APPENDIX B

IDENTIFICATION AND RESOLUTION OF SAVANNAH RIVER SITE SPENT NUCLEAR FUEL VULNERABILITIES

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APPENDIX B. IDENTIFICATION AND RESOLUTION OF SAVANNAH RIVER SITE SPENT NUCLEAR FUEL VULNERABILITIES

B.1 Purpose

The end of the Cold War brought an end to active efforts in the United States to produce nuclear weapons materials such as plutonium. As a consequence, nuclear materials produced for weapons have been stored temporarily for prolonged periods in systems and under conditions not originally designed for long-term storage. Prolonged storage in systems and under conditions designed for short-term storage has degraded the integrity of some of these materials and has led to concerns about safety. These concerns have been documented in reports by both the U.S. Department of Energy (DOE) and the Defense Nuclear Facilities Safety Board (DNFSB). The purpose of this appendix is to provide a compilation of spent nuclear fuel (SNF) storage problems (vulnerabilities) specific to the Savannah River Site (SRS), their recommended corrective actions, and the current status of those corrective actions.

B.2 Introduction and Background

For about 30 years, DOE operated heavy-water reactors at SRS for the production of defense nuclear materials. Low-temperature reactor operation allowed the use of aluminum-clad, aluminum-alloy fuel and aluminum-clad target materials. This reactor design facilitated both fuel and target fabrication and subsequent processing. At the end of a reactor cycle, the fuel and targets were normally discharged to cooling basins and stored for as long as 18 months prior to processing.

In the past, the SRS processed SNF and other reactor-irradiated nuclear materials (RINM) to recover plutonium, tritium, and other isotopes. In April 1992, with chemical separations activities already temporarily suspended, DOE implemented a decision to phase out defense-related chemical separation activities at the SRS. Processing of the "in-process" RINM was not completed. Facilities designed, constructed, and operated to store RINM for relatively short periods had to store it for relatively long periods pending decisions on the disposition of the materials.

B.3 Spent Fuel Working Group

In August 1993, the Secretary of Energy commissioned a comprehensive baseline assessment of the environmental, safety, and health (ES&H) vulnerabilities associated with the storage of reactor-irradiated nuclear materials in the DOE complex. In October 1993, a multidisciplinary Spent Fuel Working Group, comprised of DOE and contractor employees, assessed 66 facilities on 11 sites. Eight SRS facilities that contained RINM were assessed. The facilities included both wet and dry storage systems. The assessment's objective was to provide an itemized inventory of RINM and an initial assessment of ES&H vulnerabilities associated with the current storage and handling of these materials.

DOE defined vulnerabilities as conditions or weaknesses that could lead to radiation exposure to the public, unnecessary or increased exposure to the workers, or release of radioactive materials to the environment. The loss of institutional controls, such as cessation of facility funding or reductions in facility maintenance and control, could also cause vulnerabilities. Reactor-irradiated nuclear material was defined as spent nuclear fuel and irradiated nuclear targets from production and research reactors; however, it did not include fuel currently in active reactors or irradiated structural materials (other than fuel cladding).

The assessment focused on determining ES&H vulnerabilities and presenting factual information. In general, DOE did not identify or recommend future corrective actions, but did assess corrective actions already under way. Evaluations were made of facilities, structures, systems, operating conditions, and procedures necessary to protect the workers, the public, and the environment during the storage and in-facility handling of reactor-irradiated nuclear material.

On December 7, 1993, the Working Group released *Spent Fuel Working Group Report on Inventory and Storage of the Department's Spent Nuclear Fuel and Other Reactor Irradiated Nuclear Materials and Their Environmental, Safety, and Health Vulnerabilities* (DOE 1993) ("The Working Group Report," Volumes I, II and III). Volume I summarized the findings, including: (1) the characteristics and inventory of reactor-irradiated nuclear material; (2) ES&H vulnerabilities associated with different storage options; (3) five generic issues common to many storage facilities; and (4) identification of eight facilities requiring priority management attention, including the SRS L- and K-Reactor Disassembly Basins.

Volume II of the Working Group Report contains Working Group Assessment Team reports for each site, Vulnerability Development forms, and documents used by the Working Group Assessment Team as information sources. Volume II categorized vulnerabilities based on the period during which it was recommended that the vulnerability be addressed. For each of the eight SRS facilities, vulnerabilities were grouped into one of three time periods for management attention: less than 1 year, 1 to 5 years, and more than 5 years.

Volume II identified 21 SRS vulnerabilities. A twenty-second vulnerability was identified later. When DOE reviewed the ES&H vulnerabilities, it determined that two (SRS-2 and SRS-3) were not vulnerabilities and obtained agreement from the working group assessors. Table B-1 lists the SRS vulnerabilities and their assigned priorities.

Fifteen vulnerabilities warranting priority management attention, including one potential vulnerability, were identified for the SRS L-, K-, and P-Reactor Disassembly Basins. Four major vulnerabilities and one generic vulnerability were identified for the Receiving Basin for Offsite Fuel (RBOF). The *Reactor Division Disassembly Basin Management Plan* (Burke 1993) addressed and provided resolution of the vulnerabilities identified for the reactor disassembly basins and RBOF. A February 21, 1997 memorandum reports on the corrective action closure package for the reactor disassembly basins and RBOF vulnerabilities (Burke 1997).

In February 1994, DOE released the first phase of a three-phased plan to remedy vulnerabilities associated with the storage of spent fuel and irradiated materials. The *Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities, Phase I* (DOE 1994a) described actions that had been completed or for which no major funding or policy issues existed. After the Phase I report was issued, DOE resolved most funding issues associated with SNF vulnerabilities. The Phase II Plan of Action (DOE 1994b), published in April 1994, was the product of follow-on work to the Phase I report.

The Phase III Plan of Action (DOE 1994c), the second update to the original Plan of Action, was issued in October 1994. The Phase III report focused on the resolution of critical policy issues and incorporated stakeholder comments on the original Plan of Action and the first update. Table B-2 lists the Phase I, II, and III corrective action plans and their reported status.

B.4 Defense Nuclear Facilities Safety Board Recommendation 94-1

In May 1994, the DNFSB issued Recommendation 94-1, *Improved Schedule for Remediation in the Defense Nuclear Facilities Complex* (DNFSB 1994). The Board expressed its concern that imminent hazards could arise during the next 2 to 3 years unless problems related to the state of reactor-irradiated nuclear material remaining from the production of nuclear weapons were resolved.

Table B-1. SRS vulnerabilities identified in Spent Nuclear Fuel Working Group Report.

Vulnerability	Priority[a] 1	Priority[a] 2	Priority[a] 3
SRS-01, L-Reactor Disassembly Basin: Potential unmonitored build-up of radionuclide and/or fissile materials in sand filters.	√		
SRS-04, L-Reactor Disassembly Basin: Lack of authorization basis in operating sand filter cleanup system for L-Area Disassembly Basin.	√		
SRS-05, L-Reactor Disassembly Basins: Corrosion of aluminum- clad fuel, targets, and components.			√
SRS-06, L-Reactor Disassembly Basin: Cesium-137 activity level in L-Basin.	√		
SRS-07, L-Reactor Disassembly Basin: Determine if gas bubble release above the bucket storage area is a potential hazard at L-Reactor.	√		
SRS-08, K-, L-, and P-Reactors: Lack of reactor authorization basis.	√		
SRS-09, L-Reactor Disassembly Basin: Corrosion of Mark-31A and B target slugs in K- and L-Disassembly Basins.	√		
SRS-10, P-Reactor Disassembly Basin: Hoist rod corrosion.		√	
SRS-11, K- and L-Reactor Disassembly Basin: Reactor disassembly basin safety analysis envelope.	√		
SRS-12, L-Reactor Disassembly Basin: Inadvertent flooding of L-Reactor Disassembly Basin.	√		
SRS-13, K-Reactor Disassembly Basin: Inadvertent flooding of K-Reactor Disassembly Basin.	√		
SRS-14, P-Reactor Disassembly Basin: Inadvertent flooding of P-Reactor Disassembly Basin.	√		
SRS-15, RBOF, P-, L-, C-, and R-Reactors: Conduct of Operations at reactor facilities and RBOF. (NOTE: RBOF is a less-than-1-year vulnerability.)	√		
SRS-16, RBOF: Inadequate tornado protection at RBOF.		√	
SRS-17, RBOF: Seismic vulnerability of RBOF.		√	
SRS-18, H-Canyon: Seismic vulnerability of H-Canyon.			√
SRS-19, F-Canyon: Seismic vulnerability of F-Canyon.			√
SRS-20, K-, L-, and P-Reactor Disassembly Basins and RBOF: Inadequate leak detection system in the underground water-filled RINM storage basin.		√	
SRS-21, K-, L-, and P-Reactor Disassembly Basins: Inadequate seismic evaluation and potential inadequacies of structures, systems and components to withstand a Design-Basis Earthquake.	√		
SRS-22, R-Area: Potential buried spent nuclear fuel.		√	

a. **Priority 1:** Vulnerabilities identified by the Working Group as warranting immediate management attention.
Priority 2: Vulnerabilities requiring action within 1 year.
Priority 3: Vulnerabilities requiring action within 1 to 5 years (DOE 1994a).

Table B-2. Status of Savannah River Site Vulnerability Corrective Action Plans.

Identified vulnerabilities	Corrective action plans	Status
SRS-1: Potential unmonitored buildup of radionuclide/fissile material in sand filters. (L-Basin)	**SRS-1a:** Perform characterization analysis of isotopes in existing sand filter system.	**Completed 5/95.** Characterization analysis completed.
	SRS-1b: As part of the Basis for Interim Operations development, perform safety analysis for buildup of fissile material in sand filter system and potential for criticality in filters (see items 8 and 11).	**Completed 7/96.** The criticality safety evaluation determined that there is not an identifiable mechanism by which a critical configuration could be assembled in the disassembly basin sand filter. The L-Basin Basis for Interim Operations (WSRC 1996) concluded that a criticality is not a credible event in the sand filter.
SRS-4: Lack of characterization and updated safety analysis for fissile material in sludge on basin floors and sand filter cleanup systems (K- and P-Basins). (generic issue)	**SRS-4a:** Complete development and application of technologies required (at L-Basin) for characterization and analysis, removal, and disposal of sludge from L-Basin.	
	SRS-4a.1: Complete characterization of sludge from L-Basin.	**Completed 9/93.** Sludge analysis completed.
	SRS-4a.2: Complete characterization of sludge from K-Basin.	**Completed 6/93.** Sludge analysis completed.
	SRS-4a.3: Complete characterization of sludge from P-Basin.	**Completed 5/93.** Sludge analysis completed.
	SRS-4a.4: Complete removal of sludge from L-Basin.	**Phase I (Sludge Consolidation):** Completed 3/95.
	NOTE: The ability to maintain excellent basin water quality in the presence of sludge has been demonstrated, eliminating the urgency to consolidate and remove the sludge to prevent further corrosion of stored fuel.	**Phase II (Sludge Removal):** Completed 1999.
	SRS-4a.5: Complete removal of sludge from K-Basin.	**Phase I (Sludge Consolidation):** Completed 3/98 (Smith 1998).
	NOTE: The ability to maintain excellent basin water quality in the presence of sludge has been demonstrated, eliminating the urgency to consolidate and remove the sludge to prevent further corrosion of stored fuel.	**Phase II (Sludge Removal):** Cancelled 4/15/98 (Conway 1998).
	SRS-4a.6: Complete removal of sludge from P-Basin.	**Cancelled 4/15/98** (Conway 1998).
	SRS-4b: For characterization and safety analysis of fissile material in sand filters (see item 1).	**Completed 7/96.** See SRS 1a and 1b.
SRS-6: Cesium-137 activity level in L-Basin water is approaching administrative limits.	**SRS-6:** Utilize Zeolite in portable ion exchange system to lower Cesium-137 levels in L-, K-, and P-Basins.	**Completed 7/96.** Zeolite was used in a portable ion exchange system to lower the Cesium-137 levels in L- and K-Basins. P-Basin zeolite cancelled due to fuel consolidation.

TC

Table B-2. (continued).

Identified vulnerabilities	Corrective action plans	Status
SRS-5, 7, and 9: Aluminum-clad fuel and targets are severely corroded, releasing fission products and fissile material to the pool water. Gas bubble release above the bucket storage area at L-Basin might be a potential hazard. (generic issue).	**SRS 5,7,9a.01:** Modify fuel hangers to provide redundancy against fuel falling to basin floor.	**Completed 1/93.** No fuel on fuel hangers in P-Basin; fuel in L-Basin Vertical Tube Storage has been removed from hangers and placed in horizontal tube storage; fuel hangers in K-Basin Vertical Tube Storage were inspected and found to be in good condition; the fuel was relocated to horizontal tube storage in July 1997.
	SRS-5,7,9a.02: Develop and implement corrosion surveillance program.	**Completed 1/93.** The corrosion surveillance program is summarized in *Corrosion Surveillance in Spent Fuel Storage Pools* (Howell 1996).
	SRS-5,7,9a.03: Complete criticality studies in progress to support the transfer of reactor components from vertical to horizontal storage.	**Completed 1/94.** Criticality studies to support the transfer of reactor components are documented in *100 Area Irradiated Fuel Consolidation and Horizontal Storage Criticality Concerns* (Reed 1994).
	SRS-5,7,9a.04: Design and construct racks for horizontal three-deep storage.	**Completed 6/95.** Horizontal storage rack fabrication and installation completed under Project S-5982 (Guy 1995).
	SRS-5,7,9a.05: Reorient fuel currently stored vertically to the three-deep horizontal array configuration at L-Basin.	**Completed 12/95.** *Storage Solution for Fuel Tubes in the L-Area Vertical Tube Storage* (Guy 1993) provided the engineering direction for the reorientation activities. Completion of reorientation is documented in *L-3.3 Fuel Bundling* (Holmes 1995), and *Disassembled Component Log - Fuel Bundling Station* (WSRC 1995a).
	SRS-5,7 9a.06: Reorient fuel currently stored vertically to the three-deep horizontal array configuration at K-Basin.	**Completed 7/97** (Smith 1998).
	SRS-5,7,9a.07: Modify water chemistry of cleaned basins through the intensive use of portable deionizers (vendor supplied, shock deionization) at L-Basin.	**Completed 9/95.** Deionization reduced conductivity to 10 µs/cm.
	SRS-5,7,9a.08: Modify water chemistry of cleaned basins through the intensive use of portable deionizers (vendor supplied, shock deionization) at K-Basin.	**Completed 1/96.** Deionization reduced conductivity to 10 µs/cm.
	SRS-5,7,9a.09: Modify water chemistry of cleaned basins through the intensive use of portable deionizers (vendor supplied, shock deionization) at P-Basin.	**Canceled 7/95.** Deionization canceled due to P-Basin fuel consolidation (DOE 1995a).

	SRS-5,7,9a.10: Provide deionized makeup water systems for the basins.	**Completed 10/95.** Systems installed under Project S-5839. Functional performance requirements are documented in *Disassembly Basins Upgrades* (WSRC 1995b).

Table B-2. (continued).

Identified vulnerabilities	Corrective action plans	Status
	SRS-5,7,9a.11: Assess the hazard of gas releases as a result of the corroding material in the bucket storage area at L-Basin.	**Completed 8/95.** Evaluation of gas releases study indicated the exposure potential from leaking targets in the basin is insignificant (Hochel 1995).
	SRS-5,7,9a.12: Maintain basin water chemistry through the application of additional dedicated and upgraded deionizers and regeneration capabilities.	**Completed 6/96.** Continuous deionization systems were installed and tested for K- and L-Basins under Project S-5839 (New 1996a).
	SRS-5,7,9a.13: Assess deionizer regeneration at RBOF facilities to support timely regeneration of L-, K-, and P-Basin ion exchange resins.	**Completed 10/94.** Assessment of deionizer regeneration facilities at RBOF was documented in *Division Critical Item - RBOF Regeneration System Improvements* (Cederdhal and Freeman 1994).
	SRS-5,7,9a.14: Complete modifications to regeneration equipment at RBOF if determined appropriate by assessment.	**Completed 6/98** (Smith 1998).
	SRS-5,7,9a.15: Complete placement of MK-31 slugs stored in L-Basin into containment boxes to minimize the spread of fission and corrosion products.	**Completed 1/94.** Containment program was developed and implemented to reduce the spread of contamination from the corroding target slugs. Subsequently, all targets were removed from L-Basin and processed.
	SRS-5,7,9b.1: Develop acceptance criteria and validated heat transfer models for highly enriched uranium aluminum-clad fuel.	**Completed 3/96.** Acceptance criteria established and documented (Sindelar et al. 1996).
	SRS-5,7,9b.2: Complete development of generic dry storage procurement specification.	**Completed 12/95.** Specifications completed and documented (New 1995).
	SRS-5,7,9b.3: Complete preconceptual design studies for dry storage option.	**Completed 3/12/98** (G-CDR-L-00001) (Smith 1998).
	SRS-5,7,9b.4: Complete Environmental Impact Statement (EIS) for dry storage.	**Ongoing, scheduled for 04/00.** Notice of Intent issued by DOE to prepare an EIS on management of aluminum-clad fuel at SRS (61 FR 69085). The scope of the EIS will include an assessment of the impacts associated with construction and operation of a dry storage facility. TC
	SRS-5,7,9b.5: Complete civil structural design for dry storage.	**Preliminary design work is scheduled for FY03, followed by final design in FY04 and FY05.** TC

Table B-2. (continued).

Identified vulnerabilities	Corrective action plans	Status
SRS-8 and 11: Lack of adequate authorization bases (and operating procedures) including updated and approved SAR that addresses long-term storage of RINM and accident mitigation.	**SRS 8,11:** Complete Basis for Interim Operation (BIO) per DOE 5480.23 and Facility Hazards Assessment per DOE 5500.3A, currently under development for K-Basin (anticipated to be bounding for L- and P-Basins). BIO development will include: - Performance of safety analysis for buildup of fissile material in sand filter system and evaluation of potential for criticality in filters. - Evaluation of basin ventilation requirements. - Evaluation of potential cask drop hazards. - Evaluation of potential hazards associated with basin flooding. - Evaluation of capability to maintain cooling water during seismic events and other credible initiating events. Issues include a loss of emergency cooling source and results of percolation studies.	**Completed 9/95.** Completed the BIO per DOE Order 5480.23 for K-Basin, bounding for L- and P-Basins, and forwarded to DOE for review in 8/94; DOE approved the BIO in 3/95 (WSRC 1995c). Completed the Facility Hazards Assessment per DOE Order 5500.3A for K-Basin, bounding for L- and P-Basins (WSRC 1995d).
SRS-10: Failure of severely corroded hoist rod bolts on the twin hoist in the P-Basin could result in a fuel drop and subsequent fission product release or violation of criticality safety spacing requirements.	**SRS-10:** Conduct hoist assembly load test based on revised preventative maintenance procedure. This does not pose a criticality concern. Administrative controls and geometric constraints dismiss the risk of criticality. The hoist assembly load test will be conducted prior to use of the hoist. No use of the hoist is contemplated for the foreseeable future and it is not cost-effective to perform the load test until use of the hoist is required.	**Completed 11/95.** The Twin Hook Hoist was replaced in P-Area and the replacement hoist load tested using Work Request No. BHBRS (WSRC 1995e).
SRS-12-14: Flooding of basins initiated by human error or seismic event (affecting the makeup system) could result in basin overflow with resultant fission product release to environment.	**SRS-12-14:** Evaluate potential hazards associated with basin flooding as part of the Basis for Interim Operation development. (See Item SRS 8,11).	**Completed 3/95.** The potential hazards associated with basin flooding were evaluated as part of the BIO development, which concluded that 105-K, -L and -P buildings are not subject to flooding (WSRC 1995c).
SRS-15: Conduct of operations emphasis on the extended role of SRS fuel storage basins is necessary. (Vulnerability applicable to RBOF and P-, K-, L-, C-, and R-Reactors).	**SRS-15:** Conduct training to emphasize extended storage of production reactor fuels and target materials.	**Completed 2/94.** Training specifically designed to address the concerns with extended storage of SNF was conducted. Individual training records are maintained in Building 704-24K.

Table B-2. (continued).

Identified vulnerabilities	Corrective action plans	Status
SRS-16: The roof over the cask basins and the transite walls of the RBOF facility provide inadequate tornado missile protection.	**SRS-16:** Complete a detailed structural assessment for design-basis hazards (seismic, tornado, etc.). See Item SRS-17 actions. A detailed structural assessment for the design-basis hazards for the facility will be part of the safety analysis report upgrade. RBOF Technical Safety Requirements (TSRs) to be submitted to DOE in FY95. The new Safety Analysis Report will be complete in FY96.	**Completed.**. A detailed structural assessment for the design basis hazards for the facility (seismic, tornado, etc.) has been completed as part of the safety analysis upgrade. The analysis includes the basins, the above-grade walls, roof, and the storage racks. Following the analysis, limited modifications were performed. The analysis has shown RBOF meets DOE requirements for natural phenomenon hazards. (New 1996b). The Safety Analysis Report and TSRs have been approved by DOE.
SRS-17: Since the initial design, there has been no deterministic seismic evaluation of the facility. A seismic event could damage masonry walls above the pool, the sole significant makeup water line penetrating the facility foundation, and unanchored chemical storage tanks/piping adjacent to the facility, adversely affecting the RBOF. (Storage racks, although anchored to the floor and wall of the basin, are not seismically qualified.)	**SRS-17:** Complete a detailed assessment in conjunction with the efforts to upgrade the Safety Analysis Report. A detailed structural assessment for the design-basis hazards for the facility (seismic, tornado, etc.) will be part of the safety analysis report upgrade. The analysis will include the basins, the above-grade walls, roof and storage racks. In the interim, the existing safety analysis bounds radiological releases from all credible scenarios because it is extremely conservative. The new Safety Analysis Report will be complete in FY96.	**Completed.** Actions accomplished in response to SRS-16 have also completed the corrective actions required for SRS-17. (See Issue SRS-16.) The Safety Analysis Report was developed and submitted for DOE-SR review and approval in August 1997 (Smith 1998). Safety Analysis Report and TSRs have been approved by DOE.
SRS-18: Potential seismic vulnerability of H-Canyon because the facility does not meet current seismic design standards. Initial seismic calculations indicate that portions of the H-Canyon facility that house the target storage vault are not structurally adequate, which could result in a direct release path.	**SRS-18a:** Complete detailed seismic structural assessment along with Safety Analysis Report upgrade. **SRS-18b:** Complete development of new Technical Safety Requirements.	**Completed.** Analysis has shown H-Canyon meets DOE requirements of seismic resistance (Alm 1997). Also, a recent review of U.S. Geological Survey hazard maps indicates the map results would have no significant impacts on hazard results used for H-Canyon seismic analysis work (WSRC 1997a). **Completed.** Technical Safety Requirements were approved 4/97.
SRS-19: Potential seismic vulnerability of F-Canyon because the facility does not meet current seismic design standards. Initial seismic calculations indicate that portions of the F-Canyon facility that house the fuel storage vault are not structurally adequate, and that could result in a direct release path from the facility in the event of a Design Basis Earthquake. A criticality could result from seismically-induced damage to the storage racks, which could result in additional radiation release.	**SRS-19:** Complete detailed seismic analysis for F-Canyon.	**Completed 8/96.** The detailed seismic calculations were completed in 7/96. DOE-SR sent recommendations to DOE Headquarters to resume operations because results of seismic calculations were favorable. DOE Headquarters approved resumption of F-Canyon operations, which started on 8/26/96 (Alm 1996a). Also, a recent review of U.S. Geological Survey hazard maps indicates the map results would have no significant impacts on hazard results for F-Canyon seismic analysis work (WSRC 1997a).

Table B-2. (continued).

Identified vulnerabilities	Corrective action plans	Status
SRS-20: Lack of adequate leak detection system for the storage basins. The current leak detection method is not sufficiently sensitive to detect small leaks.	**SRS-20a (for L-, K-, and P-Basins):** Install additional monitoring wells (two per basin) for L-, K-, and P-Basins to ensure detection of basin leakage.	**Completed 3/95.** Monitoring wells for L-, K-, and P-Basins completed 3/2/95 (Burbage 1995). Installation completed under Project S-5839 (New 1996a).
	SRS-20a (for RBOF): Perform studies of other beneficial methods of leak detection.	**Completed 1/95.** Overall H-Area groundwater effects are monitored and reported in accordance with applicable requirements (Clark 1994; Burbage 1995).
	SRS-20b (for L-, K-, and P-Basins): Improve the basin leak detection threshold by comparing trends in radionuclide concentration observed in the monitoring wells and the basins. Chemical constituents of samples from the monitoring wells and the basins will be monitored and trended for comparison purposes.	**Completed 12/96.** Basin level trending capabilities improved with the installation of upgraded simple level monitoring instruments and a makeup water system flow totalizer. Engineering initiated basin level trending, which provides more accurate monitoring of changes in the basin level. Monitoring wells downgradient of the basins have improved the dispersion/dilution models. Comparison of monitoring well chemical constituent trend data to basin water data has been initiated; monitoring wells are sampled monthly; evaluations of the radionuclide concentrations are issued in a quarterly report (Burbage 1996).
	SRS-20b (for RBOF): Evaluate and if necessary install improved level detection.	**Completed 1/95.** A study of the beneficial methods of leak detection included a review of the level monitoring capability used at the West Valley facility in New York. No significant benefits from implementation of this system were identified. Overall H-Area groundwater effects are being monitored and reported in accordance with applicable requirements. The RBOF level detection has been determined to be adequate (Clark 1994; Burbage 1995).
	SRS-20c (for L-, K-, and P-Basins): Evaluate the need for improved level detection system to provide more accurate monitoring of changes in basin level. (The accuracy of the current basin level indication is within 7,570 liters [2,000 gallons]).	**Completed 12/94.** Several options for level and leak detection systems were evaluated. DOE determined that the installation of an upgraded, simple level monitoring instrument coupled with the new makeup water and monitoring well system will provide an adequate cost-effective basin water inventory information system (New 1994).

Table B-2. (continued).

Identified vulnerabilities	Corrective action plans	Status
SRS-21: Inadequate seismic evaluation and potential inadequacies of structures, systems, and components to withstand a Design-Basis Event. The potential exists for: the failure of basin expansion joints and water stops, causing a release of radioactive materials to the environment; the failure of vertical tube storage frames or a load drop onto fuel assemblies causing damage or reconfiguration of fuel and possible criticality, due to a seismic event. (generic issue)	**SRS-21a:** Complete soil stability assessment for input to seismic analyses for L-, K-, and P-Basin that is in progress.	**Completed 10/94.** Soil stability assessments for K- and P-Basins are not required (Burke 1994). Geotechnical investigation into L-Areas is ongoing.
	SRS-21b: Complete seismic evaluations if determined to be necessary as a result of the Basis for Interim Operations development, or soil stability assessments for L-, K-, and P-Basin. A recent assessment of the K-Basin exterior walls and foundations determined they could withstand a 0.2*g* earthquake. Minor leakage could occur but would be slow. A recent assessment determined that the consequences of an earthquake for L- and P- Basins are less than those for K-Basin because K-Basin has the highest radionuclide inventory.	**Completed 3/95.** Soil stability assessments for K-, L-, and P-Basins are not required (Burke 1994). These assessments support seismic analyses of emergency cooling systems; however, the BIO (WSRC 1995c) determined that fuels stored in the basins do not require emergency cooling after a postulated Design-Basis Event resulting in basin draindown.
	SRS-21c: Depending on results of BIO completed by 11/94, development of accident mitigation procedures might be appropriate.	**Completed 7/96.** Accident mitigation procedures are not required because this accident would result in low consequences.
	SRS-21d: See Item 5,7,9a for reorientation of fuel.	**Completed 7/97.**
SRS-22: Potential vulnerability in buried fuel at SRS.	**SRS-22:** Fuel failure of a Mark V fuel assembly occurred in the R-Area disassembly basin in 1957. Over 7 years, the fissile materials in the failed fuel assembly completely oxidized. In 1964, the remains of the assembly were retrieved with no appreciable amount of fuel or fission products remaining in the assembly. All of the oxidized fuel near the assembly was removed using filters and deionizers and subsequently processed in RBOF. The fuel material is currently held in authorized basins and tanks. No further action is required.	**Completed 12/93.**

NOTE: This item was discussed in the Spent Fuel Working Group Report summary but not addressed in vulnerability development forms. Disassembly basins do not have high efficiency (confinement/negative pressure) ventilation systems.	**NOTE:** The K-Area Basis for Interim Operation addresses the existing facility and safety margins with respect to the need for airborne release containment. The results of the BIO show there is adequate safety margin without facility upgrades. Upgrades are not required for several reasons: - Over 40 years of operating experience with no events involving the spread of particulate radioactive contamination from the basins. - Little stored energy in the disassembly basins because of radioactive decay. - Radiation level in the disassembly basin area is low (<2 millirem/hour) and the contribution from airborne particulate matter is negligible.	**Completed 3/95.** Area BIO was approved by DOE; no further action is required (WSRC 1995c).

DNFSB 94-1 addressed vulnerabilities at several DOE sites, including the following SRS vulnerabilities concerning SNF and related solutions, tanks, and processing activities:

> Several large tanks in the F-Canyon at the Savannah River Site contain tens of thousands of gallons of solutions of plutonium and transplutonium isotopes. These tanks, their appendages, and vital support systems are old, subject to deterioration, prone to leakage, and they are not seismically qualified.
>
> Processing canyons and reactor basins at the Savannah River Site contain large amounts of deteriorating irradiated reactor fuel stored under conditions similar to those at the 603 Basin at INEL [Idaho National Engineering Laboratory].
>
> There are thousands of containers of plutonium-bearing liquids and solids at ... SRS .... Large quantities of plutonium solutions are stored in deteriorating tanks, piping, and plastic bottles.... It is well known that plutonium in contact with plastic can cause formation of hydrogen gas and pyrophoric plutonium compounds leading to a high probability of plutonium fires.
>
> The slow pace of remediation and additional delays in stabilizing materials might be accompanied by further deterioration of safety and unnecessary increased risks to workers and the public.

DOE accepted the Board's Recommendation on August 31, 1994, and issued *The Defense Nuclear Facilities Safety Board Recommendation 94-1 Implementation Plan* (DOE 1995b). Table B-3 summarizes the SRS vulnerabilities identified in DNFSB 94-1 and the associated commitments made by DOE in the Implementation Plan.

B.5 DNFSB January 1995 SRS Spent Fuel Vulnerability Assessment

In January 1995, members of the DNFSB staff assessed SRS progress toward resolving vulnerabilities associated with the storage of spent fuel. Their *SRS Spent Fuel Storage Trip Report*, January 23, 1995 (Burnfield 1995) stated that although DOE Headquarters had agreed to approach spent fuel vulnerability problems using a systems approach, they had been slow in implementing that approach and there was little evidence of SRS applying the approach to the spent fuel management project.

DNFSB members expressed concern that aggressive action was not being taken to resolve vulnerabilities related to improving the water chemistry of the basins. They also highlighted two new areas of concern related to RBOF.

The report acknowledged that Westinghouse Savannah River Company had initiated an aggressive program to ensure that the risks associated with these two new areas of concern were accurately quantified and were acceptable. However, the efforts for the two areas were not tied together and therefore could result in an inability to link the two hazards successfully.

The DNFSB did not formally submit these issues and the trip report to DOE. As a consequence, formal corrective actions were not developed nor were these issues entered into and tracked by the DOE Safety Issues Management System. However, Westinghouse Savannah River Company performed two nuclear criticality safety evaluations to address these issues: *Reactivity Effects of Tilting Fuel Assemblies and Bundles in RBOF* (Reed 1995) and *Credible Water Depth for Criticality Incidents*

Table B-3. Applicability of Defense Nuclear Facilities Safety Board Recommendation 94-1 to SRS.

Identified vulnerabilities	Implementation plan commitment	Status	
Sub-recommendation (3): That preparation be expedited to process dissolved plutonium and transplutonium isotopes in tanks in F-Canyon at the Savannah River Site into forms safer for interim storage. The Board considers this problem to be especially urgent.	A stabilization method for F-Canyon has been selected. Stabilization of plutonium solutions began in February 1995 and will be completed by January 1996. A conceptual design report for the stabilization of americium and curium solutions will be completed by December 1995. All americium and curium solutions will be stabilized by September 1998. Other solutions not specifically mentioned in this recommendation but addressed in this plan will be stabilized in accordance with the following schedule: • Plutonium-242 solution in H-Canyon by November 1997 • Highly enriched uranium solutions at SRS by December 1997 • Plutonium-239 solution in H-Canyon by February 2000 • Neptunium solutions in H-Canyon by December 2002	Stabilization of plutonium solution was completed in 4/96. The Conceptual Design Report for the stabilization of americium and curium solutions was completed in 11/95. The current schedule for americium/curium solution stabilization calls for completion by 9/02. This schedule may be rebaselined in 4/00. Stabilization of Plutonium-242 in H-Canyon was completed in 12/96. Highly enriched uranium solutions continue to be stored safely. The schedule for disposition of H-Canyon uranium solutions calls for stabilization by 12/03. This schedule may be rebaselined in 4/00. Stabilization of H-Canyon plutonium-239 solutions is forecast for completion in 2002, and stabilization of H-Canyon neptunium solutions is forecast for completion in 12/05. These schedules may be rebaselined in 4/00.	TC TC TC
Sub-recommendation (5): That preparation be expedited to process the containers of possibly unstable residues at the Rocky Flats Plant and to convert constituent plutonium to a form suitable for safe interim storage.	... Residues at other sites, not specifically addressed in this recommendation will be stabilized according to the following schedules: • Sand, slag, and crucibles at SRS by December 1997	Stabilization of sand, slag, and crucible at SRS began 10/97 and is forecast for completion by 7/98.	
Sub-recommendation (6): That preparations be expedited to process the deteriorating irradiated reactor fuel stored in basins at SRS into a form suitable for safe storage until an option for ultimate disposition is selected.	The method for stabilizing fuel and targets at SRS will be selected by July 1995 pursuant to the Interim Management of Nuclear Materials (IMNM) EIS and ROD. Fuel storage basin water chemistry upgrades will be completed by May 1996. Contingent on the outcome of the IMNM EIS, targets will be stabilized via dissolution by September 1996; fuel dissolution will be completed by November 1999. Stabilization of resultant uranium solutions will be completed by April 2000.	Stabilization of Mark 31 targets was completed in 1/97. Stabilization of Mark 16 and 22 fuel assemblies began 7/97 and is forecast for completion in 2001. Fuel storage basin water chemistry upgrades were completed in 5/96. HEU from fuel will be blended down to LEU on a schedule that supports transfer of the LEU to commercial industry.	
Sub-recommendation (8): That those facilities that may be needed for future handling and treatment of the materials in question be maintained in a usable state. Candidate facilities include, among others, F- and H-Canyons and FB- and HB-Lines at SRS, ...	Sufficient capabilities will be retained to maintain future handling, treatment and safe storage of the materials addressed in this plan. A discussion of facilities currently in use or planned for use is included in Section 2.6. The facilities section of the Integrated Program Plan will be prepared by December 1995.	The Integrated Facilities Plan (DOE 1995a) addressed the utilization of the F- and H- Canyons.	
Sub-recommendation (9): Expedited preparation to accomplish actions in items (3) through (8) above should take into account the need to meet the requirements for operational readiness in	Facilities will be started or restarted in accordance with DOE Order 5480.31. These restart and startup requirements will be taken into account in the development of the facilities.	Operational Readiness Reviews for restart of the following facilities have taken into account requirements of DOE Order 5480.31: FB-Line (complete 11/95); F-Canyon (complete 9/26); H-	

accordance with DOE Order 5480.31.		Canyon Dissolving (complete 7/97); HB-Line Dissolving (complete 3/98)

in RBOF (Reed 1996). Table B-4 summarizes the SRS vulnerabilities identified in the trip report and results of the safety evaluations.

B.6 DNFSB June 1995 SRS Spent Fuel Vulnerability Assessment

In June 1995, members of the DNFSB visited the SRS to review SNF activities related to the implementation of DNFSB Recommendation 94-1 (see Section B.4). The DNFSB Chairman formally transmitted the report to DOE and identified issues that were "... not being adequately considered in the evaluation of remediation alternatives." In addition, the report identified badly corroding foreign fuel in RBOF that DOE had categorized as stable (Conway 1995).

The corroding foreign fuel that DOE had categorized as stable was failed Taiwanese Research Reactor Fuel and Experimental Breeder Reactor slugs that were being stored in cans in RBOF. Although the damaged fuel was housed in protective cans, the cans were leaking and continued deterioration was likely. DOE responded to this concern by issuing the Interim Management of Nuclear Material EIS Record of Decision (60 FR 65300), which identified chemical processing as the preferred alternative for the at-risk foreign fuel.

In the *Draft Environmental Impact Statement, Interim Management of Nuclear Materials* (DOE 1995c), DOE identified Processing to Metal as the preferred alternative for the remediation of Mark-16 and -22 fuels. DNFSB became aware that DOE was considering dry storage of aluminum-clad fuel as an alternative to chemical processing. DOE issued the Final IMNM EIS (DOE 1995d) with No Action as the preferred alternative for these fuels to allow time for further consideration of dry storage. DNFSB expressed three specific concerns on the stabilization technologies for Mark-16 and -22 fuel. DOE's final decision was to identify Chemical Processing as the preferred alternative for this material, as recorded in the second IMNM Record of Decision (61 FR 6633).

Table B-5 summarizes the SRS vulnerabilities identified in the trip report.

Table B-4. Vulnerabilities identified in the January 1995 Defense Nuclear Facilities Safety Board Trip Report.

Identified vulnerabilities	Implementation plan commitment	Status
Some fuel in RBOF is stored vertically in racks, allowing the fuel to lean from top to bottom slightly, resulting in a violation of criticality safety requirements.	The DNFSB did not choose to submit these issues and this trip report formally to DOE. Consequently, formal corrective actions were not developed nor were these issues entered into and tracked by the DOE Safety Issues Management System.	Calculations documented in *Nuclear Criticality Safety Evaluation: Reactivity Effects of Tilting Fuel Assemblies and Bundles in RBOF* (Reed 1995) resulted in the conclusion that, "There are no current situations in RBOF Storage Basin #1 in which the configuration has been determined to be more reactive than a k_{eff} of 0.95, the Technical Standard limit."
The amount of water shielding was misidentified in the safety documentation.	The DNFSB did not choose to submit these issues and this trip report formally to DOE. Consequently, formal corrective actions were not developed nor were these issues entered into and tracked by the DOE Safety Issues Management System.	An analysis documented in *Nuclear Criticality Safety Evaluation: Credible Water Depth for Criticality Incidents in RBOF* (Reed 1996), concluded that, "Thus, there is no basis to define a NIM evacuation zone (region in which personnel can receive 12 rads or more as a result of a criticality incident) for the RBOF basins. Based on requirements of DOE Order 5480.24, a criticality

		alarm system is not required for the RBOF basins."

Table B-5. Vulnerabilities identified in the June 1995 Defense Nuclear Facilities Safety Board Trip Report.

Identified vulnerabilities	Implementation plan commitment	Status
1. Contrary to the Implementation Plan for Recommendation 94-1, it appears that dry storage is being considered as the preferred alternative to remediate Mark-16 and -22 fuel assemblies at the SRS. Although dry storage, as well as chemical separation, can achieve stable conditions, the following concerns could affect the decision to dry store this deteriorating fuel:		
1.a The requirements for dry storage of highly enriched aluminum-clad spent nuclear fuel have not been developed. This represents a large uncertainty in the time and effort required to achieve dry storage and a large uncertainty in the time during which continued wet storage will be required.	Formal corrective actions were not developed nor were these issues entered in and tracked by the DOE Safety Issues Management System.	The preferred alternative for remediation of these fuels was Blending Down to Low-Enriched Uranium, as recorded in the second IMNM Record of Decision (61 FR 6633).
1.b The waste acceptance criteria needed to transition dry-stored aluminum-clad spent nuclear fuel to a geologic repository have not been developed. This raises the possibility of having to rehandle, repackage, or even process this material in the future to meet storage requirements.	Formal corrective actions were not developed nor were these issues entered in and tracked by the DOE Safety Issues Management System.	The preferred alternative for remediation of these fuels was Blending Down to Low-Enriched Uranium, as recorded in the second IMNM Record of Decision (61 FR 6633).
1.c Lengthy delays needed to implement dry storage will extend by years the period of wet storage of the deteriorating spent fuel and allow continued corrosion. This will aggravate the problems of continued degradation, potential environmental insult, radiation exposure, and waste generation.	Formal corrective actions were not developed nor were these issues entered in and tracked by the DOE Safety Issues Management System.	DOE responded to these concerns by changing the preferred alternative for remediation of these fuels to Blending Down to Low-Enriched Uranium, as recorded in the second IMNM Record of Decision (61 FR 6633).
2. In addition, corroding spent fuel in RBOF is releasing more than twice the amount of fission products to the basin water than the corroding Mark-31 targets are releasing to the L-Basin. This significant corrosion is contaminating the facility, generating significant waste, and contributing to personnel exposure. Surprisingly, DOE plans to keep the current inventory of fuel at RBOF in wet storage for the next 10 years. A more urgent response is merited.	Formal corrective actions were not developed nor were these issues entered in and tracked by the DOE Safety Issues Management System.	DOE elected to stabilize all fuel in RBOF with potential leakage. (First Record of Decision [60 FR 65300] and fourth Record of Decision [62 FR 17790].)

B.7 DNFSB 1996 SRS Spent Fuel Handling Assessment

In August 1996, members of the DNFSB assessed SRS spent fuel handling and processing operations. The Board noted that the transfer of spent fuel requires moving massive casks in spent fuel storage basins where a cask drop could cause structural damage and significant water inventory loss. Their Trip Report (Conway 1996) reported the following concerns associated with stabilization operations and the retrieval of spent fuel from the K, L, and P Basins:

1. There is no assurance that makeup water will be available after a design-basis accident.
2. The crane rope is corroded, and the fatigue life of some cranes is not known.
3. A qualified rigger is not present during critical cask lifts.
4. Although fuel is being removed from the basins, significant quantities of activated scrap metal will remain.

DOE first responded to these concerns in a letter to the Board dated November 21, 1996 (Alm 1996b). DOE provided a more detailed response in a letter dated December 13, 1996 (Alm 1996c). Table B-6 summarizes the SRS SNF transfer vulnerabilities identified in the 1996 Trip Report and the associated DOE responses and commitments (Potvin 1997).

Table B-6. Vulnerabilities identified in the August 1996 Defense Nuclear Facilities Safety Board Trip Report.

Identified vulnerabilities	Implementation plan commitment	Status
There is no assurance that makeup water will be available if a cask drop or seismic event should cause a leak. Basin water is supposed to be replaced by raw untreated water from the Emergency Service Water system; however, this line is not tested regularly, it has not been used for more than a year, and it is not seismically qualified.	Studies indicate that dropping the 63.5 metric-ton (70-ton) cask, as analyzed in the recently issued Basis for Interim Operation for L-Reactor, could potentially result in a crack with a maximum leak of 397 liters (105 gallons) per minute. At this rate, operators would have a minimum of 6 days to implement mitigative actions before radiation levels began to increase, at which point all workers in the vicinity would be evacuated. In such an event, operators could respond by implementing various procedures using available systems to restore basin water levels. Although detailed preplanned and demonstrated emergency capabilities are not required for accident scenarios that would allow adequate time for facility workers to respond, an integrated facility response to a basin leak is being developed. This response, to be completed in the second quarter of FY 97, will consist of a combination of operational procedures and engineering response plans with the objective of mitigating basin leakage.	A letter to the DOE-SR DNFSB Liaison (Voss 1997a) identified plans and procedures developed in response to this vulnerability.
A qualified rigger is not present during fuel cask lifts. Fuel cask lifts are critical and preengineered. However, a crane operator, who has only Incidental Rigger Training, performs both the rigging and crane movement. This seems to contradict the SRS Hoisting and Rigging Manual, which states that a rigger shall ensure (1) the rigging equipment has the required capacity and is in good condition, (2) the rigging equipment is per procedure, and (3) the load path is clear.	Preengineered lifts are established for routine, repetitive lifting jobs such as cask movement. For these lifts, established procedures define the rigging equipment and the process used. These cask-handling procedures are reviewed by fully qualified Site rigging personnel. Facility operators attend "incidental rigger/operator" training. The "incidental rigger" is trained to ensure the rigging equipment has the required capacity and is in good condition, the rigging equipment is utilized per procedures, and the load path is clear. These qualifications are appropriate for the routine preengineered operations conducted in the facility.	This commitment is complete (WSRC 1997b).
Corrosion is evident along the entire length of the K-Basin cask crane's wire rope and the fatigue life of basin cranes is not known. DNFSB staff were not able to view the L-Basin crane rope, but were told its condition is similar. ASME B30.2-1990 identifies excessive corrosion on wire rope as a hazard. WSRC stated that the rope is adequate based on visual inspection by site riggers. However, as noted in the Construction Safety Association of Ontario's Rigging Manual, visual inspection gives a poor indication of the extent of degradation since corrosion often begins inside the rope. A more rigorous inspection includes examining	SRS has a comprehensive crane inspection program, which is based on a compilation of various national and international codes and standards. The quarterly and annual crane inspections are performed in accordance with *Overhead and Gantry Cranes*, ASME B30.2, Chapter 2-2. The wire ropes are inspected on a monthly frequency pursuant to "Overhead and Gantry Cranes," 29 CFR 1910.179(m), and inspection criteria in accordance with ASME B30.2, Section 2-2.4. Crane inspection program documents for the K- and L-Basins and the Receiving Basin for Offsite Fuel to be provided to the DNFSB will describe inspection requirements, frequency and criteria, load tests, dye-penetrant tests, etc.	DOE responded to this as documented in a letter (Sidey 1997). On January 20, 1997, additional references were provided in response to Commitment 2 (Voss 1997b).

the rope

Table B-6. (continued).

Identified vulnerabilities	Implementation plan commitment	Status
core. If the core is corroded, the cranes' safety factor may be much less than WSRC believes.	As part of scoping stage for determining the need for a crane upgrade proposal for DOE, a representative from the crane manufacturer will perform a baseline inspection/evaluation of the 11-metric-ton (85-ton) crane and issue a report. All documentation will be transmitted within 60 days of the crane manufacturer's inspection.	
Although fuel is being removed from the basins, significant quantities of activated scrap metal will remain. Besides fuel, the basins store buckets of highly radioactive scrap metal. These buckets are suspended by rope and corroding wire cables. In contrast with the fuel, no plan of action has been formulated for retrieval of this material.	As part of efforts to enhance water quality and reduce hazards, WSRC has been pursuing removal of selected materials from the basins. Activities to date have focused on removal of the more serious hazards, including cadmium control rods, corroded fuel, and excess radioactive sources. Future efforts will be directed at the remaining materials such as irradiated metal and contaminated scrap. DOE has recently improved methods for disposing of waste at SRS. These are part of a waste certification program that ensures the identification of characteristics of all wastes to enable proper disposal. The RBOF Waste Certification Plan is in revision and will reflect the new waste disposal process. Implementation schedules will be based on resource and budget availability.	After discussions with DOE, it was determined that no deliverable was required to be forwarded to DNFSB concerning this issue.

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