the adverse action [was] taken because of the protected activity.” *See id.*

I concur that the evidence presented in this proceeding indicates, by a preponderance, that there was some disparate treatment of Mr. Gary Fiser, and that an atmosphere of hostility to whistleblowers existed at some points in time at TVA. Regarding the former, for example, the posting of the position for which Mr. Fiser and others competed in 1996, while not posting the position filled by Dr. McArthur, shows an inconsistency in how TVA applied its RIF policies and procedures. Regarding the latter, despite testimony from some employees to the effect that filing a DOL complaint is not viewed negatively at TVA, I find that sufficient evidence was presented to establish that, at least at some points in time, this was indeed negatively viewed.

I do not, however, view these facts, in the context of, and/or in combination with, the other evidence presented in this proceeding, as leading to a conclusion that a violation of 10 C.F.R. § 50.7 on the part of TVA was proven *in this proceeding*. Although I agree that it is not necessary to have a “smoking gun” to prove discrimination, and agree that any participation in protected activity is a significant matter, I would find that it has not been shown *by a preponderance of the evidence in this proceeding*, through reasonable inferences drawn from the evidence that was presented, that any disparate treatment of, or adverse action against, Mr. Fiser that did occur was taken *because of* any protected activity. Thus, I would find that there is insufficient proof to support a conclusion of discrimination or retaliation under section 50.7 in this proceeding. I must therefore dissent from the ultimate decision of my colleagues.

In reaching this determination, three issues on which I differ with my colleagues are particularly pertinent in my analysis: (1) whether “protected activities” include not only “discovering, raising, reporting, and/or documentation of [specific safety issues] but also participation in their resolution,” *see supra* p. 580; (2) whether sufficient evidence was presented to support a conclusion that Mr. Fiser engaged in any protected activity other than the filing of the two DOL complaints and the letter to Senator Sasser; and (3) whether sufficient evidence was presented to support the ultimate outcome in this proceeding with regard to the required nexus between protected activity and the adverse action(s) against Mr. Fiser, and the resulting penalty assessed against TVA.

Definition of “Protected Activities”

My colleagues adopt the Staff’s definition of “protected activity,” which includes “participation in [the] resolution” of safety matters, even when one has done nothing to discover, raise, report, or document any safety matter. *Id.* I cannot concur with this definition as adopted, as I find it neither falls within a reasonable reading of 10 C.F.R. § 50.7, nor bears any reasonable relationship to the basic nature of activities commonly understood to constitute “whistleblowing” — which is generally considered to bear some indicia of acting to one’s own possible detriment *against* the explicit or implicit directives or wishes of the employer, to address safety matters that might not otherwise be addressed. Although there might be circumstances in which participating in resolving a safety issue might place an employee in the position of being a whistleblower — i.e., circumstances in which the employee participates in actually correcting, or attempting to correct, a safety matter *against* the wishes of an employer (and thereby arguably, in effect, “refusing to engage in any practice made unlawful,” as provided in section 50.7(a)(1)(ii)) — I do not see that merely participating in resolving a safety matter, when there is no indication that such participation is undertaken against the wishes of management in order to address safety concerns that might not otherwise be addressed, is in any way encompassed within a reasonable reading of section 50.7 or a reasonable definition of “whistleblowing,” as discussed above.

Whether Sufficient Evidence of “Technical Protected Activities”

My colleagues state that they view the “technical protected activities” — which I take as referring to any activity of Mr. Fiser with regard to actual safety issues, apart from filing the complaints and signing the letter to Senator Sasser with two other TVA employees — “as necessary adjuncts to the Staff’s theory” in this proceeding. *Supra* p. 582. I tend to agree that without any findings of such “technical protected activities” on the part of Mr. Fiser the Staff’s case becomes significantly less persuasive. Given my view, however, that mere participation in resolving safety issues, as defined by my colleagues, is insufficient to constitute a protected activity, my analysis of the facts of this case leads me in a different direction than that taken by my colleagues in this case.

I note, with regard to participation in resolving safety issues, that the record in this proceeding includes evidence that management not only supported efforts to resolve safety problems and exhibited concern when they were not addressed with sufficient attention, *see, e.g.*, Tr. 4718 (Ritchie); in at least one instance in which Mr. Fiser claimed to have been a major player in discovering the source of a problem and correcting it — the situation with the diesel generator fuel oil storage tanks — another person actually pointed the way to the source of the problem and directed Mr. Fiser how to go about resolving it. According to the

testimony of Mark Burzynski, the corporate licensing manager for TVA, borne out by a handwritten memorandum from J.D. Smith, “Manager NRR,” dated August 11, 1989, *before* any indication of any meaningful involvement by Mr. Fiser and *after* “chemistry personnel” indicated a belief the NER “did not apply to Sequoyah,” *see supra* p. 588, it was Mr. Smith who identified this problem, and *specifically* directed Mr. Fiser to look, among other things, to “[h]ow was this missed in SI [surveillance instruction] review program,” to write a “CAQ/PRO as appropriate,” and to “[m]aintain working copy of all chemistry related ASTM [standards].” Tr. 4917-18 (Burzynski); TVA Exh. 128 at FI000080; TVA Exh. 147 at FI000259; *see also* Tr. 4891-92, 4908-10, 4912-13, 4926-36 (Burzynski).

In the face of evidence such as this — indicating that any participation of Mr. Fiser in resolving the diesel generator fuel oil storage tank sampling problem was not done against the wishes of TVA but rather in compliance with specific directions *to* him — I find especially troubling the *absence* of any other testimony corroborating Mr. Fiser’s own testimony on his asserted participation in addressing safety concerns, or corroborating that his participation in any activities was of a nature similar to what is generally understood by the term “whistleblowing,” or of a nature that would fall within a reasonable reading of the provisions of 10 C.F.R. § 50.7. That he may have been threatened with disciplinary action for in some way being responsible for a problem he may not have caused might, if true, be unfair, but I would not find this to equate to any attempted adverse action based on any protected activity.

In others of the situations in which my colleagues find that Mr. Fiser participated in resolving safety issues, there is no finding that he did anything against management’s wishes, other than *not* resolving an issue successfully or adequately, *see, e.g., supra* pp. 584, 586-87, or refusing to initiate a procedure that might, if *not* followed, subject TVA to a finding of a violation of procedures, *see supra* pp. 589-92.

In these circumstances, I fail to see any participation in any protected activity in any substantive sense that was actually related to a safety matter in any way reasonably encompassed by section 50.7. Thus, even under the analysis of my colleagues, I would find the “necessary adjuncts of the Staff’s theory” to be lacking. Proceeding, however, on the theory that the two DOL complaints and the letter to Senator Sasser — which all parties agree constitute “protected activity” *per se* — may constitute sufficient protected activity on their own on which to ground a ruling against TVA based on the facts in this proceeding, I analyze in the next section the letter and complaints from this perspective, considering their nature and weight (along with that of other relevant evidence) in determining whether the Staff established by a preponderance of the evidence the required “nexus” between protected activity on the part of Mr. Fiser and adverse actions against him.

Whether Sufficient Evidence of Nexus Between Protected Activity and Adverse Actions To Support Penalty Against TVA

With regard to the letter to Senator Sasser, it appears from the evidence presented that Mr. Fiser signed on to a letter that originated with two other persons who had already filed DOL complaints themselves, only *after* he had been given “surplus” and “RIF” notices that ultimately relieved him of his job in 1993. His surplus notice came in April 1993, and his RIF notice is dated August 13, 1993, three days before the August 16, 1993, letter to Senator Sasser. Although this timing does not suggest that the contents of the letter were in any way untrue, it leaves open the possible reasonable inference that, insofar as Mr. Fiser was concerned, he signed on to the letter of Mr. Jocher and Dr. Matthews only in order to better his chances of regaining his job.

My colleagues find, and I agree, that it was not proven that Fiser himself was involved in discovering, raising, reporting, or documenting any of the underlying safety matters discussed in the letter. This lack of proof that Mr. Fiser himself participated in either discovering, raising, reporting, or documenting any safety matter — *other than by signing the letter* — might support a finding that he was, in the words of my colleagues, “merely ‘working the system’ to attain personal advantage,” *see supra* p. 582, in signing the Sasser letter. I would find this to be a reasonable possibility — just as it is *possible* that Mr. Fiser *was* himself involved in discovering, raising, reporting, and documenting safety matters at TVA (notwithstanding my colleagues’ and my findings that this was not proven), and signed the Sasser letter at least in part in a genuine effort to address legitimate safety concerns. Despite the latter scenario being *possible*, however, I would not find such a genuine effort to have been proven *by a preponderance of the evidence* considering the record as a whole, in part *because of* the manifest insufficiency of the evidence to show any involvement on the part of Mr. Fiser in discovering, raising, reporting, or documenting actual safety matters, and particularly when this insufficiency is considered in conjunction with the timing of the letter.

The same analysis may be applied to Mr. Fiser’s two DOL complaints. The first, in 1993, followed after the Sasser letter, and the same observations made about that letter might also be made about the 1993 DOL complaint — which was settled in 1994 primarily through Fiser being offered and accepting a lower-level, PG-8, position. TVA FOF at 42, ¶4.0; Staff RESP FOF at 25-26, ¶2.56. The second complaint, in 1996, was filed after the posting for competition of the position that Mr. Fiser felt he deserved by virtue of it being the same position in which he was placed in settlement of his 1993 complaint. Staff Exh. 37. The timing of the 1996 complaint might support a possible reasonable inference that it thereby put Mr. Fiser in a position of more easily being able to say that any subsequent nonselection of him for the position was done in retaliation for filing the complaint, and that this was the only purpose of the filing. Again, I

am not suggesting that the preponderance of the evidence is to the effect that Mr. Fiser was “using the system”; it is quite possible that he was not, and that his 1996 complaint was genuinely based on legitimate concerns, which may earlier have originated in activities of the sort generally understood to constitute whistleblowing protected activities. But, again, in the same vein as above, I also do not find either aspect of the latter scenario to have been proven by a preponderance of the evidence.

With regard to both of the DOL complaints as well as the Sasser letter, I would find, based on the evidence presented at the hearing in this proceeding, that it is just as possible that each was undertaken in an effort solely to protect Mr. Fiser’s job, for non-safety-related reasons, as that each arose out of genuine concerns originating in and thereby relating to whistleblowing protected activities. Thus, although there is no dispute that these constitute *per se* protected activity, I would not find that the evidence preponderates in favor of these being genuine in the sense of clearly having been undertaken in a manner falling within the underlying *purposes* of the whistleblowing law and rules.

In the absence of what I would view as sufficient evidence to support a finding that the Sasser letter and the DOL complaints of Mr. Fiser were genuinely related in some way to discovering, raising, reporting, documenting, or otherwise addressing any safety-related concerns against the wishes of management in a manner that would be encompassed within whistleblowing activity as discussed above, the question remains whether sufficient evidence was presented to establish the required nexus between such *per se* protected activity alone, on the one hand, and the adverse actions against Mr. Fiser, on the other, or to support the penalty assessed against TVA. I would find this to be possible in the right case, with adequate evidence to support such a conclusion, but, *in this proceeding*, I would find that no such nexus has been proven *by a preponderance of the evidence*.

While it is possible that the questionable actions taken by Mr. McGrath, Dr. McArthur, and others, relating to (among other things) posting the position to which Mr. Fiser claimed a right in 1996, arose in part out of his filing of the complaints and signing the Sasser letter, it is also possible that they were based solely on antipathy toward him arising out of longstanding concerns about his competence in his job, particularly with regard to not asserting himself or making sure that problems were solved, along with personal dislike and similar motivations.

For example, his lack of effectiveness as a manager who could, among other things, assure that his staff was sufficiently trained to address chemistry problems and issues, was observed. *See, e.g.*, Tr. 4919-23 (Burzynski). Specific perceived weaknesses in his performance were also identified in writing from early on. Among other things, *see supra* pp. 570-71, in his January 1989 performance evaluation, it is stated that “Mr. Fiser must become more aggressive in the performance of his duties”; in September 1989 it is stated that “he demonstrated

continued weaknesses in aggressiveness and communication skills;” and in September 1991 it is stated that he was “not using the authority of his position as an Outage Manager effectively.” Joint Exhs. 30-32.

Moreover, it appears that Mr. McGrath’s animosity to Mr. Fiser began in 1991, well *before* the 1993 Sasser letter or either DOL complaint was sent — when, by his own statement, Mr. Fiser “refused” to adopt a procedure to do daily data trending after Mr. McGrath directed him to do this at the NSRB meeting. Tr. 2473-74 (Fiser); *see* Tr. 4704-05, 4708 (Ritchie). Apparently, this incident “set off” Mr. McGrath, *see* Tr. 1404-05, 1409 (McArthur); Staff FOF at 66-67, who from that point on appears to have had a strong dislike of Fiser and viewed him as “not [being] effective.” *See* Staff Response FOF at 18-19, ¶¶ 2.41, 2.42, and citations therein; *see also* Tr. 4718 (Ritchie). I would find it likely that this, along with Mr. Fiser’s perceived nonaggressive approach to problem solving in his job, actually played the determinative role in the actions against Mr. Fiser.

Drawing all reasonable inferences from the proof presented, I would also find it at least possible, if not likely, that these motivations were so strong that they overrode any other motivations — including any possible negative ones based on the Sasser letter and the DOL complaints, which in my view are the only protected activity involved in this case. These motivations appear to have been strong enough to prompt significant adverse action against Mr. Fiser *prior to* any of the documents in question being sent, and it appears to me that these factors — personal dislike and performance-based problems — were likely sufficient cause on their own for his superiors to misuse the RIF process to attempt to “get rid of” a perceived poor performer, whom they did not like. Then, when (according to what I would find to be a clear preponderance of the evidence in the record) Mr. Fiser performed poorly in the interview for the disputed job in 1996, *see, e.g.,* TVA FOF at 103-05, and citations to record found therein, responding to questions that even his supporter Jack Cox thought were fair, Tr. 1778-80 (Cox); *see* Staff FOF at 60, ¶ 2.174; TVA FOF at 94-95, ¶ 9.21; *supra* p. 598, he thereby provided the final “ammunition” needed in this possible effort to “get rid of” him.

With regard to Mr. Kent’s making reference to Mr. Fiser’s DOL complaint before the interview, it seems at least as possible as not, based among other things on my observation of Mr. Kent while testifying, that he was sincerely cautioning Dr. McArthur that he should not participate in the interview so as *not* to create any problem vis à vis the complaint. *See* Tr. 2877-79 (Corey), 3154-55 (Kent); Staff FOF at 65-66. It would also seem reasonable to infer the possibility that, indeed, there was a real effort generally at TVA to *avoid* taking any negative action against Mr. Fiser based on the protected activity of his complaints and the Sasser letter.

Regarding the taping by Mr. Fiser, it is very probable that knowledge of his undisclosed taping of conversations contributed to dislike of Mr. Fiser on the part

of some at TVA. The Staff suggests that the fact that he used these to support his DOL complaints should be viewed as rendering *them* protected activity, Staff RESP FOF at 37, and also raises questions regarding the sharing of information about the taping against Mr. Fiser's wishes that it remain confidential. *See, e.g.*, Staff FOF at 39-41. I would find some connection between the taping and protected activity to be possible. However, the possibility of annoyance or hostility toward Mr. Fiser on the part of persons who learned of themselves or others being taped would also seem to be self-evident *without regard to* whether the taping had any relationship to protected activity. And the same possibility would seem to exist with regard to such persons telling others (whether appropriately or inappropriately) that their conversations with Mr. Fiser had been or might be taped without their knowledge.

In sum, although I would agree the Staff made out a prima facie case of discrimination under section 50.7, and that some of the actions taken by TVA management against Mr. Fiser were questionable, the Staff still bears the ultimate burden of proving by a preponderance of the evidence that discrimination was a contributing factor in the adverse actions against Mr. Fiser, and this is where I find the Staff's case fails. It is certainly possible that discrimination was a contributing factor in the actions against Mr. Fiser. I find it equally possible, however, that such actions were actually based only on performance-related factors together with inappropriate as well as possibly inept management practices and actions, personality clashes, personal dislike and hostility, and related grounds. And, no matter how inappropriately undertaken, when all reasonable inferences are drawn and the possibility of the adverse actions being based only on such grounds is equally as possible as that discrimination based on protected activity played a role in the actions, the necessary conclusion is that the burden of proving some discrimination-related contributing factor, by a preponderance of the evidence, has not been met.

As the Court stated in the case of *Benzies v. Illinois Department of Mental Health*, although a "demonstration that the employer has offered a spurious explanation is strong evidence of discriminatory intent, . . . it does not compel such an inference as a matter of law. The judge may conclude after hearing all the evidence that neither discriminatory intent nor the employer's explanation accounts for the decision." 810 F.2d 146, 148 (7th Cir. 1987). "In other words," as the Supreme Court has stated, "[i]t is not enough . . . to *disbelieve* the employer; the fact finder must *believe* the plaintiff's explanation of intentional discrimination.'" *Reeves v. Sanderson Plumbing Products*, 530 U.S. 133, 147 (2000) (emphasis in original) (citing *St. Mary's Honor Center v. Hicks*, 509 U.S. 502, 519); *see also Zinn v. University of Missouri*, Nos. 93-ERA-34, 93-ERA-36, 1996 DOL Sec. Labor LEXIS 8 at *11-12 (Sec'y, Jan. 8, 1996); Staff RESP FOF at 11, 29-30. "The ultimate burden of persuading the trier of fact that the defendant intentionally discriminated against the plaintiff remains at all times with

the plaintiff.’’ *Reeves*, 530 U.S. at 143 (citing *Texas Department of Community Affairs v. Burdine*, 450 U.S. 248, 253 (1981)). I do not find that the Staff has met its burden of persuasion by a preponderance of the evidence in this proceeding.

Conclusion

For the reasons discussed above, I cannot concur with my colleagues in their sustaining of the Order Imposing Civil Monetary Penalty in this proceeding, even with the reduced penalty. Moreover, *in this case* I would find sustaining the Order to create a potential for abuse of the section 211 and section 50.7 protections, for resulting possible erosion of confidence in the process by those with truly legitimate concerns, and for possible counterproductive results as well, to an extent, on the part of management attempting to improve operational and safety performance and best utilize the skills of personnel, as in effect argued by TVA and NEI. *See* NEI Brief at 25, TVA FOF at 136-39. Such results would run counter to and could undermine the purposes of the law governing this proceeding. And without some reasonably realistic common understanding on the part of all concerned — licensees, employees, the public, and the NRC Staff — of what behavior and activities will constitute violations of section 50.7, there could be a significant potential for worse, rather than better, communication about safety issues and resolution of safety problems.

None of the previous discussion is to suggest in any manner that, in appropriate cases, there should be any hesitance to enforce section 50.7 through orders and rulings against licensees, including assessments of significant civil penalties. Nor should my dissent be taken as in any way suggesting that any atmosphere that may exist within TVA that is hostile to whistleblowers is not reprehensible. There is certainly evidence that such an atmosphere has existed, as discussed by my colleagues. If it persists today, it should be changed; indeed, if any such hostile atmosphere were *not* changed, it might well be predicted that other complaints might be brought that could result in additional future charges against TVA.

In this proceeding, however, it is alleged action against Mr. Fiser that is the central issue, not the general atmosphere at TVA with regard to whistleblowers. While such an atmosphere is relevant to the issue of whether actions taken against Mr. Fiser were based on protected activity, the evidence as a whole must preponderate in favor of such a finding in order to rule against TVA, and, as indicated above, I do not find such a preponderance, despite the possibility that this could have occurred. It may be that there were other witnesses who might have corroborated Mr. Fiser’s testimony. But they were not called to testify and provide such corroboration. Presentation of testimony uncorroborated by *any* other actual testimony, as Mr. Fiser’s was in this proceeding on virtually all of the significant points I discuss above, when there appear to have been possible witnesses who might have corroborated his testimony if true, undercuts the NRC

Staff's good work in investigating and otherwise preparing a case for litigation. It also, in this case, if Mr. Fiser was completely accurate in all he said, undercuts *his* credibility in a manner that might be said to be unfair to him.

In my view, in order to foster greater credibility all around in proceedings involving allegations of discrimination against whistleblowers, more, stronger, more substantial, and in some ways more focused evidence than was presented in this proceeding should be marshaled and presented to support appropriately significant outcomes. All proceedings involving such allegations are, and should be treated as, serious matters warranting close attention, and my dissent should not be taken as endorsing any approach that would minimize in any way their seriousness, in this or any other case. I wish to emphasize my agreement with my colleagues that *any allegation* of discrimination and/or retaliation on the basis of alleged protected whistleblowing activity is a significant matter warranting serious attention and respect, not to be taken lightly or otherwise disregarded, especially by anyone in a position to address it. I am, however, concerned that to find a violation in the absence of a stronger case, clearly establishing by the required preponderance of the evidence standard that such discrimination or retaliation has actually occurred, may actually diminish the level of meaningful attention and respect accorded the requirements of section 50.7 by employers and employees alike, and thereby potentially compromise safety consciousness in licensee sites. This would be a particularly unfortunate outcome, especially in light of the importance of the NRC mission to protect the public health and safety.

I have endeavored to give this case my close and most serious attention, and despite observing a number of questionable circumstances and recognizing the possibility of there being discrimination as alleged, I find a lack of sufficient evidence under the law and the preponderance of the evidence standard to sustain the Order. I therefore respectfully dissent from the decision of my colleagues.

Ann Marshall Young
ADMINISTRATIVE JUDGE

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