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Project Title/Work Order Central Waste Complex Interim Safety Basis, WHC-SD-WM-ISB-007		EDT No. WHC-SD-WM-ISB-007 ECN No. N/A

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Document Number: WHC-SD-WM-ISB-007, Rev. 0

Document Title: Central Waste Complex Interim Safety Basis

Release Date: May 15, 1995

**This document was reviewed following the
procedures described in WHC-CM-3-4 and is:**

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SUPPORTING DOCUMENT		1. Total Pages 126
2. Title Central Waste Complex Interim Safety Basis	3. Number WHC-SD-WM-ISB-007	4. Rev No. 0
5. Key Words Interim Safety Basis, Hazard Category 3	6. Author Name: E. G. Cain Signature Solid Waste SAR Engr. - 8M300 Organization/Charge Code A4231	
7. Abstract		

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8. RELEASE STAMP

CENTRAL WASTE COMPLEX

**Interim Safety Basis
WHC-SD-WM-ISB-007
REV 0**

May 1995

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LIST OF TERMS

AMW	alkali metal waste
X/Q'	atmospheric dispersion coefficient factors
CWC	Central Waste Complex
DE-Ci	dose equivalent-curie
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
ECN	engineering change notice
ERPG	emergency response planning guideline
FHA	Fire Hazards Analysis
PHASE	fixed head air-sampling equipment
HEDOP	Hanford Environmental Dose Overview Panel
ISB	interim safety basis
LFMW	low-flashpoint mixed waste
LLMW	low-level mixed waste
LLW	low-level waste
MWSP	mixed waste storage pad
NFPA	National Fire Protection Association
OSR	operational safety requirement
PCB	polychlorinated biphenyl
PE-Ci	plutonium equivalent-curie
PFP	Plutonium Finishing Plant (Z Plant)
RL	Richland Operations Office (DOE)
RTG	radioisotope thermoelectric generator
SAM	south alkali metal
SAR	safety analysis report
SDAR	storage/disposal approval record
SRE	sodium reactor equipment
SWITS	Solid Waste Information Tracking System
TLV	threshold level values
TRU	transuranic
TSR	technical safety requirement
TWA	time-weighted average
UBC	Uniform Building Code
UFC	Uniform Fire Code
USQ	unreviewed safety question
WAC	Washington Administrative Code
WHC	Westinghouse Hanford Company

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1.0 INTRODUCTION AND SUMMARY

This interim safety basis (ISB) provides the necessary information to conclude that hazards at the Central Waste Complex (CWC) are controlled and that current and planned activities at the CWC can be conducted safely.

U.S. Department of Energy (DOE) Orders 5480.21 *Unreviewed Safety Questions*, 5480.22, *Technical Safety Requirements*, and 5480.23 *Nuclear Safety Analysis Reports*, impose requirements to upgrade nuclear facility safety analysis reports (SARs) and technical safety requirements (TSRs). The DOE Orders require Westinghouse Hanford Company (WHC) to provide a basis for interim operation or restrictions on interim operations and administrative controls during the upgrade process. This document (ISB-007) serves to meet these requirements for the CWC until the current SAR, *Central Waste Complex Final Safety Analysis Report, FSAD Upgrade*, WHC-SD-WM-SAR-049, Rev. 0-A (WHC 1994a), and associated operational safety requirements (OSRs) are upgraded to the new requirements. ISB-007 will also serve as the authorization basis for the unreviewed safety question (USQ) process defined in DOE Order 5480.21, and WHC-CM-1-3, *Management Requirements and Procedures*, MRP 5.12, "Identifying and Resolving Unreviewed Safety Questions."

1.1 INTRODUCTION

The CWC is a multifacility complex within the Solid Waste Management Complex that receives and stores most of the solid wastes that are generated and received at the Hanford Site. The solid wastes that will be handled at the CWC include both currently stored and newly generated low-level waste (LLW), low-level mixed waste (LLMW), contact-handled transuranic (TRU), and contact-handled TRU mixed waste. The following facilities comprise the CWC:

- Waste Receiving and Staging Area
- Mixed Waste Storage Pad (MWSP)
- Low-Flashpoint Mixed Waste (LFMW) Storage Modules
- South Alkali Metal (SAM) Storage Modules
- Alkali Metal Waste (AMW) Storage Modules
- 2401-W Plutonium-Contaminated Polychlorinated Biphenyl (PCB) Storage Facility
- Mixed Waste Storage Facility 2402-W (2402-W, -WB through -WL)
- Mixed Waste Storage Facility (Buildings 2403-WA through 2403-WD).

The 272-WA Building and other surrounding office support structures are within CWC boundaries. While the personnel in these buildings are not all solid waste workers, they have been apprised of the hazards at the CWC and are sufficiently prepared to respond to an emergency situation. No hazardous

activities are carried out in the 272-WA Building or the other surrounding office support buildings. The 213-W building houses a LLW compactor whose operation falls within safety analysis risk-acceptance guidelines.

Additional storage buildings and other structures to facilitate waste verification, sampling, sorting, and repackaging are planned for installation in the near future. These structures may be temporary or permanent and can include trailers, permacon units, butler buildings, and low-flashpoint modules.

The CWC is necessary for the Hanford Site to meet DOE-Richland Operations Office (RL) Order 5820.2A, *Radioactive Waste Management*, requirements for handling radioactive waste, the *Resource Conservation and Recovery Act (RCRA)* of 1976, 42 USC 6901 et seq., requirements for handling hazardous waste, *Washington Administrative Code (WAC)* 173-303, "Dangerous Waste Regulations," as amended, and the *Toxic Substances Control Act*, 1976, 15 USC 2601 et seq.

1.2 SUMMARY OF CONFIGURATION MANAGEMENT SYSTEM

ISB-007 is based on the current facility configuration and procedures. Changes to the facility configuration or procedures could impact the authorization/safety basis and must be evaluated. A configuration management program provides the procedure to evaluate these changes.

Changes in the design and configuration are addressed in WHC-CM-6-1, *Standard Engineering Practices*. This manual establishes engineering practices to ensure that uniform methods are in place for all engineering tasks. Operating procedures are addressed in WHC-IP-0673, *Solid Waste Disposal Plant Operating Procedure Writer's Guide*. All facility and procedure modifications will be evaluated, using ISB-007 as the authorization basis, in accordance with WHC-CM-1-3, MRP 5.12 and WHC-CM-5-34, *Solid Waste Disposal Operations Administration*, Section 1.24, "Unreviewed Safety Questions." The USQ program ensures all changes to the facility and associated procedures are reviewed by trained USQ evaluators.

1.3 SUMMARY OF SAFETY ANALYSIS AND SUPPORTING INFORMATION

The hazard analysis effort includes identification and qualitative evaluation of potential hazards to the offsite public, onsite workers, facility personnel, and the environment resulting from the operation of the CWC. Based on the hazards analysis performed and documented in WHC-SD-WM-SAR-049, Rev. 0-A, the following accident scenarios were, with the exception of those involving the SAM/AMW Modules, identified and selected as the bounding accidents for quantitative analysis. The SAM/AMW scenarios were identified and selected based on the following analyses performed and documented in Appendix A:

- Truck impact into a building — no fire
- Truck impact into a building — fire
- Truck impact away from building — fire

- Design-basis earthquake
- Water-sodium reaction in the SAM/AMW modules (toxicological)
- Truck impact into a building — fire (toxicological).

Table 1-1 summarizes the results of the accident analyses. In all cases, the risk-acceptance guidelines established in WHC-CM-4-46, *Nonreactor Safety Analysis*, are met.

Table 1-1. Accident Analysis Summary.

Accident scenario	Facility	Frequency (per year)	Consequences	
			Onsite	Offsite
Truck impact (no fire)	Buildings/Quadrants ^a	1.0 E-05	4.38 mSv (4.38 E-01 rem)	7.04 E-02 mSv (7.04 E-03 rem)
Truck impact (fire)	Buildings/Quadrants	1.0 E-06	4.73 E+01 mSv (4.73 E+00 rem)	7.6 E-01 mSv (7.60 E-02 rem)
Truck rollover (fire)	In-transit	1.0 E-06	1.20 E+01 mSv (1.20 E+00 rem)	1.93 E-01 mSv (1.93 E-02 rem)
Seismic event	Buildings and LFMW modules	3.3 E-03	2.16 E+01 mSv (2.16 E+00 rem)	1.66 E+00 mSv (1.66 E-01 rem)
Water-sodium reaction (tox.)	SAM modules	Not estimated ^b	2.7 E+01 mg NaOH/m ³	3.1 E-02 mg NaOH/m ³
	AMW modules	Not estimated ^b	3.3 E+01 (mg NaOH/m ³)	8.27 E-03 (mg NaOH/m ³)
Truck impact and fire (tox.)	Buildings/Quadrants	1.0 E-06	4.48 E-06 mg Hg/m ³	1.98 E-08 mg Hg/m ³
			4.48 E-06 mg Cd/m ³	1.98 E-08 mg Cd/m ³
			4.48 E-06 mg Ba/m ³	1.98 E-08 mg Ba/m ³
			2.67 E-03 mg PCB/m ³	1.18 E-05 mg PCB/m ³
			4.26 E-04 mg CaClPO ₄ /m ³	1.88 E-06 mg CaClPO ₄ /m ³

^aIncludes the following: 2401-W Building, 2402-W series buildings, and 2403-W series buildings.

^bFrequency not estimated. Consequences acceptable at a frequency of 1/year.

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2.0 FACILITY DESCRIPTION

The CWC is located in the 200 West Area of the Hanford Site and is part of the Solid Waste Management Complex. The Solid Waste Management Complex is comprised of the facilities and activities managed by the Solid Waste Disposal organization within the 200 West Area. The Solid Waste Management Complex consists of facilities for the treatment, storage, and disposal of radioactive wastes generated at the Hanford Site and other DOE and Department of Defense Sites. A Hanford Site map is provided in Figure 2-1, the 200 West Area is shown in Figure 2-2, and the CWC Site Plan is detailed in Figure 2-3.

The CWC requires a network of paved access roads with posted speed limits to facilitate safe traffic flow. A series of concrete-filled metal posts, located around the rollup doors of the buildings and near the modules, provides some protection against vehicle impacts. Traffic flow to the CWC is restricted during evening and night shifts by fencing with locked gates and access control is monitored by the facility manager.

The CWC processes four primary types of wastes: LLW, LLMW, TRU waste, and TRU mixed waste. The CWC is designed and authorized exclusively for the receipt and storage of contact-handled waste packages, which are defined in *Hanford Site Solid Waste Acceptance Criteria*, WHC-EP-0063-4 (Willis 1994), as packages having a surface dose rate of less than 2 mSv/h (200 mrem/h). Although packages up to 200 mrem/h can be stored at the CWC, an operational limit of 1 mSv/h (100 mrem/h) has been imposed by implementation of WHC-EP-0063-4. In addition to surface dose rate, WHC-EP-0063-4 establishes waste package criteria for the waste container, surface contamination, nuclear criticality, gas generation, and thermal power. Each waste package is characterized before receipt at the CWC and based on this characterization information, incompatible forms of waste are physically segregated.

Operations conducted at the CWC include (1) receiving and inspection, (2) handling (overpacking, palletizing), (3) staging, (4) storage, and (5) inspection. All operations are conducted in compliance with currently approved procedures by qualified personnel. Sections 2.1 and 2.2 provide facility and operational summary descriptions. The information in these sections was excerpted from WHC-SD-WM-SAR-049 Rev. 0-A.

2.1 FACILITY DESCRIPTION

The purpose of each facility within the CWC, facility construction, and facility services/utilities are described in the following sections.

2.1.1 Waste Receiving and Staging Area

This facility will receive, inspect, and stage containers of radioactively contaminated waste before final storage.

Figure 2-1. Hanford Site Map.

39207002.3
CWC-1

Figure 2-3. Central Waste Complex Plan.

The facility consists of a truck dock and a 61 m x 45.8 m (200 ft x 150 ft) asphalt slab at grade level having an allowable floor loading of 55 kPa (1,150 lb/ft²). This area is designed as a receiving and staging area and is normally kept clear of inventory, except when a truckload of containers arrives. Because waste is not stored in this area, the asphalt slab is flat to allow rainwater to run off.

This is an open-air operation requiring no ventilation equipment and no electrical service.

A 17-lb Type BC manual fire extinguisher is located at the truck dock. A fire hydrant between the 2402-WF and 2402-WH Buildings provides water for fire suppression.

2.1.2 Mixed Waste Storage Pad

The facility provides staging and temporary storage for mixed waste containers until the final storage location is determined.

The pad consists of a 27.5 m x 30.5 m (90 ft x 100 ft) concrete slab at grade level with a typical thickness of 17.8 cm (7 in). It has an integrated 15.2 cm (6-in) -high perimeter concrete curb and an inclined access ramp. There are no penetrations or drains in either the floor or curb. Precipitation on the pad is collected by the slope into the center of the pad, where a 0.3 m x 30.5 m x 0.5 m (1 ft x 100 ft x 1.5 ft) deep below grade grating-covered collection trench is located. The collection trench drains to a sump, which has a lockable release mechanism that allows runoff to drain (if runoff is uncontaminated). Monitoring and sampling for contaminated rainwater and subsequent disposal are performed according to WHC procedures. The area around the pad is sloped to prevent additional rainwater run-in. The floor loading is limited to 55 kPa (1,150 lb/ft²). The pad has a 1,700 drum capacity. Figure 2-4 provides a plan view of the facility.

This is an open-air operation requiring no ventilation equipment and no electrical service. No special fire protection equipment exists for this facility. Two fire hydrants, one located between the 2402-WF and 2402-WH Buildings, and another located south of 2403-WB provide water for fire suppression.

2.1.3 Low-Flashpoint Mixed Waste Storage Modules

The LFMW storage modules are designed to provide storage for hazardous and radioactive waste containers. Low-level radioactively contaminated flammable waste is currently stored in most of the modules. Individual modules store compatible wastes only.

The LFMW modules were purchased from various vendors and therefore are similar, but not identical in design. They vary from about 4.3 m x 3.1 m x 2.6 m (14 ft x 10 ft x 8 ft 7 in.) high to 9.8 m x 3.1 m x 2.4 m (32 ft x 10 ft x 8 ft) high. The floor area ranges from 12.5 m² (135 ft²) to 29.7 m² (320 ft²). Storage capacity is module-specific and varies from 16 to 26 208-L (55-gal) drums per unit. Currently there are 19 modules providing a total

Figure 2-4. Mixed Waste Storage Pad Plan.

Metric Conversion: 2.54 centimeters per inch
0.305 meter per foot

39304068.5
CWC-1

storage capacity of 400 drums. Additional LFMW modules can be added to the CWC if the design and spacing requirements discussed in this section are met. The floor support system is designed for loads up to 12 kPa (250 lb/ft²). Figure 2-5 provides a photo of a typical LFMW storage module.

To prevent a fire from spreading, the modules are spaced 12.2 m (40 ft) side-to-side and 6.7 m (22 ft) end-to-end. The distance between modules is in accordance with the National Fire Protection Association's (NFPA) *Exterior Fire Exposures*, NFPA-80A, Vol. 9 (NFPA 1987). The exterior of the modules are constructed of metal, in accordance with *Uniform Fire Code* (UFC) 80-301.y and 80-310.a3 (UFC 1991). The modules are coated with chemical-resistant epoxy paint inside or with a corrosion resistant coating. The interior of Modules 1, 2, and 3 have fire-retardant plywood floors and ceilings. Most of the modules are constructed of metal; although, some models do have fiberglass, rather than coated steel, floor gratings. Each module is grounded to prevent the effects of static or lightning effects and tied down on each corner to prevent wind damage. All modules have a vented catch sump under the storage floor. The catch sump provides spill containment and protects other containers by keeping the storage floor clean. The containment capacity of each module sump reservoir exceeds the requirements (sufficient capacity to hold 10% of the total container volume or the volume of the largest container, whichever is greater) mandated in WAC 173-303.

All modules are designed with convection draft ventilation, which includes inlet vents near the floor and exhaust vents near the ceiling to prevent heat and volatile organic compound buildup within the modules. By the installation of an active ventilation system, Modules 7 and 8 have been modified to permit storage of flammable TRU waste.

In accordance with NFPA 30, Vol. 2, *Flammable and Combustible Liquid Code* (NFPA 1990a), this modification is necessary because the TRU drums are vented and the storage of flammable liquids in vented containers requires a mechanical ventilation system. Modules 7 and 8 each have a 30.5 cm (12-in) explosion-proof exhaust fan with a flow rate of 165.2 L/sec (350 ft³/min). In accordance with NFPA 30, both modules have beacons to indicate loss of active ventilation. Where stored drums contain TRU, an air-sampling head and vacuum pump are installed to provide and area air sample. All modules are designed with explosion-relief panels to meet the requirements of NFPA 68, Vol. 9, *Venting of Deflagrations* (NFPA 1988).

The facility is supplied with electrical power provided at 120/240 V ac to operate the active ventilation systems and air-sampling equipment in Modules 7 and 8. Each module is installed in accordance with applicable NFPA standards, and portable fire extinguishers are provided in accordance with NFPA 10, Vol. 1, *Standard for Portable Fire Extinguisher* (NFPA 1990b). Inside of several modules there are dry-chemical fire-suppression nozzles that are supplied by a 30 lb Type ABC extinguisher mounted on the exterior of the module.

Figure 2-5. Typical Low-Flashpoint Mixed Waste Storage Module.

2.1.4 South Alkali Metal/Alkali Metal Waste Storage Modules

There are currently four storage modules located near the LFMW modules designated to store AMW and eight modules located near 16th St. and Dayton Ave. with the capability to store alkali metal. As outlined in Engineering Change Notice (ECN) 152558, *Alkali Metal Waste Storage Modules at CWC* (Bonner 1992), Modules 1 through 4 meet the requirements for low-level radioactive alkali metal mixed waste storage and store the radioactive sodium metal transferred from the 4843 Building. As noted in ECN 152558, the SAM Storage Modules (1 through 8) meet the requirements for low-level radioactive alkali metal storage and stores the Sodium Reactor Experiment (SRE) sodium transferred from the 2727-WA Building in the 200 West Area. All modules meet the requirements for the storage of reactive metal under WAC 173-303, specifically, 173-303-630(b)

The SAM/AMW storage modules are similar in construction to the pre-engineered LFMW modules. All are $\approx 7.3 \text{ m} \times 2.7 \text{ m} \times 2.4 \text{ m}$ (24 ft x 9 ft x 8 ft) high, and are capable of storing 21 321.7-L (85-gal) 17-E steel overpack drums and/or boxes. The asphalt pad below each module is designed to facilitate rainwater run off. As described in *Hazard Classification for Project W-312, Mixed Waste Storage*, WHC-SD-W312-HC-001, Rev. 0 (WHC 1993a), the modules, rather than resting directly on the pad, are elevated 10.2 cm (4 in.) above the pad. Even in extreme weather, water intrusion into the modules is prevented by vents louvered or arranged to curb rain or snow entry. The vents are in accordance with UFC 80-310.a7. Each module has a spill-containment reservoir ($\approx 2,839\text{-L}$ [750 gal] capacity) under the flooring. The spill-containment reservoirs are in accordance with *Uniform Building Code* 902 (UBC 1991), UFC 79.15, 80.301, Section 1 and 2, 29 CFR 1910, "Occupational Safety and Health Standards," Section 1910.106, "Flammable and Combustible Liquids," Title 29, *Code of Federal Regulations*, as amended, and exceed the requirements mandated in WAC 173-303. The flooring in these modules is epoxy-coated steel grates. The modules have 2-hr fire rated walls and 1.5-hr fire rated doors.

The separation distance between the modules complies with NFPA 80A. The modules employ convective ventilation with roof and wall vents located to prevent the possible build-up of any hydrogen off-gas from the radioactive sodium. Complying with NFPA 68, the explosion-relief panels are designed to open at 138 kPa (20 psi) and provide a venting area of 0.08 m^2 (1 ft^2) for each 1.4 m^3 (50 ft^3) of interior space. The doors are designed to withstand internal pressures up to 689.5 kPa (100 psi). Each module is grounded to prevent the effects of static or lightning effects and tied down on each corner to prevent wind damage. No electrical service is required.

Module 1 through 4 have internal piping for a Class ABC fire-suppression system installed in conformance with applicable NFPA standards for a possible future use of the modules. These systems have been taken out of service for AMW storage. Portable fire extinguishers are also provided. A 30-lb Type D fire extinguisher is mounted on the module exterior. All extinguishing equipment is hand operated.

2.1.5 2401-W Plutonium-Contaminated Polychlorinated Biphenyl Storage Facility

The 2401-W Facility is designed to meet all requirements for PCB, hazardous, radioactive, and mixed waste storage. The facility stores combustible wastes, primarily consisting of PCB mixed waste. Compatible wastes may be stored within the same array, while incompatible wastes may be stored when precautions are taken to maintain isolation of the incompatible waste.

The 2401-W Building is a 15.3 m x 24.4 m x 6.1 m (50 ft x 80 ft x 20 ft) eave height pre-engineered steel structure with a clear span in a 15.3 m (50-ft) direction. The structure has two 3.7 m x 4.9 m (12 ft x 16 ft) high roll-up doors. The foundation is integrated into 15.2 cm (6-in.)-high perimeter concrete curbing. The building floor is at grade. There are no penetrations or drains in either the floor or curb. The building meets the containment requirements stipulated by WAC 173-303. The floor loading is limited to 21.5 kPa (450 lb/ft²), accommodating a 908 kg (2,000 lb) forklift and ≈1,072208-L (55-gal) drum equivalents. The concrete floor finish is smooth and epoxy-sealed to provide chemical resistance. A ramp is provided to cross the curb at the truck doors. A small heated room is provided in the southwest corner of the structure where water for fire-suppression enters the building. The room contains the water riser, valves, and controls for the dry-pipe sprinkler system. Figure 2-6 provides a plan and elevation view of the facility.

This facility is equipped with two electrically powered 1,416 L/sec (3,000 ft³/min) exhaust fans, in compliance with the Uniform Building Code (UBC) H-3/H-7 occupancy requirements (UBC 1985). One is located on the southwest wall, the other on the northeast wall. Inlet filter frames are located on the walls opposite the fans to direct the airflow across the storage array.

The facility is equipped with fixed head air-sampling equipment (FHASE) in order to maintain a baseline air-sampling record. Based on the requirements specified in DOE Order 5480.11, *Radiation Protection for Occupational Workers*, and WHC-CM-7-5, *Environmental Compliance*, all waste packages stored in the CWC provide double containment and radionuclide concentrations exceeding limits linked to the applicable derived air concentration are not anticipated. Therefore, continuous air monitors are not required for CWC facilities. The adequacy of the placement and settings on the FHASE(s) is documented in the workplace air-sampling document provided by the radiation protection organization.

This facility is supplied with 220/120 V ac power to operate lighting, the fire-alarm system, the ventilation system, the FHASE(s), and the electric heater for the water riser room.

The facility has a dry-pipe sprinkler system installed that complies with NFPA 13, *Installation of Sprinkler Systems*, Vol. 1 (NFPA 1991), except as modified by NFPA 231, *General Storage*, Vol. 5 (NFPA 1990c). Portable fire extinguishers are also provided. For fire annunciation, this building has a fire pull box near the personnel exit doors.

The fire-alarm control panel, located at the 272-WA Building, monitors the low-temperature switches and closure of the post-indicator valves, and transmits alarms from the riser flow switch and manual pull box. The fire-alarm control panel is connected to a radio fire alarm report system.

2.1.6 Mixed Waste Storage Facility (Buildings 2402-W, 2402-WB through 2402-WL)

The Mixed Waste Storage Facility was designed to meet the storage requirements for hazardous, mixed, and radioactive wastes. Any combination of compatible hazardous and radioactive wastes are stored in the facility buildings (toxic, oxidizers, acid, caustic, combustible, PCB, low-level, TRU).

The facility consists of 12 storage buildings constructed in 2 rows. There is a clear space of about 7.6 m (25 ft) between structures. Each of the buildings is a pre-engineered steel structure measuring 15.3 m x 24.4 m (50 ft x 80 ft) with a 6.1 m (20 ft) eave height, and a clear span in the 15.3 m (50-ft) direction. This represents 372 m² (4,000 ft²) of available storage area per building. Each building has a 1,072 drum capacity, and therefore the facility can store ≈12,864 drums. Each building has two 3.7-m x 4.9-m (12-ft x 16-ft) high rollup truck doors. The foundation is integrated into a 15.2-cm (6-in.) high perimeter concrete curb. There are no penetrations or drains in either the floor or curb. The concrete floor is smooth and is finished with a chemically resistant epoxy-sealer. The buildings meet the containment requirements stipulated by WAC 173-303. The allowable floor loading is 95.8 kPa (2,000 lb/ft²) for Buildings 2402-WB through 2402-WL, and 33.5 kPa (700 lb/ft²) for Building 2402-W. An inclined ramp is provided to cross the curb at the truck doors. A small heated room is contained within each building where the fire-suppression water enters. The room contains the water riser, valves, and controls for the dry-pipe sprinkler system. Figure 2-7 provides a typical plan and elevation view of the buildings within the facility and Figure 2-8 provides a typical floor plan.

Each building is equipped with two electrically powered 1,416 L/sec (3,000 ft³/min) exhaust fans, complying with the UBC H-3/H-7 occupancy requirements. Flow-actuated inlet dampers are located on the walls opposite the fans to direct the airflow across the storage array.

Each building within the facility is equipped with FHASEs in order to maintain a baseline air-sampling record. The adequacy of the placement and settings on the FHASE is determined in the workplace air-sampling document provided by the radiation protection organization.

The facility is provided with electrical power to operate the ventilation system, lighting, the fire-alarm system, the FHASEs, and the heaters in the water riser rooms.

The buildings have a dry-pipe sprinkler system installed in accordance with NFPA 13, except as modified by NFPA 231. Portable fire extinguishers are also provided. These buildings each have two fire pull boxes located near personnel exit doors for fire annunciation. The facility is equipped with fire-alarm control panels (2402-W Building houses the control panel covering 2402-W through 2402-WF, 2402-WH houses the control panel covering 2402-WG

Figure 2-7. Mixed Waste Storage Building (2402-W,
WB through WL) Plan and Elevation.

Metric Conversion: 2.54 centimeters per inch
0.305 meter per foot

39304068.7
CWC-1

Figure 2-8. Mixed Waste Storage Building (2402-W,
WB through WL) Typical Floor Plan.

28905022.1
CWC-1

through 2402-WL) that are connected to a radio fire-alarm report system. The fire alarm control panels monitor the low-temperature switches and closure of the post-indicator valves, and transmit alarms from the riser flow switches and manual pull boxes.

2.1.7 Mixed Waste Storage Facility (Buildings 2403-WA through 2403-WD)

The 2403 Mixed Waste Storage Facility consists of four buildings. Each building within the facility is designed to meet all the requirements for the storage of hazardous, mixed, and radioactive waste. The buildings contain four separate quadrants to facilitate the compatibility of waste. Each quadrant will contain only compatible wastes. PCBs are not allowed because of facility design limitations. This facility will accommodate $\approx 52,300$ drums (208-L [55-gal] each) of waste — Buildings 2403-WA through 2403-WC will accommodate 11,600 drums each, and 2403-WD will accommodate 17,500.

Buildings 2403-WA, -WB, and -WC are at 51.9 m x 61 m x 6.1 m (170 ft x 200 ft x 20 ft) eave height and Building 2403-WD is at 51.9 m x 99.1 m x 6.1 m (170 ft x 325 ft x 20 ft) eave height. Each roof has a 1 in 12 slope. These facilities are designed with modular beam and column ridged frame construction on 7.6 m (25 ft) centers. Each ridged frame is supported by two interior columns at each third of the building's overall width. Roof and wall panels are 26-g steel sheets with an exterior finish. Exterior rolling service doors are 3.7-m (12-ft) wide and 5.5-m (18-ft) high and are constructed of uninsulated steel slats. The allowable floor loading is 95.8 kPa (2,000 lb/ft²). The concrete floors and trenches of each building are divided into quadrants by 12.7-cm (5-in.) high concrete curbs. The slab slopes down 12.7-cm (5-in.) toward central floor sumps for each floor quadrant and back up 12.7-cm (5-in.) to the 3.7-m (12-ft) wide center aisle. The total slab retention capability is in compliance with WAC 173-303. The floor areas are finished with an impervious epoxy resin. A small heated room is provided in each building. The room contains the water riser, valves, and controls for the dry-pipe sprinkler system. Figure 2-9 provides a typical plan view of the three smaller buildings (-WA, -WB, and -WC) and Figure 2-10 provides a plan view of 2403-WD. Figure 2-11 provides a typical section and elevation view of the smaller buildings and Figure 2-12 provides a section and elevation view of 2403-WD.

These buildings do not require heating and cooling, but are ventilated at the rate of four air changes per hour by electrically powered exhausters. The ventilation complies with UBC H-3/H-7 occupancy requirements. The requirements are met in Buildings 2403-WA through 2403-WC by 8 inlets on the south side of the buildings and 4 6,296.5 L/sec (13,340 ft³/min) exhaust fans on the north side of the buildings. Building 2403-WD has 10 inlets on the east side of the building and 4 10,233 L/sec (21,680 ft³/min) exhaust fans on the west side of the building.

Each building within the facility is equipped with an FHAS in order to maintain a baseline air-sampling record. The placement adequacy and settings of the FHAS is documented in the workplace air-sampling document provided by the radiation protection organization.

Figure 2-9. Mixed Waste Storage Facility
(2403-WA, WB, and WC) Plan View.

Metric Conversion: 2.54 centimeters per inch
0.305 meter per foot

39304068.9
CWC-1

Figure 2-10. Mixed Waste Storage Facility
(2403-WD) Plan View.

39304068.10
CWC-1

Figure 2-11. Mixed Waste Storage Facility
(2403-WA, WB, and WC) Section and Elevations.

Metric Conversion: 2.54 centimeters per inch
0.305 meter per foot

39304068.8
01/11/11

Figure 2-12. Mixed Waste Storage Facility
(2403-WD) Section and Elevation.

Metric Conversion: 2.54 centimeters per inch
0.305 meter per foot

typ = typical.

39304068.11
CWC-1

The buildings are provided with 480 V ac power to operate the ventilation equipment, and 120 V ac power to operate lighting, the fire-alarm system, the FHASE, and the heaters for the water riser rooms.

Each building is provided with a dry-pipe sprinkler system, supplied by a riser located in a heated room (15.3 cm [6-in.] risers for 2403-WA, -WB, and -WC, and 38.1 cm [8-in.] risers for 2403-WD). Except as modified by NFPA 231, the sprinkler system was designed and installed in accordance with NFPA 13.

Buildings 2403-WA through 2403-WC each have four fire pull boxes located near exit doors for fire annunciation. In addition, there are 16 manual dry chemical 17 lb Type BC fire extinguishers at strategic locations throughout each building. Building 2403-WD has six fire pull boxes located near exit doors for fire annunciation. In addition, there are 21 manual dry chemical 17 lb Type BC fire extinguishers at strategic locations throughout the building. The facility is equipped with a fire-alarm control panel and is connected to a radio fire-alarm report system (located on the northeast side of 2403-WA). The fire alarm control panel monitors the low-temperature switches and closure of the post-indicator valves, and transmits alarms from the riser flow switches and manual pull boxes.

2.1.8 272-WA Operations Support Building

The personnel in the 272-WA Operations Support Building are not necessarily solid waste facility workers. However, the building is within CWC boundaries and all personnel have been trained to the CWC Building Emergency Plan. The building includes a central base for craft personnel operations, a conference area, change rooms, supply and storage rooms, maintenance shops, a garage, and a decontamination room.

The building is 1440 m² (15,500 ft²) in area and is constructed to UBC standards for office and change room spaces and also includes decontamination facilities.

Electric power is supplied to the building for the operation of lighting, convenience receptacles, and the ventilation system.

Fire hydrants on the north, south, southwest, and southeast side of the building provide water for fire suppression. The building is also equipped with a fire sprinkler system.

2.1.9 Office Buildings (MO-211, MO-281, MO-720, MO-721, and 278-WA)

The office buildings are within CWC boundary and consist of single- and multiple-wide trailers. The personnel occupying these buildings are trained to respond to emergency conditions. Additional single- and multiple-wide trailers may be located at the CWC in the future. The personnel in these buildings will receive training to respond to emergency conditions at the CWC. The office trailers are equipped with fire sprinkler systems.

2.1.10 213-W Building

The 213-W Compactor Building is controlled and operated by West Tank Farms Operations. This facility is considered to be within the boundaries of the CWC. The personnel occupying this building are trained to respond to emergency conditions at the CWC and are included in the building emergency plan. Operations of the 213-W Building involves the compaction of LLW. The 213-W Building was previously operated by Solid Waste Disposal for waste verification operations. SAR-049 (ECN 189459, Bonner 1994) demonstrates that the operation of the facility as a LLW compactor or verification building is within the Hazard Category 3 criteria and risk-acceptance guidelines.

2.2 PROCESS DESCRIPTION

2.2.1 General Operations and Procedures

Personnel at the CWC receive and inspect waste packages at the Waste Receiving and Staging Area. In accordance with all applicable procedures, transport off-loading operations are performed by handtruck, forklift, or crane (special situations only) by qualified personnel. Packages are transported, generally by forklift, to the MWSP and then to the proper storage facility. Alternatively, waste packages may be received, inspected, and unloaded at the specific facility where the waste will be stored. The typical waste package stored at the CWC is a 208-L (55-gal) drum or standard waste box; however, other nontypical packages including radioisotope thermoelectric generators (RTGs) and a CR-vault tank filter assembly are also stored within the CWC. Operational and procedural details are described in the following sections.

2.2.2 Operating Conditions

The containers handled at the CWC have controlled inventories of TRU content, non-TRU radionuclides, and hazardous waste constituents. The CWC has an inventory control system that ensures each building (2401-W and 2402-W facilities), building quadrant (2403-W facility), or module (LFMW and SAM/AMW facilities) within the CWC complies with its established inventory limit (Section 3.1.1 contains inventory limit values). These limits also apply to the Waste Receiving and Staging Area, the MWSP, and to waste shipments destined for storage within the CWC.

Before acceptance of a waste shipment, CWC personnel review the accompanying documentation to determine the CWC dose equivalent-curie (DE-Ci) content (Sections 3.1.3.1.7 and 3.1.3.6 contain detailed discussion of the CWC DE-Ci concept and the inventory limit analysis). To assign a waste shipment to a specific building or module within the CWC, personnel review the curie limits for CWC report of the Solid Waste Inventory Tracking System (SWITS). The DE-Ci content for all waste packages entered into the system is calculated by SWITS, enabling CWC personnel to track the DE-Ci values.

Whenever the CWC DE-Ci inventory is changed, a new curie limits report and the facility-specific report are generated. The facility-specific report provides specific information on the waste container including container identification, generating facility, and DE-Ci. These reports are maintained in the CWC DE-Ci Inventory Log Book located in the CWC office within MO-720.

The TRU content limit is specified in the *Central Waste Complex Criticality Prevention Specification* (WHC 1995) to ensure safe storage of the containers. Nuclear criticality is prevented in the CWC through strict control of the amount of fissionable material in containers, container segregation requirements, and container spacing requirements.

2.2.3 Pretransport Requirements and Approval

The CWC receives waste in packaged form from both onsite and offsite waste generators. Waste generators are responsible for packaging waste in accordance with WHC-EP-0063-4.

Before shipping waste to the CWC, waste generators must request and obtain formal approval from the appropriate Solid Waste Disposal Manager or designee. The approval process is detailed in WHC-EP-0063-4, and each storage request is evaluated to verify compliance with the applicable requirements of WHC-EP-0063-4, to ensure that the appropriate safety and environmental documentation is in force, and to establish the regulatory designation of the waste.

2.2.4 Package Transport

Once approved to ship waste, a waste generator is authorized to schedule shipment of the subject waste to the CWC. As the shipper, the waste generator is responsible for complying with the following applicable requirements:

- DOE Order 5480.3, *Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes*
- 10 CFR 71, "Packing and Transportation of Radioactive Material," *Code of Federal Regulations*, as amended
- 49 CFR 171-179, "Transportation," *Code of Federal Regulations*, as amended
- WHC-CM-2-14, *Hazardous Material Packaging and Shipping*.
 - In accordance with RL Order 5480.1, *Environmental Safety and Health Program for Department of Energy Operations for Richland Operations*, Section III, "Safety Requirements for the Packaging of Fissile and Other Radioactive Materials," onsite transportation may deviate from the regulations where compliance is not economically or technically practical, provided a safety analysis is performed and administrative controls are specified that offer an equivalent degree of

safety. The safety analysis and administrative controls are to be documented in a SAR for packaging. Guidance for the preparation, review, and approval of a SAR for packaging is provided in WHC-CM-2-14.

In accordance with currently approved operating procedures that implement all applicable transportation requirements, transportation to storage areas within the CWC is accomplished by handtruck, drumlift, or forklift by qualified personnel.

2.2.5 Receipt, Staging and Storage

CWC facility operations are conducted on containerized waste materials including TRU, LLW, LLMW, and TRU mixed waste. As implemented by WHC-EP-0063-4, Appendix A, in addition to the standard containers, special design containers may receive separate approval for storage at the CWC.

Definitions of waste categories, specific packaging requirements (e.g., vent clips on packages with the potential to reach explosive concentrations of explosive gases) and limits on quantities of hazardous materials, including radionuclides, are provided in WHC-EP-0063-4. Waste segregation is performed by the individual buildings and by curb-separated areas within the larger buildings. Containers are placed in appropriate storage facilities with waste types separated to prevent mixing of incompatible wastes.

Operations are conducted by Solid Waste Operations personnel in accordance with written and controlled procedures. The principle CWC operations governed by procedures include the following:

- Inspect Solid Waste Storage/Disposal Facilities
- Receive/Store/Stage Radioactive Solid Waste, CWC
- Operate the 2403-WA Mixed Waste Storage Facility.

Waste shipments arriving at the CWC are transported to the Waste Receiving and Staging Area where inspection, acceptance, and unloading occur. Waste records are checked for completeness and accuracy in accordance with procedures that provide instructions for performing detailed entry-by-entry reviews of waste records. Additionally, similar entries on different records are cross-checked for accuracy and waste packages are surveyed and inspected to verify compliance with storage requirements. To the extent practicable, this work is performed before unloading. However, partial unloading of a shipment may be necessary to complete a thorough survey and inspection.

Waste packages meeting all acceptance criteria are officially accepted for storage. Noncompliant waste packages (e.g., with paperwork errors or omissions and damaged containers) are held until the noncompliant condition is corrected to the satisfaction of the responsible Solid Waste Manager or designee. Noncompliant conditions are resolved through one or more of the following alternatives:

- The waste generator corrects the noncompliant condition at the CWC.
- The Solid Waste Manager or designee corrects the condition in accordance with procedures provided by the waste generator.
- The Solid Waste Manager or designee returns the waste package to the generating facility for correction.

Noncompliant conditions that are determined by the Solid Waste Manager or designee to pose an immediate threat to human health or the environment, such as damaged or leaking containers or high dose rates, are immediately corrected. The action taken could include, but is not limited to, overpacking the container and performing requisite decontamination procedures. A determination that a noncompliant condition poses an immediate threat triggers the initiation of an occurrence reporting process. In the event of a suspected containment breach, supervisors are immediately notified. Emergency actions and spill response are conducted in accordance with WHC-IP-0263-CWC, *Building Emergency Plan for the Central Waste Complex*, and solid waste procedures using spill kits that are located in the proximity of each facility.

Noncompliant conditions that pose no immediate threat to human health or the environment (e.g., record keeping or marking and labeling discrepancies) may be resolved with documented conversations between the responsible Solid Waste Manager, or designee, and the waste generator.

The staging of transport vehicles or incoming containers is limited to 30 calendar days to provide a distinction between staging and storage. If noncompliant conditions for a container are not resolved in 30 days, Nuclear Facility Safety and Environmental Safety is notified for assistance in resolving the noncompliance.

2.2.6 Periodic Waste Package Inspections

To detect leaking or deteriorating containers or deterioration of the containment system, in compliance with WAC-173-303, all waste containers are inspected on a weekly basis as required by WHC-CM-7-5, Chapter 7. The inspection is conducted according to procedure. To ensure access for the inspections, aisles are provided and rows may be no more than two drums wide. Nominal aisle width between container rows is 76.2 cm (30 in.) for all locations, except the LFMW modules where 61 cm (24 in.) is the minimum. Palletized 208-L (55-gal) drums are stacked no more than 3 high or 3.1 m (10 ft) high, whichever is lower. An exception is the LFMW modules where 208-L (55-gal) drums are stacked only 1 high, and smaller containers are allowed to be stacked no more than 2 high or 1.5-m (5-ft) high, whichever is lower (in accordance with NFPA 30). It is improbable that a liquid spill would occur at the CWC because wastes handled at the site are limited to solids, which may include no free liquid but up to 56.8-L (15 gal) of liquid absorbed within a 208-L (55-gal) drum. If a liquid spill does occur, the inspection program should limit the consequences by prompt detection and immediate mitigative action.

2.2.7 Facility-Specific Operations

The following subsections describe specific handling and storage requirements for each facility including inspection, monitoring, and container stacking requirements.

2.2.7.1 Waste Receiving and Staging Area. Class 1A flammable containers are not stacked. Single drums not banded to pallets are stacked no more than two tiers high. Drums that are banded are stored on pallets stacked no more than two tiers high. Other waste packages are stacked no more than 3.1-m (10-ft) high, provided that the packages are amenable to stacking.

If a container is noncompliant, it is stabilized by corrective actions taken on the pad, as required, and then returned to the shipper for corrective repackaging. Corrective action taken on the pad (primarily overpacking) does not involve activities that might result in the release of material to the environment.

2.2.7.2 Mixed Waste Storage Pad. Drums are transported by forklift from the Waste Receiving and Staging Area to the MWSP and then to the proper storage structure. Waste packages are placed for storage or staging in accordance with all applicable requirements.

2.2.7.3 Low-Flashpoint Mixed Waste Storage Modules. Within the modules, waste is generally packaged in 208-L (55-gal) drums and stored in a single tier. Waste is transported to the storage modules by forklift and within the module by hand truck. Weekly inspection of the containers is required to check for leaks and deterioration of containers. Smaller containers are allowed to be stacked up to two tiers with the maximum height of 1.5 m (5 ft). Inspection aisles of 61 cm (24 in.) must be provided.

2.2.7.4 South Alkali Metal/Alkali Metal Waste Storage Modules. Waste packages must adhere to double confinement and overpacking requirements. Weekly inspection of the containers will be required to check for leaks and container deterioration. Smaller containers (113.5 L [30 gal] or less) are allowed to be stacked up to two tiers high.

2.2.7.5 2401-W Plutonium-Contaminated Polychlorinated Biphenyl Storage Facility. Waste stored in the 2401-W Facility is typically packaged in 208-L (55-gal) drums or standard waste boxes. Other waste packages may be accepted after evaluation and approval by the Site Solid Waste Engineering Support Unit; however, only compatible wastes will occupy a single array within the facility. Drums are banded four per pallet and the pallets are stacked up to three high in rows that are one pallet wide. Operating procedures limit the gross weight of a pallet stack to 3268.8 kg (7,200 lb), to ensure the allowable floor loading is not exceeded. Rows are separated by inspection aisles that are at least 76.2-cm (30-in.) wide. Drums are stacked from the rear to the front of the building with adequate floor space to safely maneuver the forklift. A portable ladder is used to inspect the higher tiers because the drums are stacked above normal eye level.

2.2.7.6 Mixed Waste Storage Facility (2402-W, 2402-WB through 2402-WL). Drums are banded four per pallet and the pallets are stacked up to three high in rows that are one pallet wide. Rows are separated by inspection aisles

that are at least 76.2-cm (30-in.) wide. Drums are stacked from the rear to the front of the building with adequate floor space to safely maneuver the forklift. A portable ladder is used to inspect the higher tiers because the drums are stacked above normal eye level.

2.2.7.7 Mixed Waste Storage Facility (2403-WA through 2403-WD). Drums are banded four per pallet, and the pallets are stacked up to three high in rows that are one pallet wide. Rows are separated by inspection aisles that are at least 76.2-cm (30-in.) wide. Drums are stacked from the rear to the front of the building with adequate floor space to safely maneuver the forklift. Because the drums are stacked above normal eye level, a portable ladder is used to inspect the higher tiers.

3.0 INTERIM SAFETY BASIS EVALUATION

ISB-007 provides the necessary information to conclude that hazards associated with the operation of the CWC are controlled and that current and planned activities within the CWC can be conducted in a safe manner.* This section provides the following information to

- Identify the hazard category of the CWC
- Identify and evaluate hazards at the CWC
- Identify hazard control and/or mitigation systems
- Identify administrative controls and/or operational restrictions necessary to limit the risk from the identified hazards.

The information in this section was excerpted, in part, from WHC-SD-WM-SAR-049, Rev. 0-A.

3.1 HAZARD ANALYSIS

WHC-SD-WM-SAR-049, Rev. 0-A (SAR-049), provides the analytical results of the hazard analysis performed for the CWC and includes a discussion of the preliminary hazards analysis (PHA) used to identify the hazards associated with the design and operation of the CWC and the fault-tree analysis used to determine the probability of the risk-dominant accident scenarios. The following sections identify the hazard category of the CWC, summarize the PHA and fault-tree analysis, and provide consequence analysis and risk evaluation of significant potential accident and event scenarios.

3.1.1 Hazard Categorization

The *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Report*, DOE-STD-1027-92 (DOE 1992), has established a method for determining hazard categories based on radioactive materials.

In accordance with DOE-STD-1027-92, individual hazard categories can be assigned to sections of a facility that are separated from the rest of the facility or do not have a common mode accident. A facility may therefore be segmented, with a hazard category calculated for each segment. For the CWC, a hazard categorization was done for each of the following:

- Waste Receiving and Staging Area

*The accident analyses use two unique units, the PE-Ci (Plutonium Equivalent Curie) and the CWC DE-Ci (CWC Dose Equivalent Curie). To avoid confusion, no metric conversion to the calculations involving these units is provided.

- MWSP
- LFMW Storage Modules
- SAM/AMW Storage Modules
- 2401-W Building
- 2402-W and 2402-WB through 2402-WL Buildings
- 2403-WA through 2403-WD Buildings
- In-transit locations — all areas not listed above where the CWC is responsible for waste movement.

Preliminary hazard categories are determined by comparing facility radiological inventory to threshold values from tables in attachment 1 of DOE-STD-1027-92. Final hazard categorization, as specified in DOE-STD-1027-92, is based on an unmitigated release of available radioactive material. This categorization takes into account material quantity, form, location, dispersibility, and interaction with available energy sources; however, it does not consider safety features that will prevent or mitigate a release.

Hazard category is determined by comparing the quantity of each isotope available to the threshold quantity for that isotope documented in DOE-STD-1027-92, Table A.1. Threshold quantities are based on assumptions about the fraction of radioactive materials that could become airborne in an accident. The airborne release fractions used in generating the threshold quantity values for Category 2 in Table A.1 of DOE-STD-1027-92 are provided on Page A-9 of Attachment 1 to DOE-STD-1027-92. A category assigned from the use of the threshold quantity tables can be re-evaluated if the actual fractional release differs significantly from the DOE assumptions. DOE-STD-1027-92 specifies that if a credible release fraction can be shown to be significantly different than the DOE-STD-1027-92 page A-9 values, based on physical and chemical form and available dispersive energy sources, the threshold inventory values in Table A.1 may be divided by the ratio of the maximum potential release fraction to that found on Page A-9.

Facilities with ^{239}Pu inventories greater than 0.52 Ci (Category 3 threshold values) and less than 56 Ci (Category 2 threshold values) are specified by DOE-STD-1027-92, Table A.1, as Hazard Category 3 facilities. The ratio of the CWC credible release fraction (refer to Section 3.1.3.1.5) to the DOE-STD-1027-92 Page A-9 release fraction of 1 E-3 for solid/powder/liquid, yields a value of 0.265. When these Category 3 defining threshold values are divided by this ratio (0.265), the limiting threshold values for a Category 3 facility become $> 1.96 \text{ Ci}$ (Category 2 threshold values) to $> 211.32 \text{ Ci}$ (Category 2 threshold values).

Table 3-1 lists the areas of the CWC, their respective inventory limits, and the corresponding hazard category. The inventory limits are listed in terms of CWC DE-Ci, which is defined as a dose equivalence to a curie of ^{239}Pu . All TRU and fission product isotopes are converted to equivalent curies of ^{239}Pu . Sections 3.1.3.1.2 and 3.1.3.1.7 discuss this conversion in

more detail. As shown in Table 3-1, all areas of the CWC were determined to be Category 3 or less. Accordingly, the CWC is designated a Hazard Category 3 facility.

3.1.2 Preliminary Hazards Analysis

A preliminary hazards analysis (PHA) was conducted by SAR-049 to identify the hazards associated with the operation of the CWC and to evaluate the preventative and mitigating features. The PHA is also used to determine those credible events with potentially unacceptable risk by assigning each event a qualitative estimate of probability and severity of consequence.

The general sources of energy for dispersal of material in the CWC include the following:

- Potential and kinetic energy
- Chemical
- Criticality.

The events associated with each of these energy sources are evaluated in the PHA and the results are shown in Table 3-2 (SAR-049). Table 3-2 identifies the specific energy source and associated accident scenario, the potential consequences of the accident, any preventative or mitigating barriers, and qualitative estimates of probability and consequence. The qualitative estimates of probability and consequence severity, from SAR-049, are shown in Tables 3-3 and 3-4.

Table 3-1. Hazard Categorization of the Central Waste Complex by Facility Area.

Central Waste Complex Area	Area inventory limit (CWC DE-Ci)	Hazard category for area
Waste Receiving and Staging Area	121	3
Mixed Waste Storage Pad	121	3
LFMW Storage Modules	10.6 (per module)	3
SAM/AMW Storage Modules	N/A - specific waste stream only ^a	< 3
2401-W and 2402-W series buildings	121	3
Quadrants of the 2403-W series buildings	121	3
In-Transit locations (shipments)	40 (buildings) 3.5 (LFMW modules)	3

^aThe radionuclide inventory of the sodium waste stream identified for storage within the CWC results in a hazard categorization of <3. (Section 3).

Table 3-2. Central Waste Complex Preliminary Hazards Analysis. (3 sheets)

Hazard/energy source	Potential accident and sequence	Target/potential consequences	Barrier analysis		Annual probability	Severity
			Engineered	Administrative		
I. Potential/kinetic energy						
A. Vehicle accidents	1. Truck impacts building causing rupture of containers both directly and by falls.	Exposure of radiation to occupational worker. Dose consequences to onsite and offsite persons. Release of toxic material to the environment.	17C or 17H containers, steel drums in overpacks, or metal boxes.	Building inventories controlled by OSRs, preclude levels sufficient to exceed low-hazard class limits.	Extremely unlikely	Category III
	2. Truck impact away from buildings causing rupture of transported containers.	Same as above	Same as event I.A.1	Transportation inventories, controlled by OSRs, preclude levels sufficient to exceed low-hazard class limits.	Unlikely	Category III
	3. Forklift drops or causes containers to topple and rupture.	Same as above	Same as event I.A.1	Same as event I.A.1	Unlikely	Category III
	4. Forklift tines puncture containers causing rupture.	Same as above	Same as event I.A.1	Same as event I.A.1	Unlikely	Category III
B. Seismic event	Seismic activity causes containers to rupture.	Same as above	Same as event I.A.1. Also, low-flashpoint modules secured by tie-downs making them resistant to seismic and wind forces.	Same as event I.A.1	Unlikely	Category III
C. Strong wind	1. Piercing of containers by wind-generated missiles.	Same as above	Same as event I.A.1	Same as event I.A.1	Unlikely	Category III
	2. Building structure fails and container stacks topple causing container rupture.	Same as above	Same as event I.A.1	Same as event I.A.1	Unlikely	Category III

Table 3-2. Central Waste Complex Preliminary Hazards Analysis. (3 sheets)

Hazard/energy source	Potential accident and sequence	Target/potential consequences	Barrier analysis		Annual probability	Severity
			Engineered	Administrative		
1. Potential/kinetic energy (continued)						
D. Aircraft accidents	1. Helicopter impact into building causing rupture of container.	Exposure of radiation to occupational worker. Dose consequences to onsite and offsite persons. Release of toxic material to the environment.	17C or 17H containers, steel drums in overpacks, or metal boxes.	Inventories, controlled by OSRs, preclude levels sufficient to exceed low hazard class limits.	Incredible	Category III
	2. Airplane impact into building causing rupture of container.	Same as event I.D.1	Same as event I.D.1	Same as event I.D.1	Incredible	Category III
E. Flood		Release of toxic/radioactive material to the environment	Elevation above Columbia River makes facility unsusceptible to flooding	Same as above	Incredible	Category III
F. Volcanic activity	Accumulation of ash causing building structure failure.	Same as event I.D.1	17C or 17H containers, steel drums in overpacks, or metal boxes.	Same as event I.D.1	Extremely unlikely	Category III
II. Chemical						
A. Fire	1. Same as event I.A.1 plus a truck turnover or fuel tank rupture, resulting in a fuel spill. Ignition of fuel spill creates a sustained fire to ignite combustible waste in ruptured containers.	Same as event I.D.1	Same as event I.D.1	Same as event I.D.1	Extremely unlikely	Category III
	2. Same as event I.A.2 plus a truck turnover or tank rupture, resulting in a fuel spill. Ignition and sustained fire ignites waste in ruptured containers.	Same as event I.D.1	Same as event I.D.1	Same as event I.A.2	Extremely unlikely	Category III

Table 3-2. Central Waste Complex Preliminary Hazards Analysis. (3 sheets)

Hazard/energy source	Potential accident and sequence	Target/potential consequences	Barrier analysis		Annual probability	Severity
			Engineered	Administrative		
II. Chemical (continued)						
A. Fire (continued)	3. Range fire.	Exposure of radiation to occupational worker dose consequences to onsite and offsite persons. Release of toxic material to the environment.	Paved roadways and buildings provide barriers from range fires.	Response of the Hanford Fire Department	Anticipated	Category III
	4. Spontaneous combustion in single container.	Same as event II.A.3	Same as event II.A.2	Materials that will react with one another are prohibited from storage in the same container. Where permitted in the same building, they are separated by space and or physical barrier.	Anticipated	Category III
	5. H ₂ , methane, carbon monoxide build up in TRU-waste-containing container, handling ignites gas resulting in combustion of waste.	Same as event II.A.3	Vent clips and filters to vent gas. Catalyst pack recombines H ₂ to H ₂ O.	Vents and filters installed on nonflammable TRU waste containers before storage (except LFMW modules).	Extremely unlikely	Category III
III. Criticality	Dose consequences to onsite and offsite persons.	Same as event II.A.3	Fissile material is in a form and arrangement that precludes an accidental criticality.	Double-contingency principle prevents an accidental criticality, as specified in the Criticality Prevention Specification. Also, no restrictions on fire fighting category.	Incredible	Category II

DOT = U.S. Department of Transportation.
OSR = Operational safety requirements.

Table 3-3. Probability Category Definition.

Probability category	Category description	Nominal range of annual probability
Anticipated	An off-normal condition that individually may be expected to occur one or more times during plant lifetime.	1 E-02 to 1
Unlikely	Individually, the condition is not expected to occur during plant lifetime, but collectively, events in this category may occur several times.	1 E-04 to 1 E-02
Extremely unlikely	Extremely low-probability conditions that are not expected during plant lifetime but present extreme or limiting cases of faults identified as possible. This category includes design basis accidents.	1 E-06 to 1 E-04
Incredible	Accidents for which no credible scenario can be identified.	<1 E-06

Table 3-4. Qualitative Accident Severity Levels.

Severity categories	Consequences to the public, workers, or environment.
Category I	May cause morbidity onsite or loss of the facility/operation, major injuries or illness offsite, radiation exposure to offsite individuals in excess of annual limits, or severe impact to the environment.
Category II	May cause severe injuries or severe occupational illness onsite, exposure to onsite individuals in excess of annual limits, major damage to a facility/operation, minor illness or injury offsite, exposure to offsite, exposure to offsite individuals to radiation below annual limits, or major impacts to the environment.
Category III	May cause minor injury or minor occupational illness onsite, or exposure of onsite individuals to radiation below annual limits, negligible impact offsite, or minor impact to the environment.
Category IV	Will not result in injury, occupational illness, or exposure onsite or offsite, or result in a significant impact to the environment.

The PHA identified several potential accidents at the CWC with varying levels of associated risk. The potential accidents chosen for detailed quantitative analysis should bound the risk of facility operations — both frequency and consequence must be considered. The risk-dominant accidents for the CWC (taken from Table 3-2) include the following:

- Truck impact into building (with and without subsequent fire)
- Truck impact away from building (with subsequent fire)
- Seismic event (no fire).

The PHA in Table 3-2 does not address all of the hazards associated with operation of the CWC because of (1) the incorporation of additional facilities to the CWC, subsequent to the PHA, that perform unique operations, and (2) the storage of special waste packages within the CWC. These hazards are summarized in the following subsections.

SAM/AMW Modules — As discussed in Appendix A, a water-sodium reaction, sodium fire, or hydrogen explosion involving sodium could potentially occur in the SAM/AMW modules. The accident could involve radiological and toxicological consequences to the facility worker, onsite and offsite persons, and the environment. The storage modules, pad design, and storage container are engineered barriers, and operating procedures preventing the storage of SAM/AMW in an inappropriate environment are an administrative barrier. All three accident scenarios are extremely unlikely events with Category III severities. Because the storage of large quantities of sodium is unique to the SAM/AMW modules, a water-sodium reaction is selected for detailed quantitative analysis.

Radioisotope Thermoelectric Generators — The radioactive inventory of the RTGs consists of ^{90}Sr in the titanate fuel form, and the fuel sources are double encased in Hastelloy-C*. Lead, present in the RTGs in the form of PbTe, is contained within the pressure vessels of the RTGs. A safety hazard analysis (SAR-049, Appendix F) concluded that no known credible hazard within the operation of the CWC would result in failure of both fuel capsule containment and RTG outer containment. Therefore, for any credible CWC accident, the RTGs would not contribute to any radiological or toxicological release and an accident involving the RTGs is not selected for detailed analysis. The safety analysis performed for the RTGs exempts them from the CWC DE-Ci inventory limits.

CR-Vault Tank Filter Assembly — The filter assembly has several components and is stored in a U.S. Department of Transportation (DOT)-approved shipping container (TMB-V) box for shipping and storage. The filter assembly could potentially drop to the floor of the storage building and result in radiological consequences to the facility worker, onsite and offsite persons, and the environment. The DOT-approved shipping container is an engineered barrier. The filter drop scenario is an extremely unlikely event of Category III severity. The accident analysis in ECN 173246, *Storage of CR-Vault Tank Filter* (Cain 1992), demonstrates that all potential events pose acceptable

*Hastelloy is a trademark of Stellite Rod Division, Stoddy Deloro Stellite Inc.

risk, as defined by WHC-CM-4-46. The risks associated with the storage of the filter assembly are below the most stringent risk-acceptance guidelines. The accident analysis performed for the filter assembly allows exemption from the CWC DE-Ci inventory limits.

Polyethylene Overpack Drums — The 2403-WC Building stores ≈14 metal boxes containing 6 polyethylene overpacks each. The polyethylene overpacked drums contain grouted low-level mixed waste from the 183-H Basin. The grouted mixed waste is in a nondispersible form and would not result in a radioactive airborne release if the drums were breached. However, the polyethylene drums do add to the potential combustible loading of the building during a fire accident scenario. Until the polyethylene overpacks can be removed from the building, the drums will be overpacked into metal boxes as an interim precautionary measure. The metal overpack should provide a barrier to the possibility of the polyethylene melting and spreading in a fire scenario.

3.1.3 Accident Analysis

The purpose of the CWC accident analysis is to define the operating risks. The accident analysis also provides a development base for the administrative controls/operational restrictions and for the selection of safety class equipment.

The accident scenarios selected for full analysis and comparison to evaluation guidelines provide an adequate representation of the CWC operation risk. The following accident scenarios were chosen for analysis:

- Truck impact into a building — no fire
- Truck impact into a building — fire
- Truck impact away from building — fire
- Design-basis earthquake
- Water-sodium reaction in the SAM/AMW modules (toxicological)
- Truck impact into a building — fire (toxicological release).

The following subsections summarize the accident analysis methodology and provide accident analyses of the selected accident scenarios for radiological and/or toxicological consequences.

3.1.3.1 Accident Analysis Methodology. The accident analysis methodology includes (1) the waste forms in the CWC, (2) the TRU radionuclide concentrations, (3) the radiological dose calculations, (4) the selection of release fractions, (5) the TRU limit concentrations, and (6) the LLW concentration.

3.1.3.1.1 Waste Forms in the Central Waste Complex. The CWC provides storage for contact-handled radioactive waste and *Resource Conservation and Recovery Act of 1976* approved storage for mixed waste. The waste may contain TRU radionuclides that RL Order 5820.2A defines as waste contaminated with alpha-emitting transuranium radionuclides with half-lives >20 yr and a concentration >100 Ci/g. The LLW is in accordance with 49 CFR 173, "Shippers-General Requirements for Shipments and Packaging," *Code of Federal Regulations*, as amended, for LSA through Type A quantities. The accident

analyses below provide the basis for accepting containers in excess of A_2 quantities. Containers in excess of A_2 quantities may also be accepted in the same manner as the RTGs, with an approved specific safety analysis.

3.1.3.1.2 Transuranic Radionuclide Concentrations. The TRU radionuclide concentrations of 55-gal drums were estimated in *CH-TRU Waste Drum In-Situ Inspection and Vented Drum Retrieval*, WHC-SD-WM-SAR-058, Rev. 0 (WHC 1993b), by multiplying the isotopic composition (i.e., weight fractions of the various TRU isotopes) by the specific activities of each isotope, and then converting that number with correction factors taken from WHC-EP-0063-4 to plutonium-equivalent curies (PE-Ci). WHC-SD-WM-SAR-058 presents PE-Ci calculations for an isotopic distribution containing 12% (nominal) ^{240}Pu for both newly generated and 20-yr-old material. The PE-Ci per gram value for 20-yr-old material was used because it was more conservative. The PE-Ci per gram value (0.175 PE-Ci/g) was then multiplied by the number of TRU radionuclides grams per drum to estimate the total PE-Ci content of a drum. For example, if the average TRU content of a 208-L (55-gal) drum, based on information from the 224-T Transuranic Waste Storage and Assay Facility is 25 g/drum, the average plutonium loading in newly generated TRU waste is

$$(0.175 \text{ PE-Ci/g}) \times (25 \text{ g/drum}) = 4.38 \text{ PE-Ci/drum.}$$

However, a SWITS run on the CWC building inventory has shown the average to be about 4.6 g TRU per drum.

The total release quantity per drum is estimated by multiplying the radionuclide concentrations per drum by a release fraction appropriate to the accident scenario.

3.1.3.1.3 Potential Container Rupture in the CWC. Drums stored in the CWC buildings are banded four per pallet and are stacked up to three tiers high in rows that are one pallet wide. The rows are separated by inspection aisles that are at least 76.2 cm (30 in.) wide.

WHC-EP-0063-4 requires that all mixed waste accepted for storage in the CWC will be packaged in DOT 17C or 17H containers. These containers comply with 49 CFR 178, "Shipping Container Specification," *Code of Federal Regulations*, as amended, regulatory requirements for Type A packaging. 49 CFR 178 requires containers to withstand a 1.2 m (4 ft) free-fall drop test. The height of the drum and pallet package is 100.3 cm (39.5 in.). Therefore, in the event of an accident causing a drum stack to fall to a hard, unyielding surface, it would be expected that containers in the second tier would survive the fall and that containers in the third tier would be vulnerable to damage.

3.1.3.1.4 Dose Calculations. GENII software (Napier et. al 1988) was used to perform the radiation dose calculations. The GENII code is a Hanford Environmental Dose Overview Panel (HEDOP) approved code that has been validated and verified according to WHC-CM-4-2, *Quality Assurance*. Inputs to GENII used in the analysis of onsite and offsite doses are discussed in this subsection.

GENII requires the user to input the receptor location and the weather data applicable to the site being analyzed. The weather data used in this analysis were based on standard Hanford Site environmental documentation and joint-frequency data for the 200 Area were used.

Table 3-5 provides a listing of the accidents selected for full analysis and the corresponding onsite and offsite receptors. The location of the onsite receptor for all accident scenarios, except the SAM/AMW is the 272-WA Building. The onsite receptor for the SAM/AMW scenarios is located at the Plutonium Finishing Plant (PFP). Note that the atmospheric dispersion coefficient factors (χ/Q') values for the accident scenarios involving the SAM/AMW modules were calculated with the GXQ code found in the *GXQ Program User's Guide* (WHC 1993c). The GXQ code has been validated and verified by *GXQ Program Validation and Verification* (WHC 1993d), for use at Hanford according to the procedures outlined in WHC-CM-4-2.

Table 3-5. Individual Receptor Locations.

Accident scenario	Individual receptor location	
	Onsite	Offsite
Truck impact into building — no fire	300 m south	12.2 km west
Truck impact into building — fire	300 m south	12.2 km west
Truck impact away from building — fire	300 m south	12.2 km west
Seismic event	300 m south	12.2 km west
Water-sodium reaction (AMW modules)	440 m east-southeast	17.0 km south-southwest
Water-sodium reaction (SAM modules)	580 m northeast	
Toxicological release (other than AMW modules)	300 m south	12.2 km west

In order to calculate the worst-case consequence, the analyses assumed that the receptor was in the centerline of the plume for the duration of its passage. It was assumed that exposure was from submersion and inhalation.

3.1.3.1.5 Radiological Release Fractions. Radiological release fractions from mechanical and fire release mechanisms are considered in this section.

Mechanical Release — A mechanical release occurs when containers are ruptured by a direct vehicle impact, or a fall of more than 1.2 m (4 ft). A significant release is not easily realized because of the nature of the contained materials (e.g., surface and/or internally contaminated paper, plastic, metals, and rubber) and the packaging (multiple wraps of plastic). There is no data for the mechanical release of contaminants from materials

representative of the typical solid wastes stored in the CWC; however, Sutter presents release fractions for free fall spills of powders (using UO_2) in *Aerosols Generated by Free Fall Spills of Powders and Solutions in Static Air*, NUREG/CR-2139 (Sutter 1981). According to Table 6 of Sutter's document, the average fractional release from a UO_2 spill falling 1 m is 5.0×10^{-5} .

Because falling powder is not truly representative of a release to air from a breached container, a reduction factor of 0.5 (based on engineering judgement) is used to account for the more fixed form of the radiological contamination in the CWC waste packages. The resultant value used for all mechanical release scenarios is 2.5×10^{-5} .

Fire Release — A fire release occurs when the contents of a breached waste package are ignited. The package contents could be ignited by a vehicle accident and accompanying fire.

For the accident scenarios involving a fire release, with the exception of any scenario involving the LFMW modules, the NUREG-1320, *Nuclear Fuel Cycle Facility Accident Analysis Handbook* (NUREG 1988) recommended value of 5.3×10^{-4} is the base release fraction. This value is decreased to 2.7×10^{-4} , based on an estimated 50% of the drum contents being exposed to the fire (WHC 1993b).

The NUREG-1320 suggested release fraction of 3.0×10^{-3} for volatile contaminated waste is used for scenarios involving the LFMW modules because of the greater volatility of the waste.

The accident scenarios involving a fire in a building (excludes the SAM/AMW storage modules) assumes the fire does not propagate to unexposed waste (i.e., material in sealed containers will not contribute to a release). This assumption is based on engineering judgement and is not a definitive statement on fire propagation. A fire hazards analysis (FHA) is being performed for the CWC and the results of the FHA will provide a basis for assumptions regarding fire propagation for a given accident scenario. Once the FHA is complete for the CWC, the accident scenarios will be updated to incorporate the results.

3.1.3.1.6 Transuranic Limit Concentrations. The GENII calculations (SAR-049, Appendix D) show that 0.28 PE-Ci of respirable ^{239}Pu released at ground level from the CWC results in a limiting offsite dose-consequence of 0.5 rem. The calculations also show that 0.045 PE-Ci of respirable ^{239}Pu released from the CWC produces a limiting onsite dose of 5.0 rem. In addition, winter ingestion runs were made (ECN 173288, Bonner 1993a) that confirm the onsite limiting criteria of 5.0 rem for ^{239}Pu .

The dose values in this section represent one-tenth of the dose to the maximum organ. As shown in Appendix D of SAR-049, the maximum organ dose is limiting for ^{239}Pu because it is greater than ten times the EDE value. However, to allow for comparison to evaluation guidelines that do not encompass organ doses, it is conservative to use one-tenth of the maximum organ dose.

The limiting dose-consequences of 0.5 rem offsite and 5.0 rem onsite were the basis for the CWC being maintained as a low-hazard class facility in SAR-049. It must be noted that the hazard classification criteria used in SAR-049 have been replaced by the hazard categorization criteria found in DOE-STD-1027-92. According to the DOE-STD-1027-92, the CWC is a Hazard Category 2 Facility (Section 3.1.1). However, the safety class criteria (Section 3.1.3.1.8) used to identify safety class systems, structures, and components uses the same conservative consequence values as the low-hazard class criteria of 0.5 rem offsite and 5.0 rem onsite. The limiting 0.5 rem offsite consequence is used to determine the Safety Class 1 features and the limiting 5.0 rem onsite consequence is used to determine Safety Class 3 features. ISB-007 will reference safety class criteria only and the hazard classification criteria used in SAR-049 will be corrected in the next comprehensive revision of the CWC safety authorization basis.

An accident accompanied by a fire, resulting in a release 0.045 PE-Ci of respirable plutonium from the CWC, produces an onsite dose of 5.0 rem, which is the Safety Class 3 limit for onsite individuals. This indicates that 169.8 PE-Ci needs to be involved before the Safety Class 3 limit is exceeded. The calculation is

$$\frac{\text{GENII limiting onsite dose consequence}}{\text{release fraction for burning of contaminated waste}} = \frac{0.045 \text{ PE-Ci}}{2.7 \times 10^{-4}} = 169.8 \text{ PE-Ci.}$$

Compliance with the Safety Class 3 limits is ensured by establishing facility limits for the inventory of materials stored at the CWC. These inventory limits are calculated and established so that the dose-consequences of credible releases are always within the Safety Class 3 criteria. The facility limits for the CWC are based on the dose-consequences of the worst-case credible release identified and analyzed in the current authorization basis for the CWC.

The CWC maximum allowable inventory, combined with the limitation on truck inventories, is 169.8 PE-Ci total for the 2401-W Building, any of the individual 2402-W Buildings, or any quadrant of the 2403-W Buildings. In terms of gram quantities of TRU, the following conversion is used

$$\frac{(169.8 \text{ PE-Ci})}{(1.75 \times 10^{-1} \text{ PE-Ci/g})} = 970 \text{ g TRU.}$$

3.1.3.1.7 Low-Level Waste Concentration. The concept of ensuring that all dose-consequences are maintained within the Safety Class 3 criteria can be used to allow greater than A_2 quantities of LLW into the CWC. The total quantity of TRU, and LLW in excess of A_2 quantities, is administratively maintained with a curie-equivalency factor. The equivalency presented here between TRU and LLW is specific to the CWC and is based on the worst-case credible release (i.e., a truck impact into a building with a fire release,

Section 3.1.3.2.1). These factors are obtained from the analysis in SAR-049 (ECN 173251, Bonner 1993b). The CWC DE-Ci term is employed to ensure that the equivalency factors remain CWC-specific.

The equivalency factors presented in SAR-049 (ECN 173251) were determined using unit releases calculated by the GENII code with plume meander taken into account. The results of the unit releases were ratioed with the appropriate safety class criteria: onsite, offsite, and environmental impact. For each isotope, the maximum of the three ratio limits represents the most limiting criteria. The maximum limit ratio for a particular isotope may be thought of as the fraction of the safety class criteria reached per curie of that isotope released in an accident. As an example of how limit ratios are calculated, the ^{90}Sr unit releases from Appendix H of ECN 173251 are divided by the appropriate safety class criteria and shown in the following equations. The quantities calculated are the limit ratios for ^{90}Sr .

The onsite EDE is

$$\begin{aligned}\text{limit ratio} &= (7.0 \times 10^{-2} \text{ rem EDE/Ci}) / (5.0 \times 10^0 \text{ rem}) \\ &= 1.4 \times 10^{-2} \text{ Ci}^{-1}.\end{aligned}$$

The onsite maximum organ is

$$\begin{aligned}\text{limit ratio} &= (8.5 \times 10^{-1} \text{ rem EDE/Ci}) / (5.0 \times 10^1 \text{ rem EDE}) \\ &= 1.7 \times 10^{-2} \text{ Ci}^{-1}.\end{aligned}$$

The site boundary winter ingestion is

$$\begin{aligned}\text{limit ratio} &= (4.8 \times 10^{-2} \text{ rem EDE/Ci}) / (5.0 \times 10^{-1} \text{ rem}) \\ &= 9.6 \times 10^{-2} \text{ Ci}^{-1}.\end{aligned}$$

The maximum limit ratio for ^{90}Sr is $9.6 \times 10^{-2} \text{ Ci}^{-1}$ from the site boundary winter ingestion criteria. Therefore, for ^{90}Sr , the winter ingestion criteria is limiting and is used as the basis to determine its equivalency factor.

As opposed to release amount, the maximum limit ratio multiplied by a separate release fraction, defined as curies of isotope released divided by curies of isotope in inventory, puts the maximum limit ratio in terms of total inventory. The release fraction used must be appropriate for both the scenario and the isotope under analysis. Because the scenario forming the basis for the calculations is a fire, the release fraction of 2.7×10^{-4} is used. Therefore, the maximum limit ratio, in terms of total inventory, for ^{90}Sr is $(9.6 \times 10^{-2} \text{ Ci}^{-1}) \times (2.7 \times 10^{-4})$, or 4.3×10^{-3} . However, in the case

of isotopes that are, or could be, gases or volatile solids during the accident, a release fraction of 1.0 is assumed. The release fractions are discussed in SAR-049 (ECN 173251).

The final equivalency factor is calculated by multiplying the facility inventory limit, determined as 169.8 PE-Ci of ^{239}Pu in Section 3.1.3.1.6, by the maximum limit ratio (in terms of total inventory). The facility inventory limit determined in Section 3.1.3.1.6 is, in actuality, the inverse of the maximum limit ratio for ^{239}Pu . Therefore, multiplication by the inventory limit previously calculated converts the maximum limit ratio from a fraction to the equivalent number of ^{239}Pu Ci per curie of the isotope. Because the equivalency factors are specific to the CWC, the factors are termed CWC DE-Ci per curie of the isotope. As stated in Section 3.1.1, CWC DE-Ci are defined as dose consequences equivalent to a curie of ^{239}Pu allowing the final equivalency factor to be stated in units of CWC DE-Ci per curie of isotope.

In practice, the equivalency factors can be multiplied by the amount of each isotope (in Ci) to obtain the equivalent number of CWC DE-Ci. The sum of all the CWC DE-Ci calculated for a particular shipment or building is then compared to the appropriate inventory limits established for the CWC.

The following equation demonstrates how this methodology would be used by converting the contents of one 17H drum with 200 Ci of ^{90}Sr , 2,000 Ci of ^{137}Cs and 30 Ci of ^{239}Pu to an equivalent amount of CWC DE-Ci.

$$200 \text{ Ci } ^{90}\text{Sr} \times 4.3 \times 10^{-3} \frac{\text{CWC DE Ci}}{\text{Ci } ^{90}\text{Sr}} = 8.6 \times 10^{-1} \text{ CWC DE-Ci}$$

$$2,000 \text{ Ci } ^{137}\text{Cs} \times 9.6 \times 10^{-5} \frac{\text{CWC DE Ci}}{\text{Ci } ^{137}\text{Cs}} = 1.9 \times 10^1 \text{ CWC DE-Ci}$$

$$30 \text{ Ci } ^{239}\text{Pu} \times 1.0 \times 10^0 \frac{\text{CWC DE Ci}}{\text{Ci } ^{239}\text{Pu}} = 3.0 \times 10^1 \text{ CWC DE-Ci}$$

$$\text{Total} = 3.1 \times 10^1 \text{ CWC DE-Ci.}$$

The following calculation demonstrates that existing drums containing quantities not greater than the A_2 limits of LLW comprise a small percentage of the allowable limit of 169.8 CWC DE-Ci. For the case of the building and truck, this is conservatively accounted for by a reduction of the facility inventory limit by 5% (8.5 CWC DE-Ci) to 161 CWC DE-Ci. The specific building and truck inventory limits are then calculated from this reduced facility inventory. A similar approach is taken for the LFMW modules and is discussed in Section 6.2.14 of SAR-049. This approach allows LLW less than or equal to A_2 quantities to be omitted from building inventory limits.

In the example calculation below, the maximum number of drums that may potentially be breached in the truck accident scenario is multiplied by the maximum A_2 quantity of ^{60}Co allowed per drum and by the equivalency factor for ^{60}Co (SAR-049, ECN 173251). A check of the result indicates that ^{60}Co is within the 5% margin (8.5 CWC DE-Ci). The calculation for the building and the truck is

$$\begin{aligned} & ^{60}\text{Co} \text{ (36 drums) (7 Ci/drum) } \times (6.3 \times 10^{-4} \text{ CWC DE-Ci/Ci}) \\ & = 1.6 \times 10^{-1} \text{ CWC DE-Ci.} \end{aligned}$$

However, based on the calculation above, a few select isotopes exceed the 5% margin set for the Type A packages. For 15 isotopes, A_2 package limits are not listed in 49 CFR 173. Additionally, four isotopes were allowed unlimited A_2 quantities in a package. For all of these isotopes, a separate CWC package limit is set to ensure that the credible release during the truck accident remains within the 5% margin.

For containers falling within the package limits set, the 5% margin on the facility inventory limit is not exceeded by any isotope. Packages that exceed the A_2 or the CWC package limits must be counted in the CWC DE-Ci building inventory or have a safety analysis to exempt them.

3.1.3.1.8 Comparison to Guidelines. The evaluation guidelines used in this document are two-fold: the safety classification criteria in WHC-CM-1-3, MRP 5.46 "Safety Classification of Systems, Components, and Structures" are used to identify safety class and safety significant features, and the risk-acceptance guidelines in WHC-CM-4-46 are used to demonstrate risk acceptability.

The accident analysis for the specification of safety class or safety significant features requires that the accident consequences be shown without mitigation. Then, if the consequences are above the criteria, credit is taken for each successive feature until the consequences are shown to drop below the criteria. Those feature(s) taken credit for are then designated as either safety significant or safety class depending on the calculated accident consequences.

The concept of safety class and safety significant features is used to establish the inventory limits of the CWC. These inventory limits, based on the safety classification criteria in MRP 5.46, ensure that the greatest calculated accident consequences shown in this document do not exceed those criteria. Controlling inventories by this method allows the CWC to avoid the need for safety class and safety significant features, except for the inventory control system.

The risk associated with an accident scenario is defined as the combination of the frequency of the accident and its consequences. The results of that combination, taking credit for all mitigating features present during the accident, are compared to the risk-acceptance guidelines in

WHC-CM-4-46 (Chapter 7, p. 4). The guidelines are shown in Table 3-6. Those accident sequences that fall below the guidelines are considered acceptable risks in the operation of the CWC.

Table 3-6. Radiological Risk-Acceptance Guidelines*

Frequency category	Frequency range	Effective dose equivalent (rem)	Organ dose equivalent for lens of eye (rem)	Organ dose equivalent for all other organs (rem)
Offsite guidelines				
Anticipated	$1 - 10^{-2}$	0.01 - 0.5	0.03 - 1.5	0.1 - 5
Unlikely	$10^{-2} - 10^{-4}$	0.5 - 4	1.5 - 12	5 - 40
Extremely unlikely	$10^{-4} - 10^{-6}$	4 - 25	12 - 75	40 - 250
Onsite guidelines				
Anticipated	0.1 to 10^{-2}	1 to 5	3 - 15	10 - 50
Unlikely	10^{-2} to 10^{-4}	5 - 25	15 - 75	50 - 250
Extremely unlikely	10^{-4} to 10^{-6}	25 - 100	75 - 300	250 - 1,000

*Excerpted from WHC-CM-4-46, Rev. 3, Section 7, p. 4.

The risk and safety classification analyses in the accident analysis help to define the safety envelope of the CWC. The safety envelope is the combination of information relating to the management of hazards at the CWC including design, engineered safety features, and administrative controls. Risk analysis especially shows the interaction of all of the mitigating elements with the accident scenario and demonstrates that those elements are sufficient for safe operation of the CWC.

3.1.3.2 Operational Accidents.

3.1.3.2.1 Truck Impact Into Building. This section analyzes a vehicle impact to the waste drums stored in the buildings (2401-W, 2402-W series, and 2403-W series).

Scenario — The scenario model in SAR-049 consists of several conservative assumptions. First, it is assumed that the vehicle is traveling at a velocity great enough to rupture the outer structure of the building and directly impact the drums stored inside. Next, it is assumed that the vehicle involved is a truck. Third, it is assumed that the truck impacts three rows of pallets. And finally, it is assumed that the drums directly impacted by the truck, drums falling greater than 1.2 m (4 ft) onto a hard surface (Section 3.1.3.3 for a detailed analysis of drum-falling scenario), and drums impacted by other drums falling greater than 1.2 m (4 ft) are all breached.

Using these assumptions, the number of drums ruptured can be conservatively estimated. Two drums on each of three bottom tier pallets are directly impacted by the truck, resulting in 6 drums breached from direct impact. Only the top-tier drums, of all drums falling as a result of impact, have the potential to fall greater than 1.2 m (4 ft). Credit cannot be taken for the truck acting as a mitigator (preventing the drums from falling all the way to the floor) and thus it is assumed that all top-tier drums are breached. This yields 12 drums breached from falling and a subtotal of 18 breached drums. The truck could be transporting an additional 18 drums at the time of the impact. The possibility exists that falling drums could crush some of the drums on the truck, and thus it is conservatively assumed that an additional 18 drums on the truck are breached. The total number of breached drums is therefore 36: 18 stored drums + 18 drums on the truck.

Source Term — The general equation for determination of the source term is

$$\text{Source Term} = (\text{Number of Breached Drums}) \times (\text{Pu loading/drum}) \times (\text{Release Fraction}).$$

Assuming the 36 drums breached in the truck accident contain the average quantity of 25 g (4.38 PE-Ci) of TRU (Section 3.1.3.1.2) and a release fraction of 2.5×10^{-5} (Section 3.1.3.1.5), the source term is

$$\text{Source Term} = (36 \text{ Drums}) \times (4.38 \text{ PE-Ci/Drum}) \times (2.5 \times 10^{-5}) = 3.94 \times 10^{-3} \text{ PE-Ci}.$$

Consequence — The radiological consequences of airborne releases of radiological materials are calculated using the following general dose-consequence equation.

$$\text{Dose (rem)} = \text{Source Term (PE-Ci)} \times \text{UR (rem/PE-Ci)}.$$

where

$$\begin{aligned} \text{UR} = \text{Unit Release} &= (5.0 \text{ rem}/0.045 \text{ PE-Ci}) \text{ Onsite} \\ &= (0.5 \text{ rem}/0.28 \text{ PE-Ci}) \text{ Offsite.} \end{aligned}$$

The unit release values are taken from Appendix D, SAR-049.

Applying the dose-consequence equation and using the source term calculated above and the appropriate unit release values, the onsite and offsite radiological consequences for a truck accident are

$$\begin{aligned} \text{Onsite} &= 4.38 \times 10^{-1} \text{ rem} \\ \text{Offsite} &= 7.04 \times 10^{-3} \text{ rem.} \end{aligned}$$

Frequency — The initiating event for this accident is a truck impacting the waste containers stored in one of the buildings in the CWC. The fault tree (SAR-049) for this initiator is based on the driver becoming incapacitated (e.g., heart attack), losing control of the truck, and allowing it to impact a building. The fault tree estimated frequency of a truck impact is $1.0 \times 10^{-5}/\text{yr}$.

Comparison to Guidelines — The onsite evaluation guideline to determine safety significant features is 5.0 rem EDE. No truck accident scenario exceeded this guideline.

The offsite evaluation guideline to determine safety class features is 0.5 rem EDE. No truck accident scenario exceeded this guideline.

The risk-acceptance guidelines in WHC-CM-4-46 indicate a maximum acceptable onsite dose of 4.5×10^1 rem EDE for an accident with a frequency of $1.0 \times 10^{-5}/\text{yr}$. The onsite dose-consequence of the truck accident is 4.38×10^{-1} rem. Therefore, the truck accident is below the onsite risk-acceptance guidelines.

The risk-acceptance guidelines in WHC-CM-4-46 indicate a maximum acceptable offsite dose of 9.0×10^0 rem EDE for an accident with a frequency of $1.0 \times 10^{-5}/\text{yr}$. The offsite dose-consequence of the truck accident is 7.04×10^{-3} rem. Therefore, the truck accident is below the offsite risk-acceptance guidelines.

3.1.3.2.2 Truck Accident With Fire. The truck accident and accompanying fire is identical to the truck accident except for the assumption that a fire is initiated because of a fuel spill from the truck.

Scenario — The analysis in SAR-049 of the truck accident scenario assumes that 36 drums (18 stored drums + 18 drums on the truck) are breached in the truck accident. It is further assumed that the truck impact results in a fire because of a fuel spill from the truck and that 50% of the contents of all 36 drums are impacted by the fire.

As discussed previously, in Section 3.1.3.1.5, it is assumed the fire does not propagate to unexposed waste. The FHA will provide a basis for fire propagation assumptions. Once the FHA for the CWC is complete, this scenario will be updated accordingly.

Source Term — Applying the general source-term equation and using values of 4.38 PE-Ci/drum for the plutonium loading and 2.7×10^{-4} for the release fraction, the source term for the truck fire can be determined as

$$\text{Source term} = (36 \text{ Drums}) \times (4.38 \text{ PE-Ci/Drum}) \times (2.7 \times 10^{-4}) = 4.26 \times 10^{-2} \text{ PE-Ci}.$$

Consequence — Applying the dose-consequence equation and using the source term calculated above and the appropriate unit release values, the onsite and offsite radiological consequences for a truck fire accident are

$$\begin{aligned}\text{Onsite} &= 4.73 \times 10^0 \text{ rem} \\ \text{Offsite} &= 7.60 \times 10^{-2} \text{ rem.}\end{aligned}$$

Frequency — The initiating event of this accident is a truck impacting the waste containers stored in one of the CWC areas. The fault tree in SAR-049, Appendix C, for this initiator is based on the driver becoming incapacitated (e.g., heart attack), losing control of the truck, allowing it to impact a building, and a fire initiating from the resulting fuel spill. The fault tree estimate of the frequency of a truck accident and fire is $1.0 \times 10^{-6}/\text{yr}$.

Comparison to Guidelines — The onsite evaluation guideline to determine safety significant features is 5.0 rem EDE. No truck fire accident scenario exceeded this guideline.

The offsite evaluation guideline to determine safety class features is 0.5 rem EDE. No truck fire accident scenario exceeded this guideline.

The risk-acceptance guidelines in WHC-CM-4-46 indicate a maximum acceptable onsite dose of 1.0×10^2 rem EDE for an accident with a frequency of $1.0 \times 10^{-6}/\text{yr}$. The onsite dose-consequence of the truck fire accident is 4.73×10^0 rem. Therefore, the truck fire accident is below the onsite risk-acceptance guidelines.

The risk-acceptance guidelines in WHC-CM-4-46 indicate a maximum acceptable offsite dose of 2.5×10^1 rem EDE for an accident with a frequency of $1.0 \times 10^{-6}/\text{yr}$. The offsite dose-consequence of the truck fire accident is 7.60×10^{-2} rem. Therefore, the truck fire accident is below the offsite risk-acceptance guidelines.

3.1.3.2.3 Truck Accident Away From Buildings. This section analyzes a truck accident away from the buildings, but still within the boundary of the CWC.

Scenario — The scenario model in SAR-049 consists of several conservative assumptions. It is assumed that the driver loses control of the truck, it veers off of the CWC paved roads, and onto the soft, sandy road shoulder. It is assumed that the truck undergoes a rollover-type accident, is transporting the maximum allowable inventory (this value is taken from SAR-049 and represents 25% of the allowable inventory of an area within the CWC, which is reserved for shipments, Section 3.1.3.6), and all of the drums are breached in the accident. It is assumed that a fire is initiated as a result of a fuel spill and that all of the drums are involved in the fire.

Source Term — The source term for the truck accident away from the building can be determined by multiplying the truck inventory limit by the fire release fraction. Therefore the source term is

$$\text{Source Term} = (40 \text{ PE-Ci}) \times (2.7 \times 10^{-4}) = 1.08 \times 10^{-2} \text{ PE-Ci.}$$

Consequence — Applying the dose-consequence equation with the source term calculated above and the appropriate unit release values, the onsite and offsite radiological consequences for a truck accident away from the buildings are

$$\begin{aligned}\text{Onsite} &= 1.20 \times 10^0 \text{ rem} \\ \text{Offsite} &= 1.93 \times 10^{-2} \text{ rem.}\end{aligned}$$

Frequency — The initiating event of this accident is a truck rollover that results in breached drums. The fault tree in SAR-049, Appendix C, for this initiator is based on the driver losing control of the truck, thereby allowing it to rollover and initiate a fire from a fuel spill. The fault tree estimate for the frequency of this accident is $1.0 \times 10^{-6}/\text{yr}$.

Comparison to Guidelines — The onsite evaluation guideline to determine safety significant features is 5.0 rem EDE. No truck accident scenario exceeds this guideline.

The offsite evaluation guideline to determine safety class features is 0.5 rem EDE. No truck accident scenario exceeds this guideline.

The risk-acceptance guidelines in WHC-CM-4-46 indicate a maximum acceptable onsite dose of 1.0×10^2 rem EDE for an accident with a frequency of $1.0 \times 10^{-6}/\text{yr}$. The onsite dose-consequence for the scenario of the truck accident away from the buildings is 1.20×10^0 rem. Therefore, this truck accident scenario is below the onsite risk-acceptance guidelines.

The risk-acceptance guidelines in WHC-CM-4-46 indicate a maximum acceptable offsite dose of 2.5×10^1 rem EDE for an accident with a frequency of $1.0 \times 10^{-6}/\text{yr}$. The offsite dose-consequence for the scenario of the truck accident away from the buildings is 1.93×10^{-2} rem. Therefore, the truck accident away from the buildings is below the offsite risk-acceptance guidelines.

3.1.3.3 Natural Phenomena Events.

3.1.3.3.1 Design-basis earthquake. Consequences of a seismic event are closely related to those of the vehicle accident described in Section 3.1.3.2.1. The vehicle accident concerned individual buildings and the onsite dose-consequences. In a seismic event, it is possible that all of the buildings would be impacted simultaneously.

Scenario — The facilities in the CWC are designed to seismic Zone 2 criteria (UBC 1985). These criteria correspond to ground motions of 0.067 g, with a frequency of occurrence at the Hanford Site of $3.3 \times 10^{-3}/\text{years}$ as described in the *Natural Phenomena Hazards Modeling Project: Seismic Hazard Models for Department of Energy Sites*, UCRL-53582 (Coats and Murray 1984). However, during a design-basis earthquake, even though the basic structural integrity of the facility may remain intact, resultant internal events can still occur, resulting in equipment disruption and falling drums. Therefore, possible consequences within each of the major buildings are investigated for a design-basis earthquake.

As discussed in Section 2.2.7, containers are stacked in rows separated by inspection aisles 76.2 cm (30 in.) in width in CWC buildings and 61 cm (24 in.) wide in the LFMW Modules. The bands around the drums are assumed to remain intact during this event. The width of the inspection aisles will not permit banded drums or boxes to fall to the floor in the interior of the rows. Therefore, only containers located in the periphery rows may be breached.

Containers on pallets in the 2402-W series buildings are stacked 3 tiers high. The containers are separated into 6 rows and each row has a storage capacity of 14 pallets. An additional 8 pallets, 2 tiers high, are stacked near the ends on either side of the entry ramps. Each building has a storage capacity of 1,072 drum-equivalent containers.

In a seismic event, 36 third-tier peripheral pallets (2 rows x 14 pallets/row + 2 end columns x 4 pallets/column) could topple to the floor on the outside of the stacks. An identical number of 36 pallets, plus an additional 8 pallets on the ends around the entry ramps, could fall from the second tier and land just inboard of the fallen third tier. As a result of crush loading from drums strapped together and from other falling containers, it is assumed that all 4 drums on each second and third tier pallet are breached and thus 320 drum-equivalent containers are breached in each 2402-W series building.

In each quadrant of the 3 smaller 2403-W Buildings, containers on pallets are arranged in 11 rows. Each row is 22 pallets long, and the containers on pallets are stacked 3 tiers high. Thus, each of the 3 buildings has the capacity to store 11,616 drum-equivalent containers (11 rows x 22 pallets/row x 4 drums/pallet x 3 tiers x 4 quadrants/building).

In each of the three smaller 2403-W Buildings, 248 top-tier peripheral pallets (4 quadrants x [2 rows x 22 pallets/row + 2 end columns x 9 pallets/column]) could fall to the floor on the outside of the rows. An identical number of 248 pallets could fall from the second tier and land just inboard of the fallen third tier. As a result of crush loading from drums strapped together and from other falling containers, it is assumed that all 4 drums per pallet from the second and third tier are breached. Therefore, 1,984 (4 drums/pallet x [248 second tier pallets + 248 third tier pallets]) drum-container equivalents are breached in each of the smaller 2403-W Buildings.

In each quadrant of the 2403-WD Building, containers on pallets are arranged in 11 rows. Each row is 39 pallets long, and the containers on pallets are stacked 3 tiers high. Therefore, the total building storage capacity is 20,592 drum-container equivalents (11 rows x 39 pallets/row x 4 drums/pallet x 3 tiers x 4 quadrants/building).

In the 2403-WD Building, 384 third-tier peripheral pallets (4 quadrants x [2 rows x 39 pallets/row + 2 end columns x 9 pallets/column]) could fall to the floor on the outside of the rows. An identical number of 384 pallets could fall from the second tier and land just inboard of the fallen third tier. As a result of crush loading from drums strapped together and from other falling containers, it is assumed that all 4 drums per pallet from the

second and third tier are breached and thus 3,072 (4 drums/pallet $\times$ [384 sec tier pallets + 384 third tier pallets]) drum-container equivalents are breached.

Because there are 13 2402-W series Buildings (including the identical 2401-W Building) and 3 smaller 2403-W Buildings, a total of 13,184 containers ([13 2402-W Buildings $\times$ 320 breached containers/building] + [3 smaller 2403-W Buildings $\times$ 1,984 breached containers/building] + [3,072 breached containers in 2403-WD]) could be breached in a seismic event.

Regardless of the number of containers that could potentially be breached by falling, it is conservatively assumed that the entire inventory of the buildings and LFMW modules is involved in the release because of the design-basis earthquake.

Source Term — There are 29 total areas associated with the CWC (the 2401-W Building, 12 2402-W Buildings, and 4 quadrants in each of the 4 2403-W Buildings), and each area is allowed to contain 121 CWC DE-Ci of TRU contaminated waste (Section 3.1.3.6). There are currently 19 LFMW modules, and each is allowed to contain 10.6 CWC DE-Ci of TRU waste (Section 3.1.3.6). For the purpose of accident analysis, these values were converted to Ci of ^{239}Pu . Using the mechanical release fraction of 2.5×10^{-5} , the source-term calculation (SAR-049) is

Source term = Buildings + LFMW

Buildings: (29 Areas) $\times$ (121 PE-Ci/Area) $\times$ (2.5×10^{-5})

LFMW: (19 LFMW modules) $\times$ (10.6 PE-Ci/module) $\times$ (2.5×10^{-5})

Total Source Term = 9.28×10^{-2} PE-Ci.

Consequence — Applying the dose-consequence equation and using the source term calculated above and the appropriate unit release values (the design-basis earthquake has a unique onsite unit release value of 0.63 rem/0.027 PE-Ci as discussed in SAR-049), the onsite and offsite radiological consequences for a seismic event are

Onsite = 2.16×10^0 rem
Offsite = 1.66×10^{-1} rem.

Frequency — The initiating event of an earthquake is credible and the energy released has the greatest potential to cause damage to the waste containers stored at the CWC. For the purposes of comparison to risk-acceptance guidelines, the frequency of the seismic event in the fault-tree analysis (SAR-049, Appendix C) is used. This value is 3.3×10^{-3} /yr and is not the frequency of the accident, but the frequency of the initiating event, and it is used to allow a conservative comparison to risk-acceptance guidelines. The probability of an accident resulting in the consequences calculated above is less than the probability of the initiating event.

Comparison to Guidelines — The onsite evaluation guideline to determine safety significant features is 5.0 rem EDE. The design-basis earthquake scenario does not exceed this guideline.

The offsite evaluation guideline to determine safety class features is 0.5 rem EDE. The design-basis earthquake scenario does not exceed this guideline.

The risk-acceptance guidelines in WHC-CM-4-46 indicate a maximum acceptable onsite dose of 8.0×10^0 rem EDE for an accident with a frequency of 3.3×10^{-5} /year. The onsite dose-consequence of the design-basis earthquake is 2.16×10^0 rem. Therefore, the design-basis earthquake scenario is below the risk-acceptance guidelines.

The risk-acceptance guidelines in WHC-CM-4-46 indicate a maximum acceptable offsite dose of 8.0×10^{-1} rem EDE for an accident with a frequency of 3.3×10^{-5} /yr. The offsite dose-consequence of the design-basis earthquake scenario is 1.66×10^{-1} rem. Therefore, the design-basis earthquake scenario is below the risk-acceptance guidelines.

3.1.3.4 South Alkali Metal/Alkali Metal Waste Storage. The storage of sodium within the CWC involves the possibility of three release mechanisms: a water-sodium reaction, a hydrogen explosion, and a sodium fire. Three deterministic analyses were performed for both the AMW and SAM modules to determine the worst-case consequences associated with the three release mechanisms. The complete analyses are documented in Appendix A. Presented in the following sections is a summary of the water-sodium reaction. The hydrogen explosion and sodium fire are not summarized because they are bounded in risk by the water-sodium mechanisms.

The following analysis, for the purpose of radiological hazard evaluation, is applicable to two sodium inventories: (1) the 4843 Building sodium waste identified in ECN 152558 that is stored in the AMW modules (1 through 4), and (2) the SRE sodium identified in WHC-SD-W312-HC-001. Additional sodium inventory must be evaluated for radiological hazards on a case-by-case basis. The analysis, for the purpose of toxicological hazards evaluation, is applicable to any sodium inventory that does not invalidate the models used. The USQ process (or other similar screening tool) can be used to determine the applicability of this analysis to additional sodium inventories.

The SAM modules are located near the corner of 16th St. and Dayton Ave., ≈540 m South of the CWC and 580 m West of the PFP. The SAM modules only store 208-L (55-gal) drums. The AMW modules are located near the LFMW modules and store packages of various sizes.

3.1.3.4.1 Radiological Hazards. In accordance with the guidelines in DOE-STD-1027-92, the preliminary hazard category of the AMW identified for potential storage in the CWC, based on the total amount of radioactive material present regardless of waste form packaging, is less than Category 3. DOE-STD-1027-92 requires facility segments that contain combinations of radioactive materials to be designated as Category 2 or 3 if the sum of the ratios of the quantity of each material to the Category 2 or 3

threshold exceeds one. Table 3-7 lists each isotope, the total quantity of each isotope in the identified waste streams, and the Category 3 threshold quantity of each isotope (from Table A-1 of DOE-STD-1027-92).

Table 3-7. Hazard Categorization of Potential Central Waste Complex Sodium Waste.

Isotope	Total quantity (Ci)	Category 3 threshold (Ci)
^3H	6.2 E+00	1.0 E+03
^{22}Na	4.04 E-01	2.4 E+02
^{54}Mn	3.8 E-04	Not available
^{60}Co	1.0 E-05	2.8 E+02
^{65}Zn	3.4 E-04	2.4 E+02
^{106}Ru	1.4 E-04	1.0 E+02
^{133}Ba	4.25 E-03	1.1 E+03
^{134}Cs	1.0 E-05	4.2 E+01
^{137}Cs	1.26 E-01	6.0 E+01
^{239}Pu	5.06 E-06	5.2 E-01

The sum of the ratios, using the Category 3 limits and the quantities of each isotope listed in Table 3-7, is $\approx 1 \times 10^{-2}$. Based on this, storage of the sodium waste streams identified for this analysis represents a less than Category 3 facility.

3.1.3.4.2 AMW Modules Water-Sodium Reaction. The following subsection analyzes the water-sodium reaction for the sodium waste stored in modules 1 through 4 (located near the LFMW modules) to determine the worst-case toxicological consequences.

Scenario — It is assumed that firefighters, while fighting a nearby range fire, inadvertently spray water onto a sodium storage module in order to keep it cool. It is then assumed water leaks into the storage module and contacts the sodium. It is then assumed the released hydrogen is ignited, resulting in the rupture of the storage containers and the subsequent exposure of additional sodium to the water.

The governing equation for the generation of NaOH is

Thus, every mole of water added to the sodium generates one mole of NaOH.

Source Term — The AMW sodium inventory is contained in 37 208-L (55-gal) drums, 3 113.5 L (30 gal) drums, one 0.915 m by 2.7 m (3 ft by 9 ft) steel box, 1 hot trap, 1 heat exchanger and 2 small tanks. The hot trap contains 45.4 kg (100 lb) of sodium, the heat exchanger has 227 kg (500 lb), and the tanks have 10.9 kg and 5.4 kg (24 and 12 lb). In total there is 886.6 kg (1,953 lb) of sodium to be stored in the four AMW modules. Because of the unusually shaped packages, it is assumed that no more than 454 kg (1,000 lb) can be fit into any one module.

The highest rate of water delivery would result from firefighters spraying water at a flowrate of 31.5 L/sec (500 gal/min). Theoretically, if all the water contacted the sodium immediately, the entire 454 kg (1,000 lb) inventory could be consumed in 12 sec. However, as a result of the packaging of the material and configuration of the sodium (large pieces of sodium), it is assumed that the entire inventory is consumed in 10 min.

An airborne release fraction of 0.1 is used based on the presence of water contacting the reaction product (NaOH) and the propensity of the reaction to agglomerate. Furthermore, unreacted sodium will immediately deposit large amounts of NaOH — solidified and in solution — inside and surrounding the AMW module. The total amount of sodium made airborne is 7.8×10^7 and is calculated as

$$\begin{aligned}\text{Amount of sodium consumed} &= 1,000 \text{ lb} = 2.0 \times 10^4 \text{ Na} \\ \text{Amount of NaOH produced} &= 2.0 \times 10^4 \text{ moles} = 7.8 \times 10^8 \text{ mg} \\ \text{Amount of NaOH made airborne} &= (7.8 \times 10^8 \text{ mg}) \times (0.1) = 7.8 \times 10^7 \text{ mg}.\end{aligned}$$

Consequence — The toxicological consequences of an airborne release of NaOH are calculated by multiplying the source term by the x/Q' value of $4.24 \times 10^{-7} \text{ sec/m}^3$ at 440 m ESE to the 231-Z Building and an offsite x/Q' of $1.06 \times 10^{-10} \text{ sec/m}^3$ at 17,000 m SSW were determined using the GXQ code. The onsite and offsite toxicological consequences for a water-sodium reaction are

$$\begin{aligned}\text{Onsite} &= 3.3 \times 10^1 \text{ mg NaOH/m}^3 \\ \text{Offsite} &= 8.27 \times 10^{-3} \text{ mg NaOH/m}^3.\end{aligned}$$

Frequency — Because of the deterministic nature of this analysis, a frequency was not calculated. At the most stringent risk-acceptance guideline (i.e., a frequency of 1/yr), the event remains within acceptance guidelines. In actuality, it is estimated the frequency of the water-sodium accident approaches the lower bounds of credibility (10^{-6} /yr).

Comparison to Guidelines — The onsite evaluation guideline to determine safety significant features is the ERPG-3 limit for NaOH of 100 mg/m^3 . No water-sodium release mechanism was found to exceed this guideline.

The offsite evaluation guideline to determine safety class features is the ERPG-2 limit for NaOH of 40 mg/m^3 . No water-sodium reaction release mechanism was found to exceed this guideline.

The risk-acceptance guidelines in WHC-CM-4-46 indicate the most stringent onsite limit for NaOH is the ERPG-2 value of 40 mg/m^3 at a frequency of 1/yr. The maximum onsite toxicological consequence of the water-sodium reaction release mechanism is 33 mg/m^3 , which is below the most stringent onsite risk-acceptance guideline.

The risk-acceptance guidelines in WHC-CM-4-46 indicate the most stringent offsite limit for NaOH is the ERPG-1 value of 2 mg/m^3 at a frequency of 1/yr. The maximum offsite toxicological consequence of the water-sodium reaction release mechanism is 8.27×10^{-3} , which is below the most stringent offsite risk-acceptance guideline.

3.1.3.4.3 SAM Modules Water-Sodium Reaction. This section summarizes the analysis of the water-sodium reaction for the SAM Modules located near 16th and Dayton, south of the CWC. These modules store the SRE sodium.

Scenario — The scenario is the same as for the AMW modules.

Source Term — The SRE sodium is contained in 158 208-L (55-gal) drums, with each drums holding $\approx 168 \text{ kg}$ (370 lb) of sodium. Based on the size of the modules, a maximum of 21 drums can be placed inside one module. The water-sodium reaction is assumed to consume the contents of one storage module that totals $3,457.6 \text{ kg}$ (7,770 lb) of sodium. With this increased amount of sodium and the configuration of the sodium, it is assumed to take 20 min to convert all the sodium to sodium hydroxide. A release fraction of 0.1 is assumed, which is consistent with the AMW water-sodium reaction. the total amount of NaOH made airborne is 6.14×10^8 and is calculated as

$$\begin{aligned} \text{Amount of sodium consumed} &= 7,770 \text{ lb} = 1.53 \times 10^5 \text{ moles} \\ \text{Amount of NaOH produced} &= 1.53 \times 10^5 \text{ moles} = 6.14 \times 10^9 \text{ mg} \\ \text{Amount of NaOH made airborne} &= (6.14 \times 10^9 \text{ mg}) * (0.1) = 6.14 \\ &\times 10^8 \text{ mg.} \end{aligned}$$

Consequence — The toxicological consequences of an airborne release of NaOH are calculated by multiplying the source term by the X/Q' . An onsite X/Q' value of $4.63 \times 10^{-8} \text{ s/m}^3$ at 580 m NE to the PFP Facility and an offsite X/Q' value of $5.33 \times 10^{-11} \text{ s/m}^3$ at 17,000 m SSW were determined using the GXQ code. The onsite and offsite toxicological consequences for a water-sodium reaction are

$$\begin{aligned} \text{Onsite} &= 2.8 \times 10^1 \text{ mg NaOH/m}^3 \\ \text{Offsite} &= 3.3 \times 10^{-2} \text{ mg NaOH/m}^3. \end{aligned}$$

Frequency — Because of the deterministic nature of this analysis, a frequency was not calculated. At the most stringent risk-acceptance guideline (i.e., a frequency of 1/yr), the event remains with acceptance guidelines. In actuality, it is estimated the frequency of the water-sodium accident approaches the lower bounds of credibility (10^{-6} /yr).

Comparison to Guidelines — The onsite evaluation guideline to determine safety significant features is the ERPG-3 limit for NaOH of 100 mg/m^3 . No water-sodium reaction release mechanism was found to exceed this guideline.

The offsite evaluation guideline to determine safety class features is the ERPG-2 limit for NaOH of 40 mg/m^3 . No water-sodium reaction release mechanism was found to exceed this guideline.

The risk-acceptance guidelines in WHC-CM-4-46 indicate the most stringent onsite limit for NaOH is the ERPG-2 value of 40 mg/m^3 at a frequency of 1/yr. The maximum onsite toxicological consequence of the water-sodium reaction release mechanism is 28 mg/m^3 , which is below the most stringent onsite risk-acceptance guideline.

The risk-acceptance guidelines in WHC-CM-4-46 indicate the most stringent offsite limit for NaOH is the ERPG-1 value of 2 mg/m^3 at a frequency of 1/yr. The maximum offsite toxicological consequence of the water-sodium reaction release mechanism is $3.3 \times 10^{-2} \text{ mg/m}^3$, which is below the most stringent offsite risk-acceptance guideline.

3.1.3.5 Other Toxicological Hazards. This section analyzes a container rupture event and accompanying fire to determine the worst-case toxicological consequences of an accident occurring within the CWC at a facility other than the AMW modules. The hazardous materials involved (e.g., mercury, cadmium, barium, PCB, and CaClPO_4) are typical constituents in mixed waste containers.

Scenario — The scenario model in SAR-049 consists of several conservative assumptions. It is assumed that a vehicle is traveling at a velocity great enough to rupture the outer structure of the building and directly impact the drums stored inside. It is also assumed that a fire results because of a fuel leak from the truck and that 1 m^3 of waste is exposed to the fire. It is further assumed that typical quantities of hazardous materials are present in the breached drums.

Based on engineering judgement, as discussed in Section 3.1.3.1.5, it is assumed the fire does not propagate to unexposed waste. The FHA being performed for the CWC will provide a basis for fire propagation assumptions. On completion of the FHA this scenario will be appropriately updated.

Source Term — Using the average concentrations given in Table 6-7 of SAR-049, the assumed volume of waste exposed to the fire of 1 m^3 , and an assumed release fraction of 0.5, the mass release of each hazardous constituent is determined as

$$\text{Mass Released} = (\text{Average Concentration}) \times (\text{Exposed Waste Volume}) \times (0.5).$$

The release rate, or source term, is then determined by dividing the mass released by the assumed release duration of 10 min. (600 sec). Therefore, the general source-term equation is

$$\text{Source Term} = (\text{Mass of Hazardous Constituent Released}) \div (600 \text{ sec}).$$

Consequence — The toxicological consequences of an airborne release of each of the selected hazardous constituents are calculated by multiplying the specific source term by the x/Q' . As determined by the GENII code, an onsite x/Q' value of $4.3 \times 10^{-3} \text{ s/m}^3$ and an offsite x/Q' value of $1.9 \times 10^{-5} \text{ s/m}^3$ were used (SAR-049, Appendix D). The onsite and offsite toxicological consequences are found in Table 3-8.

Comparison to Guidelines — The onsite evaluation guideline to determine safety significant features is the individual TLV/time-weighted average (TWA) (threshold level value/TWA) for each of the hazardous materials analyzed. No truck impact and fire scenario was found to exceed this guideline.

The offsite evaluation guideline to determine safety class features is the individual TLV/TWA for each of the hazardous materials analyzed. No truck impact and fire scenario was found to exceed this guideline.

The risk-acceptance guidelines in WHC-CM-4-46 indicate the most stringent onsite limit for each of the hazardous materials analyzed is the TLV/TWA at a frequency of 1/year. The maximum onsite toxicological consequence of the truck impact and fire for each hazardous material is less than the TLV/TWA. Therefore, the maximum onsite consequence for the truck accident and fire is below the most stringent onsite risk-acceptance guideline.

Table 3-8. Hazardous Material Consequences.

Hazardous material	Average exposure (mg/m ³)		TLV (mg/m ³) ^a
	Onsite	Offsite	
Mercury (Hg)	4.48 E-06	1.98 E-08	5.00 E-02
Cadmium (Cd)	4.48 E-06	1.98 E-08	1.00 E-02
Barium (Ba)	4.48 E-06	1.98 E-08	5.00 E-01
PCB	2.67 E-03	1.18 E-05	5.00 E+00
CaClPO ₄ ^b	4.26 E-04	1.88 E-06	2.00 E+00

^aValues given are as follows: for PCB, the IDLH (immediately dangerous to life and health) is given; for the remaining materials, the TLV/TWA value is given in ACGIH (1989) and Sax and Lewis (1989).

^bLimits are based on CaO, a combustion product in air for CaClPO₄.

The risk-acceptance guidelines in WHC-CM-4-46 indicate the most stringent offsite limit for each of the hazardous materials analyzed is the TLV/TWA at a frequency of 1/year. The maximum offsite toxicological consequence of the truck accident and fire for each hazardous material is less than the TLV/TWA. Therefore, the maximum offsite consequence for the truck accident and fire is below the most stringent offsite risk-acceptance guideline.

3.1.3.6 Inventory Limit Analysis. Based on restricted radioactive material inventories in the buildings and administrative controls over transported containers, the operating principle for the CWC ensures that the facility review and authorization level is within Safety Class 3 criteria. Essentially, the radioactive (predominantly TRU) waste inventories in each building or shipment are restricted so that the credible involvement of the entire building or shipment will not exceed the dose-consequence limits for a Safety Class 3 facility. The limits were derived conservatively by relating the safety class criteria for onsite and offsite dose-consequences to the product of the source times the fractional release values.

It was demonstrated in Section 3.1.3.1.6 that 169.8 PE-Ci needs to be involved in an accident involving a fire release before the Safety Class 3 limit is reached for onsite individuals. The calculation is

$$\frac{\text{GENII limiting onsite dose-consequence}}{\text{release fraction for burning of contaminated waste}} = \frac{0.045 \text{ PE-Ci}}{2.7 \times 10^{-4}} = 169.8 \text{ PE-Ci.}$$

An accident, such as a truck impact into a building and fire, in the CWC could involve quantities on the order of 169.8 PE-Ci. To avoid exceeding the onsite dose-consequence limit, accumulations of radiological inventories >169.8 PE-Ci, in multiple or single containers on a truck, in the buildings, or a truck and building combination (as in an accident), are to be administratively prohibited. Because the consequences of the truck accident depend on both the truck and building TRU inventories, a concept of an accident inventory will be adopted. This allows the combined inventory of the truck and building to be restricted to avoid exceeding the onsite and offsite safety class limits.

From the preceding calculation, the limiting inventory is 169.8 PE-Ci. However, in Section 3.1.3.1.7, the concept of CWC DE-Ci was introduced to allow comparison of both TRU and non-TRU radioisotopes. Further, it was noted that the A_2 and LSA quantities of LLW comprised a small percentage of the allowable limit of 169.8 CWC DE-Ci (49 CFR 173). To conservatively account for this LLW at the CWC, the facility inventory is reduced by 5% to 161 CWC DE-Ci. In order to allow adequate inventory capacity in the buildings and for a shipment to the buildings, the limiting inventory will be divided to allow 75% (of the total limit) in the building and 25% for the shipment. Using the reduced facility inventory value, the allowable accident inventory will consist of 121 CWC DE-Ci in each building and 40 CWC DE-Ci for any shipment.

WHC-EP-0063-4 limits the contents of individual containers to 200 g of plutonium. Section 3.1.3.1.2 demonstrates that the plutonium-equivalent activity is 0.175 PE-Ci/g. The calculations assume ^{239}Pu is in the oxide form. A value of 0.175 PE Ci/g is used, representing 12% (nominal) ^{240}Pu , 20-year aged waste as used in the *Engineering Safety Study for Project W-112*, WHC-SD-W112-ES-002 and the *Hazard Classification for the Enhanced Radioactive and Mixed-Waste Storage, Phase V, Project W-112*, WHC-SD-W112-ES-002 (WHC 1991a, 1991b). This value is conservative, because some of the TRU waste stream will be newer material having less activity. However, the use of this data is necessary because the newly generated waste will probably be generated by decontamination work involving aged plutonium. Therefore, the limiting activity per container is

$$(200 \text{ g Pu/container}) \times (0.175 \text{ PE-Ci/g}) = 35.0 \text{ PE-Ci/container.}$$

Volatile or low-flashpoint waste could also be involved in a fire. Applying the release fraction for volatile contaminated waste, 3.0×10^{-3} , the onsite Safety Class 3 limit is

$$\begin{array}{l} \text{GENII limiting onsite} \\ \text{dose-consequence} \\ \text{release fraction} \\ \text{for burning of} \\ \text{contaminated liquid} \\ \text{waste} \end{array} = \frac{0.045 \text{ PE-Ci}}{3.0 \times 10^{-3}} = 15.0 \text{ PE-Ci.}$$

Applying the CWC DE-Ci concept and accounting for LLW (5% reduction) stored in the LFMW modules (as was done previously for the buildings), results in an inventory limit of 14.25 CWC DE-Ci ($15.0 \text{ PE-Ci} \times 0.95$) for each LFMW module.

Applying the inventory limit fraction developed for the buildings (stored waste and transported waste account for 75% and 25% of total inventory limit, respectively), results in a limit of 10.6 CWC DE-Ci for each LFMW module and 3.5 CWC DE-Ci for a shipment to the LFMW modules.

The A_2 package limits and the CWC package limits set for the other buildings generally apply to the LFMW modules. However, it is noted that the 5% margin for the buildings is 8.5 CWC DE-Ci, whereas the 5% margin for the LFMW modules is only 0.75 CWC DE-Ci. Consequently, a scan of the CWC DE-Ci equivalency factors in SAR-049 (ECN 173251) reveals that some of the isotopes exceed the 5% margin for the LFMW modules. To amend this, separate CWC LFMW package limits are required for those isotopes if the container is destined for storage at the LFMW modules. Refer to SAR-049 (ECN 173251), for a listing of the A_2 package limits and all of the special CWC package limits that have been set.

If a Type A package exceeds any of the three following conditions, the package must be accounted for within the LFMW module inventory limits presented in the OSR section (Section 3.2.2).

1. Package exceeds A_2 limits.
2. Package exceed CWC or LFMW package limits.
3. LFMW module in which it is to be stored exceeds 36* packages.

For packages meeting the third condition, a simple set factor may be added to the LFMW module inventory for comparison to the limit. This factor is attained by dividing 0.75 CWC DE-Ci/36 drums giving 0.02 CWC DE-Ci/drum.

Based on the CWC DE-Ci inventory control system described above, the CWC will accept waste containers that contain the following.

- A_2 quantities as defined in 40 CFR 173 and do not exceed any specific CWC package limit set for an individual isotope. The CWC Package Limits for isotopes are located in SAR-049 (ECN 173251).
- Excess of A_2 quantities or exceed a specific CWC package limit for an individual isotope but will not result in exceeding any CWC building inventory limit. A CWC DE-Ci value will be derived for each container and will be used to confirm compliance with the inventory limits listed in Table 3-1.
- Excess of A_2 quantities or exceed a specific CWC package limit for an individual isotope, on the basis of an approved safety analysis that demonstrates that the acceptance of such containers will not exceed the safety basis of the CWC.

3.2 HAZARD CONTROLS

3.2.1 Safety Structures, Systems, and Components

Section 1300.3, "Safety Class Criteria," of DOE Order 6430.1A, *General Design Criteria*, defines safety class structures, systems, and components as those whose failure could adversely affect the environment or the health and safety of the public. Based on this definition, all items can be classified as either safety class or nonsafety class. Accordingly, the purpose of safety classification is to ensure that facility structures, systems, and components are designed, fabricated, erected, and tested to standards and quality commensurate with the associated hazards and potential consequences. As derived from WHC-CM-1-3, MRP 5.46, the WHC safety class concept addresses the potential consequences to the public, onsite and facility personnel and the environment. Accordingly, the following four safety classes have been established.

- Safety Class 1 — Addresses the environment and the health and safety of the public, essentially equivalent to "safety class" as defined by Section 1300-3, "Safety Class Criteria," of DOE Order 6430.1A.

*The package limits were set based only 36 drums rupturing and burning in the truck crash accident scenario.

- Safety Class 2 — Addresses onsite worker health and safety and the environment.
- Safety Class 3 — Addresses the health and safety of facility personnel and radioactive, chemical, or thermal releases to the environment.
- Nonsafety Class 4 — No significant importance to health, safety, or environmental protection.

Criteria for establishing the safety classification of structures, systems, and components are documented in WHC-CM-1-3 MRP 5.46.

There are no Safety Class 1 or Safety Class 2 systems within the CWC. The safety class equipment within the CWC is summarized in WHC-SD-WM-SEL-0009, Rev. 3., *Central Waste Complex Safety Equipment List* (WHC 1994b).

3.2.2 Administrative Controls/Operational Restrictions

DOE Order 5480.22, *Technical Safety Requirements*, is used as a guide to develop the administrative controls and operational restrictions based on the safety analysis for the CWC. This subsection summarizes the existing OSRs, existing operating, maintenance, and surveillance procedures, and the new administrative and operational restrictions.

3.2.2.1 Existing Operational Safety Requirements. The existing OSRs are based on accident analyses contained in SAR-049 and all associated ECNs. This section identifies the existing OSRs regardless of applicability to current operation of the CWC, and provides justification for those that are no longer applicable. Section 3.2.2.3 identifies the new operational restrictions, which supersede all the safety limits and limiting conditions for operation. The sections under this heading describe the control and restrictions that existed before the development of CWC ISB.

3.2.2.1.1 Safety Limits. There are no safety limits based on the accident scenarios identified in Section 6.0 of SAR-049. The following limits were derived from SAR-049:

- 121 CWC DE-Ci within 2401-W Building or each building within the 2402-W series complex
- 121 CWC DE-Ci for each quadrant of the 2403-W Buildings
- 10.6 CWC DE-Ci for an individual LFMW storage module.

Previous building inventory limits are implemented as operational limits. DOE 5480.22 and WHC-CM-4-46, Section 6.0, note that safety limits should be established for process variables with associated passive physical barriers that are required for the facility to function and guard against and uncontrolled release of radioactive materials. Building inventory limits do not meet this criteria; they are not process variables that, if exceeded, cause and accident situation.

3.2.2.1.2 Limiting Control Setting. No limiting control settings for the CWC were developed.

3.2.2.1.3 Limiting Condition for Operation. There are no limiting conditions of operations. There were six limiting conditions in place to support the safety limits. These limiting conditions were separated into two groups of three. The first group applied to facility inventory control and the second applied to waste receipt control. The following limits were previously established but are no longer used. They have been replaced by the operational restrictions described in Section 3.2.2.3.

- Facility Inventory Control

- 115 CWC DE-Ci for the 2401-W Building and each 2402-W series Buildings
- 115 CWC DE-Ci for each quadrant of the 2403-W Buildings
- 9.6 CWC DE-Ci for any LFMW storage module.

- Waste Receipt Control

- 35 PE-Ci per waste container
- 40 CWC DE-Ci on a vehicle delivering a waste shipment (3.5 CWC DE-Ci on a vehicle delivering to the LFMW modules)
- Containers accepted for storage will not exceed specific building or facility inventory limits.

As described in Section 3.2.2.1.1 for the Safety Limits, the above Limiting Conditions of Operation are not necessary. Operational restrictions now describe the building inventory limits.

3.2.2.1.4 Administrative Controls. DOE Order 5480.22, Section 9e(5) notes that administrative controls are the provisions relating to organization and management, procedures, recordkeeping, reviews, and audits necessary to ensure the safe operation of the facility. There are 12 existing administrative controls (several of which have subsections) The administrative controls (and subsections) are listed below in separate groups based on applicability to current operation of the CWC. Justification is provided for those administrative controls no longer applicable.

Applicable Administrative Controls

- Organization
- Nuclear Criticality Safety
- Accident Analysis Source Strength Control.

NonApplicable Administrative Controls

- Facility Support and Reviews (covered under Configuration Controls System, Section 4.1)
 - Westinghouse Hanford Safety
 - Quality Assurance
- Audit Point (covered under Configuration Controls System, Section 4.1)
 - Central Waste Complex Records
 - Records Retention
- Radiation Protection (covered under Institutional Safety Programs, Section 3.2.3)
- Effluent Monitoring and Sampling (covered under Institutional Safety Programs, Section 3.2.3)
- USQ (covered under Configuration Controls System, Section 4.1)
- Compatibility (covered under Institutional Safety Programs, Section 3.2.3)
- Integrity Assessments (covered under Configuration Controls System, Section 4.1)
- Permit Program for Excavation - no accident scenario involving excavation
- Cathodic Protection - CWC has no features requiring cathodic protection.

3.2.2.2 New Administrative and Operational Restrictions. Based on guidance provided in DOE 5480.22, WHC policy on ISB documents, and the hazards and accident analyses presented in Sections 3.1.2 and 3.1.3, the administrative and operational restrictions applicable to the current operation and nuclear safety of the CWC are presented in this subsection.

3.2.2.2.1 Administrative Controls. The applicable existing administrative controls, as listed in Section 3.2.2.1.4, have been regrouped and structured to support the operation and nuclear safety of the CWC.

Organization and Management — Lines of authority, responsibility, and communication will be established and defined for the highest management levels through intermediate levels to, and including, all safety and operating organization positions. These relationships shall be documented and updated, as appropriate, in the form of organization charts, functional descriptions of departmental responsibilities and relationships, and job descriptions for key personnel positions, or in equivalent forms of documentation.

Nuclear Criticality Safety — A program will be established, implemented, and maintained to prevent an accidental criticality during CWC activities in accordance with DOE Order 5480.5 and WHC-CM-4-29, *Nuclear Criticality Safety Manual*.

CWC Operational Safety — A program will be established, implemented, and maintained to ensure that specific assumptions and commitments made in the CWC ISB regarding safe operation of the facility are implemented.

3.2.2.2 Operational Restrictions.

CWC Inventory Control — A program will be established, implemented, and maintained for CWC inventory control. The program will be based on maintaining the total inventory of each CWC facility at values that maintain the CWC as a Hazard Category 3 facility as established in Section 3.1.1. The inventory control system is defined and presented in Section 3.1.6.

3.2.3 Institutional Safety Programs

WHC utilizes the following control manuals to provide additional safety programs for the facility and its personnel:

- WHC-CM-1, *Company Policies and Charters*
- WHC-CM-1-3, *Management Requirements and Procedures*
- WHC-CM-2-15, *Training Administration*
- WHC-CM-4-2, *Quality Assurance*
- WHC-CM-4-3, *Industrial Safety, Vols. 1-3*
- WHC-CM-4-5, *Quality Assurance Instructions*
- WHC-CM-4-11, *ALARA Program*
- WHC-CM-4-40, *Industrial Hygiene*
- WHC-CM-4-41, *Fire Protection Program*
- WHC-CM-4-43, *Emergency Management Procedures*
- WHC-CM-4-44, *Emergency Preparedness Administration*
- WHC-CM-5-34, *Solid Waste Disposal Operations Administration*
- HSCRM-1, *Hanford Site Radiation Control Manual*.

As defined control manuals, the *Hanford Generic Interim Safety Basis - Health, Safety, and Quality Program*, WHC-SD-GN-ISB-30001 (WHC 1994c), identifies WHC programs and requirements that are an integral part of the authorization basis for nuclear facilities and are generic to all WHC-managed facilities.

The Solid Waste Management training program includes training courses covering training requirements for nuclear operators and operations managers.

3.3 SUMMARY

The hazard analysis presented in Section 3.1.2 identified and qualitatively evaluated potential hazards. Based on the results of the hazard analysis, a group of potential accidents was selected for quantitative analysis based on frequency and consequence considerations. The selected group of accidents was analyzed in Section 3.1.3. The WHC risk-acceptance

guidelines established in WHC-CM-4-46 are met in all cases. Safety Class 3 equipment has been identified based on the accident analyses and in accordance with established WHC requirements. Administrative controls/operational restrictions have been developed for the mitigation of potential hazards and implementation of established safety programs. Thus, it is concluded that the risk of continued operation of the CWC is acceptable.

4.0 CONFIGURATION CONTROLS SYSTEM

4.1 CONFIGURATION CONTROL PROCEDURES

DOE-STD-1073-93, *Guide for Operational Configuration Management Program* (DOE 1993), defines configuration management as an integrated management program encompassing design control, document control, and change control. The purpose of the Configuration Management Program is to ensure that the facility's physical configuration conforms with the reviewed and approved design requirements and that facility design requirements are accurately reflected in the facility documentation.

Changes in the design and configuration of the facility are addressed in WHC-CM-6-1, which establishes engineering practices to ensure that uniform methods are in place for all WHC engineering tasks. These practices provide uniform methods for tasks such as design review, configuration control, change control, and engineering documentation preparation. The review and approval requirements for engineering documentation are found in WHC-CM-3-5, *Document Control and Records Management*. In addition, all facility modifications will be evaluated, using ISB-007 as the authorization basis, in accordance with WHC-CM-1-3, MRP 5.12 (see Section 4.2).

Configuration management for the WHC control manuals is addressed in WHC-CM-6-2, *Project Management*, Section 16, "Procedure Document Control." This section of WHC-CM-6-2 provides a method for initiating new procedures and making changes to existing procedures. Personnel performing project management activities may request a new procedure or a revision to an existing procedure. The request is evaluated by Project Administrative Services. Project Administrative Services prepares the new or revised procedure and may request a project engineer to perform a user trial of the draft procedure before it is sent out for review. The affected managers are sent a copy of the procedure for review and comments. The review comments are sent back to Project Administrative services for disposition. As required, Project Administrative Services obtains approval of the procedure from the Manager of the Projects Department, or from the Manager of Project Integration and Support. Project Administrative Services coordinates distribution of the new or revised procedure. In accordance with WHC-CM-1-3, MRP 5.12 (see Section 4.2), using the ISB as the authorization basis, all procedure modifications will be evaluated.

Configuration Management for the plant operating procedures is addressed in WHC-IP-0673. All new and revised operating procedures will be prepared and revised by the CWC Operations support group in accordance with the content of this guide. The review and approval process involves four phases: (1) technical review, (2) user test, (3) acceptance review, and (4) approval and release. The cognizant engineer or the author prepares a required Document Acceptance Review Form and an optional Operating Document Preliminary Review Form to accompany the procedure through the review.

A new or revised plant operating procedure is submitted for technical editing before technical review. The procedure is reviewed by a technically-knowledgeable individual who is not directly involved in the document preparation.

The reviewer lists significant comments, signs, and returns the Operating Document Preliminary Review Form to the author.

A user test is conducted to verify the effectiveness of the new plant operation procedure or revised draft. The user test involves a read through and, in some cases, a walk through. A first-line manager selects testers and observers to review the draft document. New procedures or procedures that have undergone a major revision are reviewed by a minimum of two knowledgeable operators, in addition to user testing.

The author delivers the Document Acceptance Review Form and the document to the Approval Authority for signature after the Acceptance Review Team approves the draft document. A final documented assessment of the operating document is conducted to ensure that it may be followed as intended.

The cognizant engineer and certified operator sign the Document Acceptance Review Form and return it to the author to finalize and submit for release after validation. Documents reviewed in accordance with the Operating Document review process are released via the Operating Document Control System (Facility Documentation). The organization that prepares the document files copies of the Document Acceptance Review Form and the approval document in its document development and historical files. Facility Documentation maintains the record and auditable procedure files.

4.2 UNREVIEWED SAFETY QUESTION PROCEDURES

The subject of USQs is addressed in WHC-CM-1-3, MRP 5.12, and WHC-CM-5-34, Section 1.24, "Unreviewed Safety Questions," provides a procedure specific to the Solid Waste Disposal Operations division. This procedure describes the USQ screening process, evaluation process, review process, records retention, and training requirements for USQ evaluators.

4.3 QUALITY ASSURANCE PROCEDURES

The WHC Quality Assurance Manual, WHC-CM-4-2, contains 19 sections, which are based on the requirements of national standard NQA-1. This manual meets or exceeds all of the requirements of Title 10 of the Code of Federal Regulations (CFR) part 830, *Nuclear Safety Management, Subpart A, General Provisions*, Section 830.12, "Quality Assurance Requirements." 10 CFR 830.120 is the codification of DOE Order 5700.6C.

Guidance for Solid Waste Management Implementation of 10 CFR 830.120 is provided in WHC-CM-5-34, *Solid Waste Disposal Operations Administration*; Section 1.9, "Quality Assurance Program Plan." This plan describes the Quality Assurance program as it relates to operations conducted within solid waste management, including engineering, documentation, training, procurement, inspection, testing, corrective action, and records control. Implementation of this Quality Assurance Program Plan supports the objective of achieving total quality.

5.0 REFERENCES

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- WHC-IP-0673, *Solid Waste Disposal Plant Operating Procedure Writer's Guide*, Westinghouse Hanford Company, Richland, Washington.
- Willis, N. P., 1994, *Hanford Site Solid Waste Acceptance Criteria*, WHC-EP-0063-4, Westinghouse Hanford Company, Richland, Washington.

5.4 WESTINGHOUSE HANFORD COMPANY CONTROLLED MANUALS

- HSCRM-1, *Hanford Site Radiation Control Manual*, Westinghouse Hanford Company, Richland, Washington.
- WHC-CM-1, *Company Policies and Charters*, Westinghouse Hanford Company, Richland, Washington.
- WHC-CM-1-3, *Management Requirements and Procedures*, Westinghouse Hanford Company, Richland, Washington.
- MRP 5.12, "Identifying and Resolving Unreviewed Safety Questions"
- MRP 5.46, "Safety Classification of Systems, Components, and Structures."
- WHC-CM-2-14, *Hazardous Material Packaging and Shipping*, Westinghouse Hanford Company, Richland, Washington.
- WHC-CM-2-15, *Training Administration*, Westinghouse Hanford Company, Richland, Washington.
- WHC-CM-3-5, *Document Control and Records Management*, Westinghouse Hanford Company, Richland, Washington.
- WHC-CM-4-2, *Quality Assurance*, Westinghouse Hanford Company, Richland, Washington.
- WHC-CM-4-3, *Industrial Safety*, Westinghouse Hanford Company, Richland, Washington.

- WHC-CM-4-11, *ALARA Program*, Westinghouse Hanford Company, Richland, Washington.
- WHC-CM-4-29, *Nuclear Criticality Safety*, Westinghouse Hanford Company, Richland, Washington.
- WHC-CM-4-40, *Industrial Hygiene*, Westinghouse Hanford Company, Richland, Washington.
- WHC-CM-4-41, *Fire Protection Program*, Westinghouse Hanford Company, Richland, Washington.
- WHC-CM-4-43, *Emergency Management Procedures*, Westinghouse Hanford Company, Richland, Washington.
- WHC-CM-4-44, *Emergency Preparedness Administration*, Westinghouse Hanford Company, Richland, Washington.
- WHC-CM-4-46, *Nonreactor Facility Safety Analysis*, Westinghouse Hanford Company, Richland, Washington.
- WHC-CM-5-34, *Solid Waste Disposal Operations Administration*, Westinghouse Hanford Company, Richland, Washington.
- WHC-CM-6-1, *Standard Engineering Practices*, Westinghouse Hanford Company, Richland, Washington.
- WHC-CM-6-2, *Project Management*, Westinghouse Hanford Company, Richland, Washington.
- WHC-CM-7-5, *Environmental Compliance*, Westinghouse Hanford Company, Richland, Washington.

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APPENDIX A

**ACCIDENT ANALYSIS FOR THE STORAGE OF METALLIC
SODIUM IN THE CENTRAL WASTE COMPLEX**

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APPENDIX A

ACCIDENT ANALYSIS FOR THE STORAGE OF METALLIC
SODIUM IN THE CENTRAL WASTE COMPLEX

A1.0 INTRODUCTION

This accident analysis applies to the storage of any metallic sodium within the Central Waste Complex (CWC), including the 4843 Building sodium which will be stored in Alkali Metal Waste (AMW) storage modules near the Low-Flashpoint Mixed Waste (LFMW) modules and the SRE sodium which will be stored in Alkali Metal (AM) storage modules located near the corner of 16th and Dayton.

Several accident analyses exist regarding the storage of metallic sodium at the CWC (Medsker 1992a and b; 1993; 1994a and b; and WHC 1992; 1993a and b). However, only the latest analyses (Medsker 1994a and b) are used herein as the baseline, with modifications due to the availability of new information.

The distances and directions used to determine the offsite receptor locations are those used for the CWC in past analyses (WHC 1992) (WHC 1993a and b) (Medsker 1994a and b). The distances and directions used to determine the onsite receptor are those corresponding to the distance and direction to the buildings of the Plutonium Finishing Plant (PFP).

This sodium accident analysis supersedes all the previous sodium accident analyses (Medsker 1992a and b; 1993; 1994a and b; and WHC 1992; 1993a and b).

A2.0 SUMMARY

The consequences of the analyzed release mechanisms for the two possible storage configurations are shown below. The maximum onsite consequences calculated are below the onsite safety classification (ERPG-3) of 100 mg/m^3 and the onsite risk acceptance (ERPG-2) of 40 mg/m^3 (at a frequency of 1.0 yr^{-1}). The maximum offsite consequences are below the offsite safety classification (ERPG-2) of 40 mg/m^3 and the offsite risk acceptance (ERPG-1) of 2 mg/m^3 (at a frequency of 1.0 yr^{-1}).

Release mechanism	Storage configuration	Maximum onsite consequences (mg/m ³ NaOH)	Maximum offsite consequences (mg/m ³ NaOH)
Water-Sodium	4843 Sodium	33	8.3×10^{-3}
Water-Sodium	SRE Sodium	27	3.1×10^{-2}
H ₂ Explosion	4843 Sodium	0.094	3.0×10^{-5}
H ₂ Explosion	SRE Sodium	0.11	7.0×10^{-5}
Sodium Fire	4843 Sodium	7.5	2.1×10^{-3}
Sodium Fire	SRE Sodium	1.3	1.1×10^{-3}

A3.0 ANALYSIS

This analysis is separated into radiological impacts and toxicological impacts.

A3.1 SOURCE TERM

The 4843 sodium inventory is contained in thirty-seven 55 gal drums, three 30 gal drums, one 3 ft by 9 ft steel box, one hot trap, one heat exchanger (part), and two small tanks. The hot trap, heat exchanger, and tanks are parts from the dismantled Fermi sodium cooled reactor and are especially counted for in this analysis because of their odd shapes. From WHC (1992) Appendix G, Table G-1, the hot trap has 100 lb of sodium, the heat exchanger has 500 lb, and the tanks have 24 and 12 lb respectively. The total 4843 sodium inventory consists of 1,953 lb of sodium.

The SRE sodium inventory is contained in 158 55-gal drums, each containing ≈ 370 lb of metallic sodium. The total SRE sodium inventory consists of about 58,500 lbs of metallic sodium.

A4.0 RADIOLOGICAL IMPACTS

A4.1 4843 BUILDING SODIUM

The radiological impacts associated with the potential accidental releases involving the 4843 Building Sodium are adequately covered in WHC (1992), Appendix G. The models used include a 100% release fraction with no credit for plume meander, plume rise, building wake, or any other mitigating factor which might reduce the estimated consequence. New meteorological data and models (Rittmann 1993) has come into effect for the Hanford Site since the issuance of WHC (1992), but this would be more than offset by the redefinition of the CWC onsite receptor from 142 m south to 440 m west or southwest (to the PFP).

The dose consequences reported in WHC (1992) are 2.5×10^{-2} rem EDE to the maximum onsite receptor and 3.2×10^{-5} rem EDE to the maximum offsite receptor. These values are substantially below the onsite and offsite safety class criteria of 5.0 rem EDE and 0.5 rem EDE respectively. In addition, they are well below the most stringent risk acceptance guidelines associated with a frequency of 0.1 per year of 1.0 rem EDE onsite and 0.01 rem EDE offsite. Therefore, the potential radiological dose consequences of an accident involving the 4843 Building sodium are insignificant and are not analyzed further.

A4.2 SRE SODIUM

The radiological impacts of the SRE sodium evaluated in WHC (1993b) determined a radiological concentration of approximately 3 nCi/g, which is just slightly above the Department of Transportation (DOT) definition of radioactive material. The conclusion of the hazard classification short form in WHC (1993b) is that the Radiological Hazard Classification Value is five orders of magnitude below the low hazard classification criteria. Therefore, the storage of SRE sodium does not necessitate further radiological analysis.

A5.0 TOXICOLOGICAL IMPACTS

The accident consequences presented below are stated as concentrations of sodium hydroxide (NaOH) in air at receptor locations. NaOH is not the only product of sodium reactions, but it is the most toxic. For conservatism, it is assumed here, as in Medsker (1994a) that complete conversion of sodium to NaOH occurs, neglecting other sodium aerosols which might be formed.

The criteria for NaOH concentrations resulting from accidents are taken from guidance in WHC-CM-4-46, Safety Analysis Manual (WHC 1994). WHC (1994) states that Emergency Response Planning Guideline (ERPG) values should be used as the basis of risk acceptance and safety classification for accidents involving the release of toxic materials. For NaOH, the ERPG values are: ERPG-1 = 2 mg/m^3 , ERPG-2 = 40 mg/m^3 , and ERPG-3 = 100 mg/m^3 . The Safety Class 1 (safety class), Safety Class 2 (safety significant), and onsite and offsite risk acceptance guidelines for NaOH are:

Safety class 1 (offsite)	Safety class 2 (onsite)	Onsite risk	Offsite risk
ERPG-2:	ERPG-3:	ERPG-2:	ERPG-1:
40 mg/m^3	100 mg/m^3	40 mg/m^3	2 mg/m^3

Thus, if it can be shown that the maximum onsite consequence is less than 40 mg/m^3 , then the hypothesized accident consequence is within the Safety Class 2 criteria and risk acceptance guidelines. If it can be shown that the

maximum offsite consequence is less than 2 mg/m^3 , then the hypothesized accident consequence is within the Safety Class 1 criteria and risk acceptance guidelines.

Medsker (1994a) analyzes three different cases: a water-sodium reaction, a hydrogen explosion, and a sodium fire. These cases will be applied to two storage configurations; the 4843 sodium to be stored in AMW storage modules near the LFMW storage modules and the storage of the SRE sodium in AM storage modules at the 16th and Dayton location.

A6.0 CASE 1: WATER-SODIUM REACTION

Scenario — The water-sodium scenario involves rainfall leaking into the storage area and contacting the sodium, producing hydrogen and sodium hydroxide (NaOH). Hydrogen is released in the reaction and is ignited, resulting in the rupture of the drums and the storage module, and subsequent exposure of more sodium to water. Alternate sources of water include firefighting activities which spray water on the sodium modules to cool them in an event of a range fire, or a vehicle impacting a storage module with firefighters spraying water to extinguish the fire.

The consumption of sodium and the production of NaOH is governed by the following reaction.

Thus, one mole of NaOH is produced by every mole of sodium consumed in the reaction.

A6.1 4843 BUILDING SODIUM

Source Term — Due to the nature of the packaging, 1,000 lb of the 4843 building sodium is assumed to be contained in one AMW storage module and consumed in the water-sodium reaction. Although the entire inventory of sodium could theoretically be consumed in 12 sec with a water flowrate of 500 gal/min, it is assumed the entire inventory is consumed in 10 min. This is due to the physical configuration of the sodium (large pieces of sodium) and the inability of all the water to react with the sodium. An airborne release fraction of 0.1 is used based on the presence of water (contacting the NaOH) and the propensity of the reaction to form large masses of NaOH and unreacted sodium which will deposit immediately, leaving large amounts of NaOH solidified and in solution inside and around the AMW storage module. The total amount of NaOH made airborne is $7.8 \times 10^7 \text{ mg}$.

Amount of sodium consumed = 1,000 lb = $2.0 \times 10^4 \text{ moles}$
 Amount of NaOH produced = $2.0 \times 10^4 \text{ moles} = 7.8 \times 10^8 \text{ mg}$
 Amount of NaOH made airborne = $(7.8 \times 10^8 \text{ mg}) * (0.1) = 7.8 \times 10^7 \text{ mg}$.

Atmospheric Dispersion — The atmospheric dispersion of the plume of NaOH resulting from the water-sodium reaction was modeled by the GXQ code in accordance with the methodology specified in the NRC Regulatory Guide 1.145 (NRC 1983). The acute 99.5% maximum sector χ/Q is used for the specified onsite receptor locations, while the 99.5% maximum sector χ/Q is compared to the 95% site-wide χ/Q for the offsite receptor. Credit is taken for the phenomenon of plume depletion.

For plume depletion, the Chamberlain model implemented in GXQ (WHC 1993c) is used. The model uses the input deposition velocity to estimate the depletion of the plume as it travels downwind. The deposition velocity for NaOH is taken to be 0.05 m/s. For most solids (as particulates entrained in air) this would be a high estimate of deposition velocity, but for NaOH, which tends to agglomerate, this value is appropriate. This is especially true in light of the water being delivered as part of the scenario model.

The initial volumetric flowrate of the plume can be estimated in one of two ways. A theoretical flowrate, based on the water-sodium reaction, could be used as a conservative estimate of the initial flowrate. However, this value would be extremely high and would result in particulate loadings in air which are impossible to attain. The second possible method for calculating an initial flowrate would be to assume a conservative maximum particulate loading and then use the source term to estimate the flowrate. The assumed maximum particulate air loading is 5,000 mg/m³. The initial volumetric flowrate is 26 m³/s.

$$\text{NaOH release rate} = (7.8 \times 10^7 \text{ mg}) / (600 \text{ s}) = 1.3 \times 10^5 \text{ mg/s}$$

$$\text{NaOH initial flowrate} = (1.3 \times 10^5 \text{ mg/s}) / (5,000 \text{ mg/m}^3) = 26 \text{ m}^3/\text{s}.$$

The stack height was assumed to be 1 m and the stack diameter was assumed to be 12 m due to the loss of containment of the sodium.

The 99.5% maximum sector onsite χ/Q is $4.24 \times 10^{-7}/\text{m}^3$ at 440 m ESE to the 231-Z Building. The maximum sector offsite χ/Q is $1.06 \times 10^{-10}/\text{m}^3$ at 17,000 m SSW. The GXQ runs are included in Appendix A.

Consequences — The onsite and offsite consequences were calculated by multiplying the source term with the respective onsite and offsite χ/Q s. The calculations are

$$\begin{aligned} \text{Onsite consequences} &= (7.8 \times 10^7 \text{ mg of NaOH}) * (4.24 \times 10^{-7}/\text{m}^3) \\ &= 33 \text{ mg/m}^3 \text{ NaOH} \end{aligned}$$

$$\begin{aligned} \text{Offsite consequences} &= (7.8 \times 10^7 \text{ mg of NaOH}) * (1.06 \times 10^{-10}/\text{m}^3) \\ &= 8.27 \times 10^{-3} \text{ mg/m}^3 \text{ NaOH.} \end{aligned}$$

The maximum onsite consequences calculated are below the onsite safety classification (ERPG-3) of 100 mg/m^3 and the onsite risk acceptance (ERPG-2) of 40 mg/m^3 (at a frequency of 1.0 yr^{-1}). The maximum offsite consequences are below the offsite safety classification (ERPG-2) of 40 mg/m^3 and the offsite risk acceptance (ERPG-1) of 2 mg/m^3 (at a frequency of 1.0 yr^{-1}).

6.1.2 SRE Sodium

Source Term — The SRE sodium is contained in 158 55-gal drums, with each drum containing $\approx 370 \text{ lb}$ of sodium. A maximum of 21 drums can be stored in a single AM module. For this scenario, it is assumed that the total contents of one storage module is consumed in the water-sodium reaction, $7,770 \text{ lb}$ (twenty-one 55-gal drums with $\approx 370 \text{ lb}$ of sodium per drum). Due to the increased amount of sodium available to react, it is assumed to take 20 min to convert all the sodium to NaOH. The airborne release fraction is assumed to be 0.1, consistent with the 4843 building sodium scenario. The total amount of NaOH made airborne in this scenario is $6.14 \times 10^8 \text{ mg}$.

Amount of sodium consumed = $7,770 \text{ lb} = 1.53 \times 10^5 \text{ moles}$

Amount of NaOH produced = $1.53 \times 10^5 \text{ moles} = 6.14 \times 10^9 \text{ mg}$

Amount of NaOH made airborne = $(6.14 \times 10^9 \text{ mg}) * (0.1) = 6.14 \times 10^8 \text{ mg}$.

Atmospheric Dispersion — The same methodology to calculate the χ/Qs for the 4843 building sodium was used to calculate the χ/Qs for this scenario, with the following exceptions. The source term and release duration were increased in this scenario, therefore the initial volumetric flowrate is $102 \text{ m}^3/\text{s}$.

NaOH release rate = $(6.14 \times 10^8 \text{ mg}) / (1,200 \text{ s}) = 5.11 \times 10^5 \text{ mg/s}$

NaOH initial flowrate = $(5.11 \times 10^5 \text{ mg/s}) / (5,000 \text{ mg/m}^3) = 102 \text{ m}^3/\text{s}$

The 99.5% maximum sector onsite χ/Q is $4.63 \times 10^{-8}/\text{m}^3$ at 580 m NE to the PFP facility. The maximum sector offsite χ/Q is $5.33 \times 10^{-11}/\text{m}^3$ at 17,000 m SSW. The GXQ runs are included in Appendix A.

Consequences — The onsite consequences were calculated by multiplying the source term with the respective onsite and offsite χ/Qs . The calculations are

Onsite consequences = $(6.14 \times 10^8 \text{ mg of NaOH}) * (4.63 \times 10^{-8}/\text{m}^3)$
 $= 28 \text{ mg/m}^3 \text{ NaOH}$

Offsite consequences = $(6.14 \times 10^8 \text{ mg of NaOH}) * (5.33 \times 10^{-11}/\text{m}^3)$
 $= 3.3 \times 10^{-2} \text{ mg/m}^3 \text{ NaOH}$.

The maximum onsite consequences calculated are below the onsite safety classification (ERPG-3) of 100 mg/m^3 and the onsite risk acceptance (ERPG-2) of 40 mg/m^3 (at a frequency of 1.0 yr^{-1}). The maximum offsite consequences are below the offsite safety classification (ERPG-2) of 40 mg/m^3 and the offsite risk acceptance (ERPG-1) of 2 mg/m^3 (at a frequency of 1.0 yr^{-1}).

A7.0 CASE 2: HYDROGEN EXPLOSION

Scenario — This hydrogen explosion scenario involves the buildup of hydrogen gas in a 55-gal drum with a resulting explosion. The explosion causes a "puff" release of NaOH.

A7.1 4843 BUILDING SODIUM

Source Term — The methodology for determining the source term for this release mechanism is presented in Medsker (1994a), which is based on an explosion in a 55-gal drum. The Medsker analysis implicitly assumed that the sodium would be placed in the drums as a liquid with a void space in the top of the drum. In contrast, the 4843 Building sodium constitutes the remnants of clean-up activities from sodium spills at the Fast Flux Test Facility (FFTF) and oddly shaped packages from offsite sources. The contents of these packages represent the possibility of substantially larger void spaces for the generation of hydrogen (which determines the source term for this release mechanism).

Given the unknowns associated with the possible void spaces in the packages, the void volume of hydrogen, is conservatively estimated to be the entire volume of a 55-gal drum (0.21 m^3), which yields $5.2 \times 10^{-3} \text{ kg}$ of H_2 , or 0.21 kg of NaOH, according to the following methodology from Medsker (1994a)

Mass of hydrogen: Assume that a stoichiometric mixture of hydrogen and air exists within the void volume, which is 30% hydrogen (at 298 K and 1 atm the density of $\text{H}_2 = 0.0818 \text{ kg/m}^3$)

Volume of $\text{H}_2 = (0.30) * (0.21 \text{ m}^3) = 0.063 \text{ m}^3$
 Mass of $\text{H}_2 = (0.063 \text{ m}^3) * (0.0818 \text{ kg/m}^3) = 5.2 \times 10^{-3} \text{ kg}$
 Moles of $\text{H}_2 = (5.2 \text{ g}) / (2 \text{ g/mole}) = 2.6 \text{ moles}$

Mass of NaOH: 2 moles of NaOH are produced with every mole of H_2 from the reaction $2 \text{ Na} + 2 \text{ H}_2\text{O} \implies 2 \text{ NaOH} + \text{H}_2$.

Moles of NaOH = (2 moles NaOH/mole H_2) * (2.6 moles H_2) = 5.2 moles NaOH
 Mass of NaOH = (5.2 moles NaOH) * (40 g/mole) = 210 g/mole
 Mass of NaOH = $2.1 \times 10^5 \text{ mg NaOH}$.

The airborne release fraction is assumed to be 0.01 due to the packaging of the 4843 sodium (the sodium inside of smaller containers and spread over equipment, rags, etc). This release fraction is still an order of magnitude greater than the release fraction used in explosion scenarios involving radiological materials (DOE 1993 recommends using an airborne release fraction of 1×10^{-3} for a release due to blast effects from an explosion). The total amount of NaOH made airborne is $2.1 \times 10^3 \text{ mg}$.

Atmospheric Dispersion — The atmospheric dispersion is done in the same fashion as the corresponding analysis in Medsker (1994a). The atmospheric dispersion of the plume of NaOH resulting from the explosion is difficult to model. A "puff" release is assumed, but the complicating factor of plume depletion causes problems in the GXQ code. The problems in the code are such that it is not possible to search for specified frequency of exceedence value

for the χ/Q in the hydrogen explosion cases. Therefore, six χ/Q values were calculated with different input windspeeds and stability classes, with the maximum value to be used in this analysis. The six combinations are

Case	Windspeed	Stability class
1	1.0 m/s	F
2	3.0 m/s	F
3	10.0 m/s	F
4	1.0 m/s	D
5	1.0 m/s	A
6	3.0 m/s	A

In each of the combinations above, several parameters serve as additional inputs. These parameters are deposition velocity, effective puff diameter (to determine stack height), volumetric flowrate, and release duration.

The deposition velocity is assumed to be one-tenth that for the sodium fire cases, or 0.01 m/s. As in all cases, the Chamberlain plume depletion model incorporated into the GXQ code is used to estimate the depletion of the plume.

The initial volume (and thus the effective diameter, volumetric flowrate, and release duration) of the puff generated by the hydrogen explosion may be estimated by the ideal gas law

$$\frac{P_1 V_1}{P_2 V_2} = \frac{n_1 R T_1}{n_2 R T_2}$$

or

$$V_2 = \frac{n_2 T_2 V_1 P_1}{n_1 T_1 P_2}$$

where:

- a "1" indicates the parameter before the explosion
- a "2" indicates the parameter after the explosion
- P = Pressure

V = Volume
 n = total number of moles
 T = Temperature
 R = Universal Gas Constant.

The total number of moles before and after the explosion may be determined from the chemical reaction:

$$\begin{aligned} n_1 &= 3.76 + 1 + 2 = 6.76 \text{ moles} \\ n_2 &= 3.76 + 2 = 5.76 \text{ moles} \end{aligned}$$

The gas is assumed to expand freely until the pressure equalizes so that $P_1 = P_2$, canceling both from the equation.

The temperatures are

$$\begin{aligned} T_1 &= 298 \text{ K} \\ T_2 &= 3,000 \text{ K.} \end{aligned}$$

Note that the actual adiabatic flame temperature for H_2 is theoretically greater than 3,000 K, but the physical limit to the temperature rise is $\approx 3,000\text{K}$.

Thus, with $V_1 = V_{\text{void}} = 0.21 \text{ m}^3$
 $V_2 = 1.8 \text{ m}^3$.

The stack height is set equal to the effective radius of the puff plus the drum height (1 m); the release duration (t_a) is set to the time it takes for the puff to travel one effective diameter; and the initial volumetric flowrate of the plume (V_0) is the volume of the plume divided by the release duration.

The effective diameter of the plume is taken from the assumption that the puff is a sphere:

$$\begin{aligned} D_{\text{eff}} &= 2 * r_{\text{eff}} \\ r_{\text{eff}} &= (3*V/4\pi)^{1/3} \\ V &= V_2 \\ r_{\text{eff}} &= 0.75 \text{ m} \\ D_{\text{eff}} &= 1.5 \text{ m} \end{aligned}$$

Making the stack height

$$\text{Stack height} = 1 \text{ m} + 0.75 \text{ m} = 1.75 \text{ m.}$$

The release duration and initial volumetric flowrate are calculated by assuming an ambient windspeed. By varying the windspeed in the different cases noted above, the release duration and initial plume volumetric flowrate become dependent on which case is being analyzed. The following shows the windspeed, release duration, and initial volumetric flowrate for each case analyzed.

Case	Stability class	Windspeed (m/s)	Release duration	Flowrate (m ³ /s)
1	F	1.0	1.5	1.2
2	F	3.0	0.5	3.6
3	F	10.0	0.15	12
4	D	1.0	1.5	1.2
5	A	1.0	1.5	1.2
6	A	3.0	0.5	3.6

Consequences — These variations resulted in the following onsite and offsite χ/Q s and consequences (consequence = source term * χ/Q). The maximum onsite and offsite consequences, which must be compared to the relevant criteria, are followed by an asterisk.

Distance (m)	Windspeed (m/s)	Stability class	χ/Q (s/m ³)	Consequences (mg/m ³)
440	1.0	F	2.41×10^{-5}	4.90×10^{-2}
440	3.0	F	3.0×10^{-5}	7.95×10^{-2}
440	10.0	F	4.62×10^{-5}	$9.42 \times 10^{-2*}$
440	1.0	D	3.57×10^{-6}	7.26×10^{-3}
440	1.0	A	1.30×10^{-7}	2.65×10^{-4}
440	3.0	A	1.48×10^{-7}	3.03×10^{-4}
12,000	1.0	F	5.15×10^{-10}	1.05×10^{-6}
12,000	3.0	F	6.13×10^{-9}	1.25×10^{-5}
12,000	10.0	F	1.46×10^{-8}	$2.98 \times 10^{-5*}$
12,000	1.0	D	3.22×10^{-10}	6.57×10^{-7}
12,000	1.0	A	3.67×10^{-11}	7.50×10^{-8}
12,000	3.0	A	4.57×10^{-11}	9.33×10^{-8}

The maximum onsite consequences calculated to be 9.42×10^{-2} mg/m³ NaOH are below the onsite safety classification (ERPG-3) of 100 mg/m³ and the onsite risk acceptance (ERPG-2) of 40 mg/m³ (at a frequency of 1.0 yr⁻¹).

The maximum offsite consequences calculated to be $2.98 \times 10^{-5} \text{ mg/m}^3$ NaOH are below the offsite safety classification (ERPG-2) of 40 mg/m^3 and the offsite risk acceptance (ERPG-1) of 2 mg/m^3 (at a frequency of 1.0 yr^{-1}).

A7.2 SRE SODIUM

Source Term — The methodology for calculating the source term for the SRE sodium is similar to 4843 building sodium with a few modifications. The void volume for the SRE sodium is 0.049 m^3 , due to the consistent mass of sodium in each drum (160 kg).

$$V_{\text{Na}} = (160 \text{ kg}) / (970 \text{ kg/m}^3) = 0.16 \text{ m}^3 = 42 \text{ gal}$$

$$V_{\text{void}} = 55 \text{ gal} - 42 \text{ gal} = 13 \text{ gal} = 0.049 \text{ m}^3.$$

Assuming a stoichiometric mixture of hydrogen and air exists within the void volume (as in the 4843 building sodium), the amount of hydrogen is 0.60 moles.

$$\text{Volume of H}_2 = (0.30) * (0.049 \text{ m}^3) = 0.015 \text{ m}^3$$

$$\text{Mass of H}_2 = (0.015 \text{ m}^3) * (0.0818 \text{ kg/m}^3) = 0.0012 \text{ kg}$$

$$\text{Moles of H}_2 = (1.2 \text{ g}) / (2 \text{ g/mole}) = 0.60 \text{ moles.}$$

The sodium hydroxide present on the surface of the sodium metal will be dispersed. If 0.60 moles of hydrogen are formed in the reaction, then the amount of sodium hydroxide present is $4.8 \times 10^4 \text{ mg}$.

$$\text{Moles of NaOH} = (2 \text{ moles NaOH/mole H}_2) * (0.60 \text{ moles H}_2) = 1.2 \text{ moles}$$

$$\text{Mass of NaOH} = (1.2 \text{ moles NaOH}) * (40 \text{ g/mole}) = 48 \text{ g} = 4.8 \times 10^4 \text{ mg.}$$

The amount of NaOH released to the air is $4.8 \times 10^3 \text{ mg}$, assuming that 10% of the NaOH present is released to the air.

Atmospheric Dispersion — The atmospheric dispersion calculations for the SRE sodium hydrogen explosion follows the same methodology as the 4843 building hydrogen explosion. The same six windspeed and stability class combinations are used to calculate the χ/Q values. The volumetric flowrate and release duration are all similarly derived, but the effective puff diameter was modified because the concentrations within the puff volume are impossible to attain. Therefore, the maximum particulate loading ($5,000 \text{ mg/m}^3$) was used to modify the puff volume. The deposition velocity is also the same as the 4843 building sodium hydrogen explosion (0.01 m/s). The following values were calculated using the same methodology as the 4843 sodium (with the plume volume modified)

$$V_{\text{plume}} = (4.8 \times 10^3 \text{ mg}) / (5,000 \text{ mg/m}^3) = 0.96 \text{ m}^3$$

$$D_{\text{eff}} = 1.2 \text{ m}$$

$$\text{stack height} = 1 \text{ m} + 0.6 \text{ m} = 1.6 \text{ m}.$$

As in the initial case, the release duration and initial volumetric flowrate of the plume are function of the case being analyzed. The cases, windspeeds, release durations, and initial volumetric flowrates are

Case	Stability class	Windspeed (m/s)	Release duration	Flowrate (m ³ /s)
1	F	1.0	1.2	0.8
2	F	3.0	0.4	2.4
3	F	10.0	0.12	8.0
4	D	1.0	1.2	0.8
5	A	1.0	1.2	0.8
6	A	3.0	0.4	2.4

Consequences — These variations resulted in the following onsite and offsite χ/Q s and consequences (consequence = source term * χ/Q). The maximum onsite and offsite consequences, which must be compared to the relevant criteria, are followed by an asterisk.

Distance (m)	Windspeed (m/s)	Stability class	χ/Q (s/m ³)	Consequences (mg/m ³)
580	1.0	F	1.041×10^{-5}	4.99×10^{-2}
580	3.0	F	1.89×10^{-5}	9.07×10^{-2}
580	10.0	F	2.33×10^{-5}	$1.11 \times 10^{-1*}$
580	1.0	D	1.65×10^{-6}	7.92×10^{-3}
580	1.0	A	4.79×10^{-8}	2.30×10^{-4}
580	3.0	A	5.51×10^{-8}	2.65×10^{-4}
12,000	1.0	F	4.97×10^{-10}	2.39×10^{-6}
12,000	3.0	F	6.06×10^{-9}	2.91×10^{-5}
12,000	10.0	F	1.45×10^{-8}	$6.96 \times 10^{-5*}$
12,000	1.0	D	3.17×10^{-10}	1.52×10^{-6}
12,000	1.0	A	3.66×10^{-11}	1.75×10^{-7}
12,000	3.0	A	4.56×10^{-11}	2.19×10^{-7}

The maximum onsite consequences calculated to be $1.11 \times 10^{-1} \text{ mg/m}^3$ NaOH are below the onsite safety classification (ERPG-3) of 100 mg/m^3 and the onsite risk acceptance (ERPG-2) of 40 mg/m^3 (at a frequency of 1.0 yr^{-1}). The maximum offsite consequences calculated to be $6.96 \times 10^{-5} \text{ mg/m}^3$ NaOH are below the offsite safety classification (ERPG-2) of 40 mg/m^3 and the offsite risk acceptance (ERPG-1) of 2 mg/m^3 (at a frequency of 1.0 yr^{-1}).

A8.0 CASE 3: SODIUM FIRE

A8.1 4843 BUILDING SODIUM

Source Term — The source term for this release mechanism is determined in the same fashion as in the corresponding analysis in Medsker (1994a). The determination of the burn area is different because of the fewer number of drums and the presence of oddly shaped packages.

The following assumptions are made for the source term analysis: the number of 55 gal drums involved in this scenario is assumed to be 20, the drum burn area is increased by 50%, and the total drum burn area is doubled to account for the oddly shaped packages. The area per drum is 0.25 m^2 , resulting in a drum burn area of 7.5 m^2 , and a total burn area of 15 m^2 . The airborne release rate is 35 wt% (aerosolization rate) of the sodium burn rate. The source term is therefore $9.82 \times 10^4 \text{ mg NaOH/s}$

Burn rate of sodium metal (HEDL 1979, p. 4):

$$40 \text{ kg/m}^2 \text{ hr} = 11,000 \text{ mg/m}^2 \text{ s}$$

$$\text{Single drum cross-sectional area} = 0.25 \text{ m}^2$$

$$\text{Total drum cross-sectional area} = 20 * 0.25 \text{ m}^2 = 5 \text{ m}^2$$

$$\text{Total burn area} = (5 \text{ m}^2) * (1.5) * (2) = 15 \text{ m}^2$$

$$\text{Burn rate} = (11,000 \text{ mg/m}^2 \text{ s}) * (15 \text{ m}^2) = 1.65 \times 10^5 \text{ mg Na/s}$$

$$\begin{aligned} \text{NaOH burn rate} &= (1.65 \times 10^5 \text{ mg Na/s}) * (1.7 \text{ mg NaOH/mg Na}) \\ &= 2.8 \times 10^5 \text{ mg NaOH/s} \end{aligned}$$

$$\begin{aligned} \text{Airborne release rate} &= (2.8 \times 10^5 \text{ mg NaOH/s}) * (0.35) \\ &= 9.82 \times 10^4 \text{ mg NaOH/s.} \end{aligned}$$

Atmospheric Dispersion — As in the sodium-water reaction, the atmospheric dispersion of the plume of NaOH resulting from the fire was modeled by the GXQ code (WHC 1993c) in accordance with NRC Regulatory Guide methodology (NRC 1983). The acute 99.5% maximum sector χ/Q is used for the specified onsite receptor locations, while the 99.5% maximum sector χ/Q is compared to the site-wide χ/Q for the offsite receptor. Credit is taken for the phenomenon of plume depletion.

For plume depletion, the Chamberlain model was used with a deposition velocity of 0.1 m/s . This is a large value for deposition velocity that was taken from a series of experiments performed at the Idaho National Engineering Laboratory (INEL) in 1978 (Johnson, et al. 1979). The purpose of the experiments was to gain insights into the consequences of sodium fires which might occur in Liquid Metal Fast Breeder Reactor (LMFBR) heat transfer

systems. In the experiments, the deposition and composition of the sodium aerosols from the plumes off of sodium fires (4 spray and fan fires and 1 pool fire) was measured as a function of distance downwind. Tracer gas releases from a met tower provided data on the atmospheric conditions prevalent during the fires. The results, while not given specifically in terms of deposition velocities, were successfully reproduced for the given conditions by a computer code when the input deposition velocity was set to 0.1 m/s. (As a side note, the quantity of NaOH which was found out to 200 m was less than 1% of the total combustion products. This indicates that little conversion to NaOH took place close to the source for a relative humidity of 17%).

In addition to the plume depletion model, the volumetric flowrate correction model in the GXQ code is also used. This model initializes the calculations for the characteristics of the plume.

The initial volumetric flowrate of the plume is estimated by dividing the source term by the maximum assumed particulate air loading, which resulted in a value of 20 m³/s.

$$\begin{aligned}\text{initial volumetric flowrate} &= (9.82 \times 10^4 \text{ mg NaOH/s}) / (5,000 \text{ mg/m}^3) \\ &= 20 \text{ m}^3/\text{s}.\end{aligned}$$

The effective stack height is set at 1.0 m, the height of a drum, while the effective stack diameter is set equal to the diameter of a circle which has an area equal to the total burn area, or 4.4 m.

The 99.5% maximum sector onsite χ/Q is $7.63 \times 10^{-5} \text{ s/m}^3$ at 440 m ESE to the 231-Z Building. The maximum sector offsite χ/Q is $2.16 \times 10^{-8} \text{ s/m}^3$ at 12,000 m W. The GXQ runs are included in Appendix B.

Consequences — The onsite and offsite consequences were calculated by multiplying the source term with the respective onsite and offsite χ/Q s. The calculations are

$$\begin{aligned}\text{Onsite consequences} &= (9.82 \times 10^4 \text{ mg NaOH/s}) * (7.63 \times 10^{-5} \text{ s/m}^3) \\ &= 7.5 \text{ mg NaOH/m}^3\end{aligned}$$

$$\begin{aligned}\text{Offsite consequences} &= (9.82 \times 10^4 \text{ mg NaOH/s}) * (2.16 \times 10^{-8} \text{ s/m}^3) \\ &= 2.1 \times 10^{-3} \text{ mg NaOH/m}^3.\end{aligned}$$

The maximum onsite consequences calculated are below the onsite safety classification (ERPG-3) of 100 mg/m³ and the onsite risk acceptance (ERPG-2) of 40 mg/m³ (at a frequency of 1.0 yr⁻¹). The maximum offsite consequences are below the offsite safety classification (ERPG-2) of 40 mg/m³ and the offsite risk acceptance (ERPG-1) of 2 mg/m³ (at a frequency of 1.0 yr⁻¹).

A8.2 SRE SODIUM

Source Term — The source term for this release is developed using the same methodology as the 4843 building sodium fire scenario, with one exception. The SRE sodium is contained in only 55-gal drums, therefore it is not necessary to double the burn area to account for oddly shaped packages. By dividing the 4843 building sodium fire scenario source term by 2 (taking out the doubling factor), the SRE sodium fire scenario source term was determined to be 4.91×10^4 mg NaOH/s.

$$\text{Source Term} = (9.82 \times 10^4 \text{ mg NaOH/s}) / 2 = 4.91 \times 10^4 \text{ mg NaOH/s}$$

Atmospheric Dispersion — The same methodology and inputs were used to calculate the SRE sodium fire scenario χ/Q_s as were used in the 4843 building sodium scenario, with the following exceptions: The onsite receptor was changed to 580 m NE to PFP (from 440 m ESE), the initial volumetric flowrate of the plume was changed to $9.8 \text{ m}^3/\text{s}$ (from $20 \text{ m}^3/\text{s}$) to account for the reduced source term, and the stack diameter was decreased to 3.1 m (from 4.4 m) to account for the reduced burn area. All other inputs will remain the same.

The 99.5% maximum sector onsite χ/Q is $2.67 \times 10^{-5} \text{ s/m}^3$ at 580 m NE to the PFP facility. The maximum sector offsite χ/Q is $2.16 \times 10^{-8} \text{ s/m}^3$ at 12,000 m W. The GXQ runs are included in Appendix A.

Consequences — The onsite and offsite consequences were calculated by multiplying the source term with the respective onsite and offsite χ/Q_s . The calculations are as follows:

$$\begin{aligned} \text{Onsite consequences} &= (4.91 \times 10^4 \text{ mg NaOH/s}) * (2.67 \times 10^{-5} \text{ s/m}^3) \\ &= 1.3 \text{ mg NaOH/m}^3 \end{aligned}$$

$$\begin{aligned} \text{Offsite consequences} &= (4.91 \times 10^4 \text{ mg NaOH/s}) * (2.16 \times 10^{-8} \text{ s/m}^3) \\ &= 1.1 \times 10^{-3} \text{ mg NaOH/m}^3 \end{aligned}$$

The maximum onsite consequences calculated are below the onsite safety classification (ERPG-3) of 100 mg/m^3 and the onsite risk acceptance (ERPG-2) of 40 mg/m^3 (at a frequency of 1.0 yr^{-1}). The maximum offsite consequences are below the offsite safety classification (ERPG-2) of 40 mg/m^3 and the offsite risk acceptance (ERPG-1) of 2 mg/m^3 (at a frequency of 1.0 yr^{-1}).

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APPENDIX B

GXQ RUNS

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GXQ Version 3.1 C
June 8, 1993

General Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 0.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 0.
Code Custodian is Brit E. Hey, WHC, ext. 6-2921.

Run Date = 1/ 3/1995
Run Time = 7:55 34.23

Case 1
Water - Sodium
Reaction
SRE Sodium
Revised

INPUT ECHO:

Input title line

c GXQ Ver. 3.1 Input File

c mode

1

c

c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology

c mode = 2 then X/Q based on atmospheric stability class and wind speed

c mode = 3 then X/Q plot file is created

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop icon

T F F F F F T

c ifox = t then joint frequency used to compute frequency to exceed X/Q

c = f then joint frequency used to compute annual average X/Q

c inorm = t then joint frequency data is normalized (as in GENII)

c = f then joint frequency data is un-normalized

c icdf = t then cumulative distribution file created (CDF.OUT)

c = f then no cumulative distribution file created

c ichk = t then X/Q parameter print option turned on

c = f then no parameter print

c isite = t then X/Q based on joint frequency data for all 16 sectors

c = f then X/Q based on joint frequency data of individual sectors

c ipop = t then X/Q is population weighted

c = f then no population weighting

c icon = t then X/Q is air concentration

c = f then X/Q is integrated exposure

c

c MODEL CHOICES:

c idep iwake ipm irise igrav iwash iflow iwind

1 0 0 0 0 0 1 0

c idep = 1 then plume depletion model turned on (Chamberlain model)

c iwake = 1 then NRC RG 1.145 building wake model turned on

c = 2 then MACCS virtual distance building wake model turned on

c ipm = 1 then NRC RG 1.145 plume meander model turned on

c = 2 then 5th Power Law plume meander model turned on

c = 3 then sector average model turned on

c irise = 1 then momentum/buoyancy plume rise model turned on, buoyancy

c rise based on sensible heat emission

c = 2 then momentum/buoyancy plume rise model turned on, buoyancy

```

c      rise based on initial plume density
c      grav = 1 then gravitational settling model turned on
c      lwash = 1 then stack downwash model turned on
c      iflow = 1 then sigmas adjusted for volume flow rate
c      lwind = 1 then wind speed corrected for plume height
c      = 0 to turn any of the above models off
c
c  PARAMETER INPUT:
c      stack      wind      frequency
c      release    speed      to      scaling
c      height     height    height  exceed  factor
c      (m)        (m)      (m)    (%)    (?)
c      1.00000E+00  1.00000E+01  1.00000E+03  5.00000E-01  1.00000E+00
c
c      building   building   release   deposition   gravitational
c      width      height    duration  velocity    settling
c      (m)        (m)      (hr)    (m/s)      velocity
c      0.00000E+00  0.00000E+00  3.33000E-01  5.00000E-02  1.00000E-03
c
c      initial    sensible
c      plume      heat
c      plume      flow      stack    emission
c      density    rate      diameter rate
c      (g/cc)     (m3/s)    (m)    (cal/s)
c      0.00000E+00  1.02000E+02  9.00000E+00  0.00000E+00
c
c  RECEPTOR DEPENDENT DATA
c  FOR MODE      make      RECEPTOR DEPENDENT DATA
c  1 (site specific)      sector distance z-height
c  2 (by class & wind speed) class windspeed distance offset z-height
c  3 (create plot file)   class windspeed xmax imax ymax jmax xqmin power
c
c  RECEPTOR PARAMETER DESCRIPTION:
c  sector = 0, 1, 2... (all, S, SSW, etc.)
c  distance = meters
c  class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c  windspeed = m/s
c  offset = meters offset from plume centerline
c  xmax = maximum distance to plot or calculate to (m)
c  imax = distance intervals
c  ymax = maximum offset to plot (m)
c  jmax = offset intervals
c  xqmin = minimum scaled X/Q to calculate
c  power = exponent in power function step size
c
MODE:
Site specific X/Q calculated

LOGICAL CHOICES:
Joint frequency used to calculate X/Q based on
frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for single sector.
Output is maximum normalized air concentration.

MODELS SELECTED:
Chamberlain plume depletion
Flow adjustment model.

```

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)

Created 8/26/92 KR

Input title line

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (1/m3)	AVERAGE INDIVIDUAL SCALED X/Q (1/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
E	440	0	14.05	1	1.67E-07	1.67E-07	G	4.70
ESE	440	0	18.80	1	1.79E-07	1.79E-07	G	4.70
SE	510	0	10.83	1	8.50E-08	8.50E-08	F	7.15
NE	580	0	3.90	1	4.63E-08	4.63E-08	E	4.70
S	15700	0	6.30	1	5.03E-11	5.03E-11	D	19.00
SSW	17000	0	4.53	1	5.33E-11	5.33E-11	D	7.15
SW	16800	0	2.93	1	1.37E-11	1.37E-11	D	2.65
WSW	12200	0	2.72	1	3.00E-11	3.00E-11	B	4.70
W	12000	0	4.80	1	3.49E-11	3.49E-11	D	2.65
WNW	12200	0	3.98	1	3.30E-11	3.30E-11	D	2.65
NW	14800	0	4.72	1	2.42E-11	2.42E-11	B	4.70
NNW	16000	0	4.58	1	4.10E-11	4.10E-11	E	4.70
N	19800	0	4.36	1	2.39E-11	2.39E-11	E	4.70
NNE	27800	0	2.49	1	1.03E-11	1.03E-11	B	7.15
NE	31800	0	3.90	1	1.52E-11	1.52E-11	D	7.15
ENE	26500	0	6.17	1	2.40E-11	2.40E-11	D	15.60
E	26500	0	14.05	1	2.33E-11	2.33E-11	E	7.15
ESE	31300	0	18.80	1	1.81E-11	1.81E-11	D	12.70
SE	26800	0	10.83	1	2.32E-11	2.32E-11	D	9.80
SSE	23500	0	4.78	1	1.01E-11	1.01E-11	A	7.15

Execution Time = 0 hr 0 min 11.42 sec

Stop - Program terminated.

GXQ Version 3.1 C
June 8, 1993

General Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 0.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 0.
Code Custodian is Brit E. Hey, WHC, ext. 6-2921.

Run Date = 10/17/1994
Run Time = 9:37 20.90

Case 2
Hydrogen Explosion
Example
4843 Sodium

INPUT ECHO:

Input title line

c GXQ Ver. 3.1 Input File

c mode

2

c

c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology

c mode = 2 then X/Q based on atmospheric stability class and wind speed

c mode = 3 then X/Q plot file is created

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop icon

T F F F F F T

c ifox = t then joint frequency used to compute frequency to exceed X/Q

c = f then joint frequency used to compute annual average X/Q

c inorm = t then joint frequency data is normalized (as in GENII)

c = f then joint frequency data is un-normalized

c icdf = t then cumulative distribution file created (CDF.OUT)

c = f then no cumulative distribution file created

c ichk = t then X/Q parameter print option turned on

c = f then no parameter print

c isite = t then X/Q based on joint frequency data for all 16 sectors

c = f then X/Q based on joint frequency data of individual sectors

c ipop = t then X/Q is population weighted

c = f then no population weighting

c icon = t then X/Q is air concentration

c = f then X/Q is integrated exposure

c

c MODEL CHOICES:

c idep iwake ipm irise igrav iwash iflow iwind

1 0 0 0 0 0 1 0

c idep = 1 then plume depletion model turned on (Chamberlain model)

c iwake = 1 then NRC RG 1.145 building wake model turned on

c = 2 then MACCS virtual distance building wake model turned on

c ipm = 1 then NRC RG 1.145 plume meander model turned on

c = 2 then 5th Power Law plume meander model turned on

c = 3 then sector average model turned on

c irise = 1 then momentum/buoyancy plume rise model turned on, buoyancy

c rise based on sensible heat emission

c = 2 then momentum/buoyancy plume rise model turned on, buoyancy

```

c      rise based on initial plume density
c igrav = 1 then gravitational settling model turned on
c iwash = 1 then stack downwash model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c iwind = 1 then wind speed corrected for plume height
c      = 0 to turn any of the above models off
c
c PARAMETER INPUT:
c      stack      wind      frequency
c      release    speed      to
c      height     height    mixing    exceed    scaling
c      (m)        (m)       (m)      (%)      factor
c      1.75000E+00 1.00000E+01 1.00000E+03 5.00000E-01 1.00000E+00
c
c      building   building   release   deposition   gravitational
c      width      height    duration  velocity    settling
c      (m)        (m)       (hr)     (m/s)       velocity
c      0.00000E+00 0.00000E+00 4.17000E-04 1.00000E-02 1.00000E-03
c
c      initial    initial    sensible
c      plume      flow      heat
c      density    rate      stack    emission
c      (g/cc)     (m3/s)   diameter rate
c      0.00000E+00 1.20000E+00 1.50000E+00 0.00000E+00
c
c RECEPTOR DEPENDENT DATA
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific) sector distance z-height
c 2 (by class & wind speed) class windspeed distance offset z-height
c 3 (create plot file) class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION:
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = meters
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = m/s
c offset = meters offset from plume centerline
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size

```

MODE:

X/Q calculated by stability class and wind speed.

LOGICAL CHOICES:

Output is maximum normalized air concentration.

MODELS SELECTED:

Chamberlain plume depletion
Flow adjustment model.

WARNING/ERROR MESSAGES:

Input title line

ATM. STAB. CLASS	WIND SPEED (m/s)	DISTANCE (m)	OFFSET (m)	RECEPTOR HEIGHT (m)	SCALED X/Q (1/m3)
F	1.00	440	0	0	2.41E-05
F	1.00	12000	0	0	5.15E-10
A	1.00	440	0	0	1.30E-07
A	1.00	12000	0	0	3.67E-11
D	1.00	440	0	0	3.57E-06
D	1.00	12000	0	0	3.22E-10

Execution Time = 0 hr 0 min .33 sec
Stop - Program terminated.

GXQ Version 3.1 C
June 8, 1993

General Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 0.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 0.
Code Custodian is Brit E. Hey, WHC, ext. 6-2921.

Run Date = 11/ 4/1994
Run Time = 7:45 15.44

Case 2
Hydrogen Explosion
Example
SRE Sodium

INPUT ECHO:

Input title line

c GXQ Ver. 3.1 Input File

c mode

2

c

c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology

c mode = 2 then X/Q based on atmospheric stability class and wind speed

c mode = 3 then X/Q plot file is created

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop icon

T F F F F F T

c ifox = t then joint frequency used to compute frequency to exceed X/Q

c = f then joint frequency used to compute annual average X/Q

c inorm = t then joint frequency data is normalized (as in GENII)

c = f then joint frequency data is un-normalized

c icdf = t then cumulative distribution file created (CDF.OUT)

c = f then no cumulative distribution file created

c ichk = t then X/Q parameter print option turned on

c = f then no parameter print

c isite = t then X/Q based on joint frequency data for all 16 sectors

c = f then X/Q based on joint frequency data of individual sectors

c ipop = t then X/Q is population weighted

c = f then no population weighting

c icon = t then X/Q is air concentration

c = f then X/Q is integrated exposure

c

c MODEL CHOICES:

c idep iwake ipm irise igrav iwash iflow iwind

1 0 0 0 0 0 1 0

c idep = 1 then plume depletion model turned on (Chamberlain model)

c iwake = 1 then NRC RG 1.145 building wake model turned on

c = 2 then MACCS virtual distance building wake model turned on

c ipm = 1 then NRC RG 1.145 plume meander model turned on

c = 2 then 5th Power Law plume meander model turned on

c = 3 then sector average model turned on

c irise = 1 then momentum/buoyancy plume rise model turned on, buoyancy

c rise based on sensible heat emission

c = 2 then momentum/buoyancy plume rise model turned on, buoyancy

c rise based on initial plume density
 c igrav = 1 then gravitational settling model turned on
 c iwash = 1 then stack downwash model turned on
 c iflow = 1 then sigmas adjusted for volume flow rate
 c iwind = 1 then wind speed corrected for plume height
 c = 0 to turn any of the above models off

c PARAMETER INPUT:

c stack	wind		frequency	
c release	speed	mixing	to	scaling
c height	height	height	exceed	factor
c (m)	(m)	(m)	(%)	(?)
1.60000E+00	1.00000E+01	1.00000E+03	5.00000E-01	1.00000E+00
c building	building	release	deposition	gravitational
c width	height	duration	velocity	settling
c (m)	(m)	(hr)	(m/s)	velocity
0.00000E+00	0.00000E+00	3.30000E-04	1.00000E-02	(m/s)
				1.00000E-03
c initial	initial		sensible	
c plume	plume		heat	
c density	flow	stack	emission	
c (g/cc)	rate	diameter	rate	
0.00000E+00	(m3/s)	(m)	(cal/s)	
	8.00000E-01	1.20000E+00	0.00000E+00	

c RECEPTOR DEPENDENT DATA

c FOR MODE make RECEPTOR DEPENDENT DATA
 c 1 (site specific) sector distance z-height
 c 2 (by class & wind speed) class windspeed distance offset z-height
 c 3 (create plot file) class windspeed xmax imax ymax jmax xqmin power

c RECEPTOR PARAMETER DESCRIPTION:

c sector = 0, 1, 2... (all, S, SSW, etc.)
 c distance = meters
 c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
 c windspeed = m/s
 c offset = meters offset from plume centerline
 c xmax = maximum distance to plot or calculate to (m)
 c imax = distance intervals
 c ymax = maximum offset to plot (m)
 c jmax = offset intervals
 c xqmin = minimum scaled X/Q to calculate
 c power = exponent in power function step size

MODE:

X/Q calculated by stability class and wind speed.

LOGICAL CHOICES:

Output is maximum normalized air concentration.

MODELS SELECTED:

Chamberlain plume depletion
 Flow adjustment model.

WARNING/ERROR MESSAGES:

Input title line

ATM. STAB. CLASS	WIND SPEED (m/s)	DISTANCE (m)	OFFSET (m)	RECEPTOR HEIGHT (m)	SCALED X/Q (1/m3)
F	1.00	580	0	0	1.04E-05
D	1.00	580	0	0	1.65E-06
A	1.00	580	0	0	4.79E-08
F	1.00	12000	0	0	4.97E-10
D	1.00	12000	0	0	3.17E-10
A	1.00	12000	0	0	3.66E-11

Execution Time = 0 hr 0 min .27 sec
Stop - Program terminated.

GXQ Version 3.1 C
June 8, 1993

General Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 0.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 0.
Code Custodian is Brit E. Hey, WHC, ext. 6-2921.

Run Date = 10/26/1994
Run Time = 8: 4 36.73

Case 3
Sodium Fire
4843 Sodium

INPUT ECHO:

Input title line

c GXQ Ver. 3.1 Input File

c mode

1

c

c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology

c mode = 2 then X/Q based on atmospheric stability class and wind speed

c mode = 3 then X/Q plot file is created

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop icon

T F F F F F F

c ifox = t then joint frequency used to compute frequency to exceed X/Q

c = f then joint frequency used to compute annual average X/Q

c inorm = t then joint frequency data is normalized (as in GENII)

c = f then joint frequency data is un-normalized

c icdf = t then cumulative distribution file created (CDF.OUT)

c = f then no cumulative distribution file created

c ichk = t then X/Q parameter print option turned on

c = f then no parameter print

c isite = t then X/Q based on joint frequency data for all 16 sectors

c = f then X/Q based on joint frequency data of individual sectors

c ipop = t then X/Q is population weighted

c = f then no population weighting

c icon = t then X/Q is air concentration

c = f then X/Q is integrated exposure

c

c MODEL CHOICES:

c idep iwake ipm irise igrav iwash iflow iwind

1 0 0 0 0 0 1 0

c idep = 1 then plume depletion model turned on (Chamberlain model)

c iwake = 1 then NRC RG 1.145 building wake model turned on

c = 2 then MACCS virtual distance building wake model turned on

c ipm = 1 then NRC RG 1.145 plume meander model turned on

c = 2 then 5th Power Law plume meander model turned on

c = 3 then sector average model turned on

c irise = 1 then momentum/buoyancy plume rise model turned on, buoyancy

c rise based on sensible heat emission

c = 2 then momentum/buoyancy plume rise model turned on, buoyancy

```

c      rise based on initial plume density
c igrav = 1 then gravitational settling model turned on
c iwash = 1 then stack downwash model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c iwind = 1 then wind speed corrected for plume height
c      = 0 to turn any of the above models off
c
c PARAMETER INPUT:
c      stack      wind      mixing      frequency
c      release    speed      height      to
c      height     height     height     exceed
c      (m)         (m)        (m)        (%)
c      1.00000E+00 1.00000E+01 1.00000E+03 5.00000E-01 1.00000E+00
c
c      building   building   release    deposition    gravitational
c      width      height     duration   velocity      settling
c      (m)         (m)        (hr)      (m/s)         velocity
c      0.00000E+00 0.00000E+00 0.00000E+00 1.00000E-01 1.00000E-03
c
c      initial    initial    sensible
c      plume      plume      heat
c      plume      flow       emission
c      density    rate       diameter  rate
c      (g/cc)     (m3/s)    (m)      (cal/s)
c      0.00000E+00 2.00000E+01 4.40000E+00 0.00000E+00
c
c RECEPTOR DEPENDENT DATA
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance z-height
c 2 (by class & wind speed) class windspeed distance offset z-height
c 3 (create plot file)   class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION:
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = meters
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = m/s
c offset = meters offset from plume centerline
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size

```

MODE:

Site specific X/Q calculated

LOGICAL CHOICES:

Joint frequency used to calculate X/Q based on frequency of exceedance.

No normalization of joint frequency.

X/Q calculated for single sector.

Output is atmospheric dispersion coefficient.

MODELS SELECTED:

Chamberlain plume depletion

Flow adjustment model.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)

Created 8/26/92 KR

Input title line

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
E	440	0	14.05	1	7.39E-05	7.39E-05	G	4.70
ESE	440	0	18.80	1	7.63E-05	7.63E-05	G	4.70
SE	440	0	10.83	1	5.82E-05	5.82E-05	F	4.70
NE	580	0	3.90	1	2.62E-05	2.62E-05	E	4.70
S	15700	0	6.30	1	1.62E-08	1.62E-08	A	4.70
SSW	17000	0	4.53	1	1.54E-08	1.54E-08	D	7.15
SW	16800	0	2.93	1	1.33E-08	1.33E-08	A	7.15
WSW	12200	0	2.72	1	1.46E-08	1.46E-08	D	4.70
W	12000	0	4.80	1	2.16E-08	2.16E-08	A	2.65
WNW	12200	0	3.98	1	2.09E-08	2.09E-08	B	4.70
NW	14800	0	4.72	1	1.62E-08	1.62E-08	B	4.70
NNW	16000	0	4.58	1	1.45E-08	1.45E-08	B	4.70
N	19800	0	4.36	1	1.05E-08	1.05E-08	D	7.15
NNE	27800	0	2.49	1	4.25E-09	4.25E-09	D	7.15
NE	31800	0	3.90	1	5.63E-09	5.63E-09	C	12.70
ENE	26500	0	6.17	1	8.18E-09	8.18E-09	A	4.70
E	26500	0	14.05	1	7.99E-09	7.99E-09	B	7.15
ESE	31300	0	18.80	1	6.23E-09	6.23E-09	A	4.70
SE	26800	0	10.83	1	8.09E-09	8.09E-09	A	4.70
SSE	23500	0	4.78	1	7.97E-09	7.97E-09	A	2.65

Execution Time = 0 hr 0 min 11.59 sec

Stop - Program terminated.

GXQ Version 3.1 C
June 8, 1993

General Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 0.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 0.
Code Custodian is Brit E. Hey, WHC, ext. 6-2921.

Run Date = 10/26/1994
Run Time = 8:16 16.70

Case 3
Sodium Fire
SRE Sodium

INPUT ECHO:

Input title line

c GXQ Ver. 3.1 Input File

c mode

1

c

c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology

c mode = 2 then X/Q based on atmospheric stability class and wind speed

c mode = 3 then X/Q plot file is created

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop icon
T F F F F F F

c ifox = t then joint frequency used to compute frequency to exceed X/Q

c = f then joint frequency used to compute annual average X/Q

c inorm = t then joint frequency data is normalized (as in GENII)

c = f then joint frequency data is un-normalized

c icdf = t then cumulative distribution file created (CDF.OUT)

c = f then no cumulative distribution file created

c ichk = t then X/Q parameter print option turned on

c = f then no parameter print

c isite = t then X/Q based on joint frequency data for all 16 sectors

c = f then X/Q based on joint frequency data of individual sectors

c ipop = t then X/Q is population weighted

c = f then no population weighting

c icon = t then X/Q is air concentration

c = f then X/Q is integrated exposure

c

c MODEL CHOICES:

c idep iwake ipm irise igrav iwash iflow iwind
1 0 0 0 0 0 1 0

c idep = 1 then plume depletion model turned on (Chamberlain model)

c iwake = 1 then NRC RG 1.145 building wake model turned on

c = 2 then MACCS virtual distance building wake model turned on

c ipm = 1 then NRC RG 1.145 plume meander model turned on

c = 2 then 5th Power Law plume meander model turned on

c = 3 then sector average model turned on

c irise = 1 then momentum/buoyancy plume rise model turned on, buoyancy

c rise based on sensible heat emission

c = 2 then momentum/buoyancy plume rise model turned on, buoyancy

c rise based on initial plume density
 c igrav = 1 then gravitational settling model turned on
 c iwash = 1 then stack downwash model turned on
 c iflow = 1 then sigmas adjusted for volume flow rate
 c iwind = 1 then wind speed corrected for plume height
 c = 0 to turn any of the above models off

c PARAMETER INPUT:

c stack	wind		frequency	
c release	speed	mixing	to	scaling
c height	height	height	exceed	factor
c (m)	(m)	(m)	(%)	(?)
1.00000E+00	1.00000E+01	1.00000E+03	5.00000E-01	1.00000E+00
c building	building	release	deposition	gravitational
c width	height	duration	velocity	settling
c (m)	(m)	(hr)	(m/s)	velocity
0.00000E+00	0.00000E+00	0.00000E+00	1.00000E-01	1.00000E-03
c initial	initial		sensible	
c plume	plume		heat	
c plume	flow	stack	emission	
c density	rate	diameter	rate	
c (g/cc)	(m3/s)	(m)	(cal/s)	
0.00000E+00	9.80000E+00	3.10000E+00	0.00000E+00	

c RECEPTOR DEPENDENT DATA

c FOR MODE make RECEPTOR DEPENDENT DATA
 c 1 (site specific) sector distance z-height
 c 2 (by class & wind speed) class windspeed distance offset z-height
 c 3 (create plot file) class windspeed xmax imax ymax jmax xqmin power

c RECEPTOR PARAMETER DESCRIPTION:

c sector = 0, 1, 2... (all, S, SSW, etc.)
 c distance = meters
 c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
 c windspeed = m/s
 c offset = meters offset from plume centerline
 c xmax = maximum distance to plot or calculate to (m)
 c imax = distance intervals
 c ymax = maximum offset to plot (m)
 c jmax = offset intervals
 c xqmin = minimum scaled X/Q to calculate
 c power = exponent in power function step size

MODE:

Site specific X/Q calculated

LOGICAL CHOICES:

Joint frequency used to calculate X/Q based on
 frequency of exceedance.
 No normalization of joint frequency.
 X/Q calculated for single sector.
 Output is atmospheric dispersion coefficient.

MODELS SELECTED:

Chamberlain plume depletion
 Flow adjustment model.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)

Created 8/26/92 KR

Input title line

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
E	440	0	14.05	1	7.82E-05	7.82E-05	G	4.70
ESE	440	0	18.80	1	8.09E-05	8.09E-05	G	4.70
SE	440	0	10.83	1	5.99E-05	5.99E-05	F	4.70
NE	580	0	3.90	1	2.67E-05	2.67E-05	E	4.70
S	15700	0	6.30	1	1.62E-08	1.62E-08	A	4.70
SSW	17000	0	4.53	1	1.54E-08	1.54E-08	D	7.15
SW	16800	0	2.93	1	1.33E-08	1.33E-08	A	7.15
WSW	12200	0	2.72	1	1.46E-08	1.46E-08	D	4.70
W	12000	0	4.80	1	2.16E-08	2.16E-08	A	2.65
WNW	12200	0	3.98	1	2.09E-08	2.09E-08	B	4.70
NW	14800	0	4.72	1	1.62E-08	1.62E-08	B	4.70
NNW	16000	0	4.58	1	1.45E-08	1.45E-08	B	4.70
N	19800	0	4.36	1	1.05E-08	1.05E-08	D	7.15
NNE	27800	0	2.49	1	4.25E-09	4.25E-09	D	7.15
NE	31800	0	3.90	1	5.63E-09	5.63E-09	C	9.80
ENE	26500	0	6.17	1	8.18E-09	8.18E-09	A	4.70
E	26500	0	14.05	1	7.99E-09	7.99E-09	B	7.15
ESE	31300	0	18.80	1	6.23E-09	6.23E-09	A	4.70
SE	26800	0	10.83	1	8.09E-09	8.09E-09	A	4.70
SSE	23500	0	4.78	1	7.97E-09	7.97E-09	A	2.65

Execution Time = 0 hr 0 min 11.42 sec

Stop - Program terminated.

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APPENDIX C
PEER REVIEW CHECKLISTS

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Attachment 3

GENERAL PEER REVIEW CHECKLIST

Document Reviewed: Accident Analysis for the Storage of Metallic Sodium in the Central Waste Complex

Author: M. R. Greutman

Date: October 25, 1994

Scope of Review: Reviewed the analysis write up except for the GXQ appendix for technical accuracy. Ran EPI computer runs to cross check GXQ results.

Yes	No*	NA	
☒	☐	☐	Accident scenarios explicitly stated and supported.
☒	☐	☐	Conclusions consistent with analytical results.
☒	☐	☐	Safety issues adequately defined.
☒	☐	☐	Hazardous material inventories defined and/or stated.
☐	☐	☐	Document format and content per approved preparation plan.
☒	☐	☐	Hazardous areas, complex areas, or processes within a facility or activity identified.
☐	☐	☒	Facility or activity type and hazard classification identified.
☐	☐	☒	Adequate engineering features or controls defined to reduce or control hazards.
☐	☐	☒	Safety boundaries of the facility or activity defined for this analysis.
☒	☐	☐	The level of detail corresponds to the hazards and risks.
☒	☐	☐	Risk of activity or process adequately defined.
☒	☐	☐	Risk acceptable per risk acceptance guidelines.
☒	☐	☐	Radiological dose consequences stated.
☐	☐	☐	Radiological dose consequences HEDOP approved.
☐	☒	☐	Frequency of accidents stated.
☒	☐	☐	Hazardous systems, components, or materials consistently emphasized and stated throughout the document.
☐	☐	☐	Appendices adequately support the document.
☐	☐	☐	References adequately support the document.
☒	☐	☐	All qualitative and quantitative analyses peer reviewed and approved.
☒	☐	☐	DOCUMENT APPROVED FOR FUNCTIONAL REVIEW

* All "NO" responses must be explained on this page or additional page.

Comments: Frequency of accidents was assumed to be 1 per year for risk acceptance purposes.

T.B. POWERS

Reviewer (Printed Name and Signature)

10/25/94

Date

T.B. Powers

HEDOP REVIEW CHECKLIST

Document Reviewed: "Accident Analysis for the Storage of Metallic in the Central Waste Complex (Revised)" Internal Memo by Mike Greutman, November 7, 1994, 8D141-094-045

Scope of Review: Whole Thing

Yes No* N/A

☒	☐	☐	1. A detailed technical review and approval of the environmental transport and dose calculation portion of the analysis has been performed and documented.
☒	☐	☐	2. Detailed technical review(s) and approval(s) of scenario and release determinations have been performed and documented.
☐	☒	☐	3. HEDOP-approved code(s) were used. <i>6XQ Version 3.1C</i>
☒	☐	☐	4. Receptor locations were selected according to HEDOP recommendations.
☒	☐	☐	5. All applicable environmental pathways and code options were included and are appropriate for the calculations.
☒	☐	☐	6. Hanford site data were used.
☒	☐	☐	7. Model adjustments external to the computer program were justified and performed correctly.
☒	☐	☐	8. The analysis is consistent with HEDOP recommendations.
☐	☒	☐	9. Supporting notes, calculations, comments, comment resolutions, or other information is attached. (Use the "Page 1 of X" page numbering format and sign and date each added page.)
☒	☐	☐	10. Approval is granted on behalf of the Hanford Environmental Dose Overview Panel.

*All "No" responses must be explained. The use of nonstandard methods must be justified.

HEDOP Reviewer: Paul D. Rittmann, PhD CHP

Paul Rittmann
Signature

Nov 7, 1994
Date

COMMENTS (add additional signed and dated pages if necessary):