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<p>7. Abstract</p> <p>This Interim Safety Analysis document supports the authorization basis for the interim operation and restrictions on interim operations for the near-surface land disposal of solid waste in the Solid Waste Burial Grounds. The Solid Waste Burial Grounds Interim Safety Basis supports the upgrade process for the safety analysis report and the technical safety requirements for the operations in the Solid Waste Burial Grounds. Accident safety analysis scenarios have been analyzed based on the significant events identified in the preliminary hazards analysis. The interim safety analysis provides an evaluation of the operations in the Solid Waste Burial Grounds to determine if the radiological and hazardous material exposures will be acceptable from an overall health and safety standpoint to the worker, the onsite personnel, the public, and the environment.</p>		
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Solid Waste Burial Grounds Interim Safety Analysis

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**SOLID WASTE BURIAL GROUNDS
INTERIM SAFETY ANALYSIS**

WHC-SD-WM-SARR-028

Revision 0

This document provides technical support for the Interim Safety Basis and the Technical Safety Requirements for the Solid Waste Burial Grounds.

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CHAPTER 1.0
PRINCIPAL DESIGN CRITERIA

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LIST OF TERMS

ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
DOE	U.S. Department of Energy
EDE	effective dose equivalent
EHSC	environmental hazard safety classification
EPA	U.S. Environmental Protection Agency
IEEE	Institute of Electrical and Electronics Engineers
LLW	low-level waste
MW	mixed waste
NFPA	National Fire Protection Association
PMF	probable maximum flood
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
RH	remote-handled
SSC	systems, structures, and components
SWBG	Solid Waste Burial Grounds
TRU	transuranic
UBC	<i>Uniform Building Code</i>
WAC	<i>Washington Administrative Code</i>
WHC	Westinghouse Hanford Company

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1.0 PRINCIPAL DESIGN CRITERIA

1.1 PURPOSE OF THE FACILITY

The purposes of the Solid Waste Burial Grounds (SWBG) are to permanently dispose of low-level waste (LLW) and mixed waste (MW) and retrievably store transuranic (TRU) waste. The SWBG are also used to dispose of remote-handled (RH) MW and store RH TRU wastes on a case-by-case basis. The MW will be disposed in trenches that meet appropriate regulatory requirements such as the *Resource Conservation and Recovery Act of 1976 (RCRA)*.

1.1.1 Waste Stream

The SWBG receive wastes generated at the Hanford Site in support of operation (primarily decontamination, decommissioning, waste management, and environmental restoration activities) of the various chemical processing and nuclear reactor facilities. Wastes are also received for storage or disposal from other Hanford Site contractors and other U.S. Department of Energy (DOE) facilities throughout the United States. In addition, the SWBG is the location for disposal of U.S. Department of Transportation Type B compliant waste packages in support of the U.S. Navy. Additional details on the types and quantities of radioactive and mixed waste currently in the active SWBG, as well as wastes to be received in the future, are presented in Chapter 3.0.

1.1.2 Products and Byproducts

The SWBG is not a production facility and therefore does not produce a "product" or "byproduct." Small quantities of radioactive wastes may be generated at the SWBG as a result of failure of waste containers and routine SWBG operations (e.g., contaminated clothing, sample bottles, leachate collection, etc.). These secondary wastes are handled and managed in accordance with established requirements.

1.1.3 Facility Functions

The main functions of the SWBG are the permanent disposal of LLW and MW, and the retrievable storage of TRU waste and irradiated fuel waste. The SWBG, in conjunction with the waste packages placed therein, provide confinement of radioactive/hazardous materials and protection of waste disposal packages from the effects of externally and internally initiated accidents.

1.1.4 Design Approach

The design of the SWBG accommodates a wide variety of waste characteristics, including RH and contact-handled waste packages of various sizes. The trench designs provide flexibility to receive commonly-used waste packages, such as 208-L (55-gal) drums, as well as large waste packages, such as defueled submarine reactor compartments and reactor pressure vessels. Bulk wastes, such as contaminated soils and debris, may also be placed in the SWBG.

The trench designs are intended to provide permanent near-surface confinement of LLW and MW and to provide retrievable storage for TRU waste. MW will be disposed in RCRA-compliant landfills. Radionuclide confinement is provided by the SWBG trench cover. The excavated trenches and soil backfill placed over filled trenches provide confinement by preventing precipitation from contacting and degrading the waste packages and also serve to retard radionuclide migration from failed waste packages. The soil backfill also protects the waste packages from heavy equipment accidents, earthquakes, range fires, etc. The soil provides shielding to reduce the radiation dose rates emitted from the trenches.

1.2 STRUCTURAL AND MECHANICAL SAFETY CRITERIA

The structural and mechanical safety criteria for the SWBG conform to the applicable requirements of the DOE Order 6430.1A, *General Design Criteria*, DOE Order 5480.1B, *Environment, Safety, and Health Program for Department of Energy Operations*, DOE Order 5820.2A, *Radioactive Waste Management*, and SDC-4.1, *Standard Architecture-Civil Design Criteria, Design Loads for Facilities* (RL 1991). The following subsections describe and reference the applicable general design loads for all SWBG facilities.

The trenches in the SWBG are non-Category 1 structures, i.e., they are facilities that do not perform a function required for nuclear criticality safety or whose failure will result in a significant release of radioactive, hazardous, or toxic materials as defined by DOE Order 5480.5, *Safety of Nuclear Facilities*. Environmental and geological features of the Hanford Site, which are used as design criteria, are addressed in the following subsections.

1.2.1 Wind

The SWBG is designed to meet the American National Standards Institute (ANSI) A58.1, *Minimum Design Loads for Buildings and Other Structures*, Section 6 (ANSI 1982), using the following criteria from SDC-4.1:

- Basic wind speed for Hanford Site -- 112.6 km/h (70 mi/h)
- Importance factor $I = 1.07$ (for 100-year recurrence interval)
- Exposure category, C.

The Hanford Site area is subject to prolonged, straight, and gusting winds. Therefore, the effects of wind loadings on the trenches from erosion and missile generation and the spread of contaminated bulk wastes are addressed in the design. Missile generation is discussed (and dismissed) in Section 1.2.4. Wind erosion is discussed below.

Wind erosion may be the major erosive contributor (as opposed to surface water, discussed in Section 1.2.3) over the long term. The U.S. Environmental Protection Agency (EPA) and the DOE have estimated a net soil loss of 7.9 metric tons/hectare/yr (3.5 ton/acre/yr), which exceeds the EPA recommended limit of 4.5 metric tons/hectare/yr (2 ton/acre/yr) (EPA 1979 and RL 1990, Appendix 11F). Thus, wind loadings need be addressed, with respect to any long-term potential to erode the trenches of the SWBG. Because the TRU

waste trenches are not intended for permanent disposal, long-term effects of soil erosion in the retrievable storage trenches are minimal. The long-term effects of soil erosion need to be considered in the design of LLW and MW disposal trenches, particularly in the design of the permanent covers to be placed over the burial grounds.

1.2.2 Tornadoes

Tornadoes are rare at the Hanford Site and tend to be small with only minor damage potential. Only 24 tornadoes have been reported within 160 km (100 mi) of the Hanford Site since 1916 (DOE 1987). An annual probability of $\approx 3 \times 10^{-6}$ is estimated for extreme winds approaching 160 km/h (100 mi/h) associated with a tornado (DOE 1987). The Hanford Site design basis tornado for Nonreactor Safety Class 1 facilities consists of a maximum horizontal wind speed of 160 km/h (100 mi/h), pressure drop of 960 Pa/m^2 (20 lb/ft^2), and rate of pressure change of $340 \text{ Pa/m}^2\text{-s}$ ($7 \text{ lb/ft}^2\text{-s}$) (RL 1991).

As with wind loadings (Section 1.2.1), the only conceivable effects of tornado loadings on the trenches would be erosion and missile generation. The latter is discussed (and dismissed) in Section 1.2.4. The *Low-Level Burial Grounds Dangerous Waste Permit Application* (RL 1990) suggests that wind erosion may be the major erosive contributor (as opposed to surface water, discussed in Section 1.2.3) over the long term (see Section 1.2.1). Thus, tornado loadings need to be addressed, but only in the same context as that for wind loadings, i.e., with respect to any long-term potential to erode the trenches of the SWBG. The TRU waste trenches are not intended for permanent disposal and the long-term effects of soil erosion are minimal, so these effects need not be addressed in the facility design.

1.2.3 Surface Water (Floods)

Annual precipitation averages 16 cm (6.3 in), with a range over an 80-year period from 8 to 29 cm (3 to 11.5 in). Forty percent falls from November through January and 11% from July through September. Extremes between 1946 and 1975 include three days when rainfall exceeded 2.5 cm/d (1 in/d). Rainfall of 2.5 cm/h (1 in/h) for one hour is expected only once every 500 years (DOE 1986, p. 3-159). At the other extreme, there were 81 days during the summer of 1967 without measurable precipitation. The maximum precipitation over 24 hours expected to occur once every million years is 30 cm (11 in).

According to SDC-4.1, the probable maximum flood (PMF) is $40,776 \text{ m}^3/\text{s}$ ($1,440,000 \text{ ft}^3/\text{s}$). Figure 3 in SDC-4.1 shows that the Columbia River mean sea level at the 100-B Area is 132 m (435 ft) and drops to 116 m (380 ft) at the 300 Area during the PMF. The Columbia River surface elevation resulting from a 50% breach of the Grand Coulee Dam is 140 m (460 ft) above mean sea level. The lowest point in the SWBG is about 200 m (660 ft) above mean sea level. Neither the PMF nor the 50% breach in Grand Coulee Dam would directly threaten the SWBG. Therefore, no design considerations are required for the PMF or the 50% breach in Grand Coulee Dam. As a result, dynamic water forces and flood loads are not a factor in the structural design for the SWBG facilities.

Based on the ability of the SWBG to withstand these worst-case precipitation and flood events, erosive effects from surface water can be dismissed as well. Thus, surface water effects on the trenches of the SWBG need not be addressed in the structural design of the SWBG facilities.

1.2.4 Missiles

This section addresses the effects of missile penetration due to high wind in terms of the penetrability of the solid waste containers within the trenches. Any possible resistance to this penetration (e.g., cushioning) from a filled trench is not considered. Thus, the results of the analysis for missile penetration of four Class A waste drum bundles are bounding (WHC 1992b, Section 6.1.4.2.3).

The following missile penetration requirements are from the Hanford Site design criteria for missiles for Nonreactor Safety Class 1 facilities (RL 1991):

- Sustained winds >145 km/h (>90 mi/h)
- Weight = 63.1 kg (139 lb) for a wood plank 0.10 m x 0.30 m x 3.66 m (4 in x 12 in x 12 ft), or 34.5 kg (76 lb) for a 0.076-m (3-in) standard steel pipe 3.0 m (10 ft) long
- End area = 0.027 m² (0.29 ft²) for the wood plank, or 0.0062 m² (0.067 ft²) for the steel pipe
- Horizontal velocity¹ = 97 km/h (88 ft/s) for the wood plank, or 65 km/h (59 ft/s) for the steel pipe.

Missiles of this magnitude are evaluated in WHC-SD-WM-SAR-047, *Retrievable Storage of Irradiated Fuels in the Solid Waste Burial Grounds* (WHC 1992a, Section 8.2.2.4) and WHC-SD-W025-PSAR-001, *Mixed Waste Lined Landfill (Project W025 Preliminary Safety Analysis Report* (WHC 1992b, Section 6.1.4.2.3). The results of these analyses indicate potential release of up to 0.29 Ci of ⁶⁰Co, yielding onsite and offsite inhalation doses of 0.020 rem and 3 x 10⁻⁴ rem, respectively. These are well below their respective release limits of 6.2 rem and 0.8 rem. Thus, missile penetration need not be addressed in the structural design of the SWBG facilities.

1.2.5 Seismic Phenomena

According to SDC-4.1 (RL 1991), earthquake loads for non-Category 1 structures, systems, and components will be calculated and designs will be in accordance with the *Uniform Building Code* (UBC), Chapter 23 (ICBO 1988), for

¹Vertical missile velocity is 2/3 horizontal, with no vectorial combination.

earthquake Zone 2, where applicable. Seismic design criteria are based primarily on the guidelines of UCRL-15910 (Kennedy et al. 1989) and the UBC.

A seismic network installed at Hanford in 1969 shows that most seismic events have been microearthquakes (magnitudes <3.5) at shallow depths (<5 km [<3 mi]) consisting of up to 100 events lasting a few days to several months (DOE 1988). Historically, tremors have been recorded since 1850. The largest occurred with an epicenter ≈ 137 km (≈ 85 mi) east of the SWBG with a surface wave magnitude of ≈ 5.8 . Other events in 1893, 1918, and 1979 measured <4.5 (RL 1990, p. 5-37).

The Washington Public Power Supply System estimated an annual frequency of 1×10^{-4} /yr for a seismic event exceeding 0.25g (Supply System 1981). The DOE estimated that such an event, with an assumed maximum surface-wave magnitude of 6.5, could produce maximum horizontal peak accelerations of 0.25g and 0.40g at exceedance levels of 50% and 16%, respectively (DOE 1988).

SDC-4.1 (RL 1991) specifies that seismic loadings for Safety Class 3 and 4 structures will be based on the provisions of Section 2312 of the UBC (ICBO 1988) for seismic Zone 2B. For the SWBG, the soil coefficient will be taken as 1.2.

For Safety Class 2 nonreactor structures, SDC-4.1 specifies a 0.12g horizontal and 0.08g vertical acceleration for the design basis earthquake. Thus, seismic loadings from a design basis earthquake producing 0.12g horizontal and 0.08g vertical acceleration must be addressed for Safety Class 2 SWBG facilities. Seismic response spectra are given in SDC-4.1.

For Safety Class 1 structures, SDC-4.1 specifies a 0.20g horizontal and 0.13g vertical acceleration for the design basis earthquake. There are no Safety Class 1 SWBG facilities.

1.2.6 Snow

Snow loadings on roofs or other exposed surfaces will be in accordance with ANSI A58.1, Section 7 (ANSI 1982). According to SDC-4.1, 73.2 kg/m^2 (15 lb/ft^2) will be used as the ground snow load but in no case will roofs be designed for less than 97.7 kg/m^2 (20 lb/ft^2) snow load.

Hanford experiences an average annual snowfall of 34 cm (13.4 in), with the snow depth exceeding 15 cm (5.9 in) approximately once every 8 years. The DOE reports the record snow accumulation on the ground to be 62 cm (24.5 in) in February 1916 (DOE 1986, p. 3-159). Any possible effects from snow accumulation would be much smaller than those from surface water (Section 1.2.4). Therefore, because surface water (flood) effects need not be addressed for the SWBG facilities, neither must snow.

1.2.7 Ashfall Loadings

Ashfall loadings are applicable only to Safety Class 1 structures. The design basis ashfall criteria are as follows (RL 1991):

Thickness of ashfall:	15.2 cm (6 in) uncompacted 7.6 cm (3 in) compacted
Duration of ashfall	24 hours
Maximum ashfall rate	1.14 cm/h (0.45 in/h) for 6 hours
Average ashfall rate	0.635 cm/hr (0.25 in/h)
Design ashfall loading:	0.767 kPa (16 lb/ft ²) dry, compacted 0.958 kPa (20 lb/ft ²) wet, compacted
Density of ash	1.153 g/cm ³ (72 lb/ft ³)
Dry, compacted	1.533 g/cm ³ (96 lb/ft ³)
Wet, compacted	1.162 g/cm ³ (72 lb/ft ³)

Ashfall loading is to be combined with snow loadings but is not to be combined with earthquake or wind loadings (RL 1991).

1.2.8 Process and Equipment

For a MW disposal trench, the liner system is intended to serve as a confinement barrier against leachate and hazardous material release. The liner system must maintain its integrity under normal and reasonably likely abnormal conditions arising from process and equipment. WHC (1990, Sections 5.1.1 to 5.1.3) addresses static and dynamic loads on the liner system during normal MW emplacement operations.

For a TRU waste trench, the asphalt pad on the bottom is mainly intended to provide stability for the containers. The asphalt pad should perform its intended function under normal and reasonably likely abnormal conditions arising from process and equipment activity. Plywood added between layers of drums improves stacking stability. Tarps placed over and around the stacked waste containers enhance retrievability by preventing soil from falling between containers. Normal conditions would include static and dynamic loads associated with the emplacement of the waste containers, including the equipment (e.g., trucks and forklifts) employed in the process. Reasonably likely abnormal conditions would include static and dynamic loads during an accident, such as a waste container upset during emplacement.

1.2.9 Subsurface Water

The subsurface hydrology for the Hanford Site is presented in detail by Last et al. (1989). Groundwater under the SWBG occurs in confined and unconfined aquifers. The upper portions of the latter include the water table, which lies from ~56 m (~180 ft) to 100 m (330 ft) below ground surface (DOE 1987, p. 4-18). At the SWBG, the water table lies ~73 m (~240 ft) below ground (Last et al. 1989, p. 6-21). Sources of natural recharge to this aquifer exist from rainfall, river and stream water, and runoff from

neighboring higher elevations. Artificial recharge occurs from waste water storage ponds. Westinghouse Hanford Company (WHC 1992a, Section 2.5) reports a natural recharge rate of 5,000,000 L/d (180,000 ft³/d) and an artificial recharge rate approximately 10 times higher.

RL (1990) addresses the potential for subsidence, sinkhole development, and uplift of the composite liner system beneath a MW disposal trench due to subsurface water effects. Last et al. (1989, p. 6-21) consider it unlikely that the groundwater level would ever rise enough to influence the SWBG. WHC (1990, Section 3.2) dismisses the need for groundwater investigations for a MW disposal landfill. Given the nature of the underlying soil (coarse-grained sand and gravel), the depth of the groundwater (≈ 73 m [≈ 240 ft]), and the absence of aquitards, this potential is negligible. This conclusion is applicable to further expansions, including additional MW disposal trenches. Thus, subsurface water effects on the trenches of the SWBG need not be addressed.

1.2.10 Other

Other forces could potentially impact the trenches of the SWBG. Crashes from general, commercial, or Hanford Patrol aircraft are dismissed from credibility due to their extremely low likelihoods ($< 1 \times 10^{-6}$ /yr). A train accident near a trench in the SWBG is deemed incredible. Thus, neither aircraft crashes nor train accidents need be addressed for possible effects on the trenches of the SWBG.

WHC (1990) addresses possible thermal (nonfire) stresses on the high-density polyethylene geomembrane to be employed in the liner system of a MW disposal trench. These stresses are expected to peak during installation of the liner. WHC (1990, Section 5.4.1) indicates that such strain under worst-case conditions will lie well below the high-density polyethylene liner yield strain. Thus, liner material thermal (nonfire) stresses need not be addressed.

1.2.11 Load Combinations

The following loads have been identified as potentially impacting the operation of the SWBG:

- Wind
- Tornadoes (long-term erosion only)
- Seismic phenomena
- Process and equipment
- Fire (fuel ignition during transport vehicle accident)
- Volcanic ashfall
- Snow.

The first two loads (wind and tornadoes) can be combined as one in terms of the long-term erosion potential on the SWBG trenches. The coincidence of any pair of these events (combining wind and tornadoes) is considered incredible (e.g., an earthquake occurring during emplacement operations which causes a transport vehicle accident with a resulting fuel fire). However, in

accordance with SDC-4.1, combinations of snow and volcanic ashfall loads must be addressed for Safety Class 1 structures. Other load combinations need not be addressed for the SWBG.

1.3 SAFETY PROTECTION

In addition to the structural and mechanical safety criteria discussed in Section 1.2, the following aspects of safety protection apply to the SWBG.

1.3.1 Special Considerations

The TRU waste must be stored so as to be retrievable. Once a permanent waste disposal repository is available to receive TRU waste for final disposal, the retrievable TRU waste containers will be removed from the TRU waste trenches of the SWBG.

1.3.2 Confinement Systems

The DOE provides general design criteria for radioactive solid waste facilities in Section 1324 of DOE Order 6430.1A. The following subsections are applicable to confinement systems associated with the SWBG:

- 1324-2.2.1, "Siting Design Objectives for Normal Operations and Anticipated Operational Occurrences — Disposal (Permanent Isolation) Facilities"
- 1324-5.3, "Low-Level Waste Disposal Facility Confinement"
- 1324-6.1, "Confinement Systems — General"
- 1324-6.4, "Confinement Systems — Tertiary Confinement System."

Confinement criteria must be addressed for TRU waste packages with respect to providing isolation during the retrievable storage period. For LLW, no additional confinement requirements are given beyond those stated in DOE Order 6430.1A. The subsections listed above indicate that the following items must be addressed with regard to the confinement systems of the SWBG:

- Whole body and organ annual dose equivalents
- Use of low permeability materials at the trench walls and bottom
- Minimization of contact between emplaced waste containers and water
 - Placement of a layer of highly permeable materials beneath the waste
 - Mounding of the soil surface
 - Use of a cover with low permeability, protected by an overburden layer

- Provision of a site diversion system for surface water during operation (but not after closure)
- Revegetation of the overburden
- Confinement system floors for storage of TRU waste designed to prevent puddles due to accidental flooding of the storage area
- Confinement by the natural geologic setting after closure
- Maintenance of functionality during normal operations, anticipated operating occurrences, and required design basis accidents, including severe natural phenomena
 - No maintenance after closure
 - Limitation of groundwater contaminant levels below the requirements of 40 CFR 141
 - Reliance on institutional controls for no more than 100 years to preclude reclamation activities.

Additional requirements for solid waste landfill design are provided in WHC-CM-7-5, *Environmental Compliance*. One requirement that relates to confinement systems states that the "landfill shall be designed to prevent contamination of the groundwater beneath the landfill" (Section 7.3.2.3[1]). The requirement further states the following.

- The design shall meet the arid design requirement that is to provide vadose zone moisture monitoring.
- Groundwater monitoring devices shall consist of at least one up-gradient well and three down-gradient wells.

1.3.3 Auxiliary Systems

With the exception of the MW disposal trenches, there are no supporting or auxiliary systems, such as electric power and sanitary sewage, needed to operate the SWBG. The design criteria for auxiliary systems for a MW disposal trench are addressed below.

WHC (1990) addresses the following auxiliary systems associated with MW disposal trenches:

- Leachate drainage system that, in addition to the liner system, consists of sump pumps, storage tank (with associated transfer pump), piping, and leachate level sensors
- Electric power, including area lighting
- Fire protection (see Section 1.3.6; also applicable to LLW and TRU facilities).

The leachate collection system is specific to MW lined trenches and requires supplied electric power (WHC 1992a, Section 8.2.1). With respect to electric power for the leachate collection MW trenches, the general design criteria in the following subsections of DOE Order 6430.1A apply:

- 1605-1
- 1605-2
- 1630-1
- 1630-2
- 1630-3
- 1650-1
- 1650-2
- 1660-99.0.

These subsections indicate that the following items must be addressed:

- Compliance of basic electrical materials and methods with National Fire Protection Association (NFPA) 70, ANSI C2, ANSI C84.1 (ANSI 1989), Institute of Electrical and Electronics Engineers (IEEE) 242 (IEEE 1986), and IEEE C37 (IEEE 1993)
- Compliance of load requirements with NFPA 70 (NFPA 193), IEEE 493 (IEEE 1990b), and the *Standard Handbook for Electrical Engineers* (Fink and Beaty 1993)
- Redundancy of electric power supply conforming with IEEE 399 (IEEE 1990a) and IEEE 493 (IEEE 1990b)
- Adequacy of exterior lighting, including both primary and emergency power supplies and selective manual/automatic switching systems. Lighting will comply with the *IES Lighting handbook* (IES 1981).

1.3.4 Nuclear Criticality Safety

Nuclear criticality safety design criteria are derived from the nuclear criticality safety requirements mandated by DOE Orders 5480.5 and 6430.1A and the referenced national consensus standards. The SWBG operating contractor has a nuclear criticality safety program whose purpose is to ensure that accidental criticality events will not occur. Assessments of criticality safety have been prepared for various waste disposal and storage activities. It has been determined that there should be no criticality safety concerns associated with operation of the SWBG because the fissile materials are in low concentrations in the wastes emplaced in the SWBG. However, the reactivities of all unique waste package and emplacement configurations must be analyzed as required by WHC-CM-4-29, *Nuclear Criticality Safety*, to ensure an adequate margin of subcriticality.

Criticality for the SWBG is addressed in WHC (1992a, Sections 8.2.1, 8.2.2.1, and Appendix E) and in CSER 91-003, *Criticality Safety Review for 1978-1990 Burial Ground Emplacements* (Hess 1994).

1.3.5 Radiation Protection

The SWBG must meet the radiological protection design criteria specified in DOE Orders 6430.1A, *General Design Criteria*, and 5400.5, *Radiation Protection of the Public and the Environment*. Facility designs and administrative controls will ensure that personnel exposures to radiation will be maintained as low as reasonably achievable (ALARA) and within the limits specified by these DOE orders.

In addition to the radiation protection measures discussed in Section 1.3.2, the SWBG is monitored under programs established for the Hanford Site. Radiation protection, including monitoring and health physics, must be addressed for the SWBG. These manuals and/or successor guidance documents include, but are not limited to, the following:

- WHC-CM-1-6, *Radiation Protection*
- WHC-CM-4-9, *Radiological Design Criteria*
- WHC-CM-4-11, *ALARA Program Manual*
- WHC-CM-4-12, *Operational Health Physics Practices Manual*
- WHC-CM-4-13, *Health Physics Procedures Manual*
- WHC-CM-4-15, *Radiation Work Requirements and Permits Manual*
- WHC-CM-4-16, *Dosimetry Manual*
- WHC-CM-7-5, *Environmental Compliance*
- ANSI N323-1978, *Radiation Protection Instrumentation Test and Calibration* (ANSI 1978)
- PNL-MA-0562, *Radiation Protection Instrumentation Manual* (PNL 1989).

1.3.6 Fire Protection

The SWBG facilities will be designed to ensure that the requirements for an "improved risk" facility, as defined in DOE Order 5480.7A, *Fire Protection*, and DOE Order 6430.1A, are met. Fire protection for the SWBG is provided by the Hanford Fire Department.

The general design criteria in the following subsections of DOE Order 6430.1A apply to the SWBG:

- 0101-2
- 0110-6.1
- 0110-6.2
- 0110-6.4
- 1530-1

- 1530-2
- 1530-9
- 1530-99.0.

In addition, applicable fire protection requirements are included in DOE Order 5480.7A, 29 CFR 1910, and NFPA 101 (NFPA 1991).

The requirements indicate that the following items must be addressed:

- Analysis of the facility to ensure that the objectives of DOE Order 5480.7A are met
- Ease of access by outside emergency personnel
- The need for an automatic fire suppression system will be determined by the fire hazards analysis. Typical examples of when a fire suppression system would be required are as follows:
 - Maximum possible fire loss >\$250,000
 - Hazard to human life exists
 - Danger exists for fire to release toxic or hazardous materials
 - Adequate separation from other facilities does not exist
 - Fire will cause unacceptable delays to important operations or program missions, as discussed in DOE 5480.7A
- Redundancy of fire protection systems or methods, including
 - Fire department response capability
 - Hazards involved during operation
 - Operating and program-mission effect of interruption and delays due to fire
- Compliance of portable fire extinguishers with NFPA 10 (NFPA 1990).

Portable fire extinguishers are also available, including those located on vehicles operating in or near the trenches. As required by the DOE, personnel must be trained in the use of portable fire extinguishers (RL 1990, p. 6-5).

1.3.7 Radioactive Waste Handling

Radioactive waste handling must be addressed for the trenches of the SWBG. Specific information on the following is provided for LLW, MW, and TRU waste in WHC-EP-0063, *Hanford Site Solid Waste Acceptance Criteria* (WHC 1993):

- Waste form definition
- Waste generation

- Waste characterization
- Waste container criteria
- Waste form criteria
- Waste package criteria
- Labeling and marking.

Waste characterization, an important aspect of waste handling, also follows *Washington Administrative Code (WAC) 173-303-070*.

1.3.8 Nonradiological Safety

Nonradiological hazards could arise from chemicals and compounds that will be placed in trenches. Possible release concentrations, both onsite and offsite, must fall below allowable limits (WHC-CM-4-46, *Nonreactor Facility Safety Analysis Manual*, Table 4-2). Thus, nonradiological hazards must be addressed for the trenches of the SWBG within the limits specified by WAC 173-303-070 and WHC-EP-0063 (WHC 1993).

1.4 CLASSIFICATION OF SYSTEMS, STRUCTURES, AND COMPONENTS

DOE Order 6430.1A, Section 1300-3, "Safety Class Criteria," requires that facility systems, structures, and components (SSCs) be designed, fabricated, erected, and tested to standards and quality commensurate with the hazards and potential consequences associated with both the facility and the role of each SSC in mitigating the consequences of design basis accidents. Accordingly, the DOE distinguishes between "safety class" items, defined as SSCs whose failure could adversely affect the environment or the safety and health of the public, and "nonsafety class" items. The management and operations contractor has established a safety class policy that implements the DOE safety class system as specified in WHC-CM-1-3, *Management Requirements and Procedures*, MRP 5.46, and as summarized in Table 1-1.

Safety class identifies and ranks those SSCs according to importance to safety and environmental protection, as stated in WHC-CM-1-3. Safety class determines hardware requirements and administrative control of hardware. Safety class is determined by the health effects of an unmitigated accident to onsite and offsite receptors and impact to the environment. Consideration for such an accident would include the inherent hazards associated with a facility based on material inventory, form, and dispersion. This is measured by the exposure a maximum offsite or maximum onsite receptor receives and threshold values placed on releases to the environment.

SSCs are Safety Class 1 if their failure results in an offsite exposure that exceeds the guidelines for the offsite receptor. SSCs are Safety Class 2 if their failure results in an onsite exposure that exceeds the guidelines for the onsite receptor. SSCs are Safety Class 3 if their failure does not exceed the exposure guidelines for the onsite receptor. It should be noted that comparing the exposures to the Safety Class criteria in WHC-CM-1-3 is waived.

The environmental releases are compared to the safety class criteria in WHC-CM-1-3 and summarized in Table 1-2.

1.4.1 Safety Class Analysis for Radiological Release to Maximum Onsite/Offsite Receptors

Bounding, unmitigated releases derived from accidents and natural events are analyzed in Chapter 6.0. There are no dose consequences that exceed the radiological risk comparison guidelines for maximum onsite and offsite receptors; therefore there are no Safety Class 1 or 2 SSCs associated with the SWBG operation.

1.4.2 Safety Class Analysis for Environmental Release

WHC-CM-1-3, MRP 5.46, defines an analysis to determine safety classification based on adverse environmental impact from dispersible radioactive materials. Because the radioactive materials in the SWBG are in dispersible form under accident conditions, an analysis is performed using the work sheet from WHC-CM-6-1, *Standard Engineering Practices*, Section EP-1.4, Appendix C, Figure C2 for the bounding release scenario in LLW, low-level MW, and TRU waste.

1.4.2.1 Bounding Environmental Hazard Safety Classification Scenario for Low-Level Waste. The seismic event in Section 6.2.2.3.5.1 is referenced for this analysis. The inventory as explained in Section 6.2.2.3.5.1 is assumed to be ^{90}Sr . It has a half-life of 29.1 years. The total isotopic inventory released to the environment is calculated as follows:

$$\left(1.5E+04 \frac{\text{Ci}}{\text{m}^3}\right) * \left(0.208 \frac{\text{m}^3}{\text{drum}}\right) * 1,164 \text{ drums} = 3,631,680 \text{ Ci}$$

The environmental hazard safety classification (EHSC) calculated in Figure 1-1 is 10,000, which corresponds to Safety Class 3.

1.4.2.2 Bounding Environmental Hazard Safety Classification Scenario for Low-Level Mixed Waste. The seismic event in Section 6.3.1.5.5 is referenced for this analysis. The total inventory of ^{90}Sr released to the environment is calculated as follows:

$$\left(1.5E+04 \frac{\text{Ci}}{\text{m}^3}\right) * \left(0.208 \frac{\text{m}^3}{\text{drum}}\right) * 34,482 \text{ drums} = 107,583,840 \text{ Ci}$$

The EHSC calculated in Figure 1-2 is 50,000, which corresponds to Safety Class 3.

1.4.2.3 Bounding Environmental Hazard Safety Classification Scenario for Transuranic Waste. The seismic event in Section 6.4.2.3.4.1 is referenced for

this analysis. The inventory is based on the isotopic distribution for 12% (nominal) ^{240}Pu aged 20 years as shown in Table 1 of Appendix 9D. The isotopic inventory released to the environment based on 6,072.1 g is calculated as follows:

Isotopes with half-life 1 - 100 years

^{238}Pu accounts for 1.37×10^{-2} Ci/g or 83.19 Ci
 ^{241}Pu accounts for 1.13 Ci/g or 6,861.47 Ci
Total = 6,944.66 Ci

Isotopes with half-life >100 years

^{239}Pu accounts for 5.20×10^{-2} Ci/g or 315.75 Ci
 ^{240}Pu accounts for $2.94 \text{ E-}02$ Ci/g or 178.52 Ci
 ^{242}Pu accounts for $1.17 \text{ E-}06$ Ci/g or 0.007 Ci
 ^{241}Am accounts for $5.99 \text{ E-}02$ Ci/g or 363.72 Ci
Total = 858 Ci

The EHSC calculated in Figure 1-3 is 2,000, which corresponds to Safety Class 3.

1.4.3 Conclusions

All bounding, unmitigated releases derived from accidents and natural events analyzed in Chapter 6.0 fall within the risk acceptance guidelines and, therefore, there are no Safety Class 1 or 2 systems, structures, or components.

1.5 DECOMMISSIONING AND POSTCLOSURE

Solid waste landfill design requirements related to decommissioning and closure are presented in WHC-CM-7-5, Section 7.3.2.3[5] and stated below.

- Closure shall be designed to minimize further maintenance.
- Closure design shall allow for continued monitoring until the landfill is stabilized.
- Deactivated trenches shall be covered with at least 0.6 m (2 ft) of 1×10^{-5} cm/s or lower permeability soil or artificial liners with a minimum thickness of 50 mil. The grade of surface slopes shall not be less than 2%, nor the grade of side slopes more than 33%.

These design requirements are applicable to permanent disposal facilities, including LLW and MW disposal landfills. The SWBG operating contractor is responsible for filling trenches, applying backfill materials, and applying soil dust control measures, such as revegetation. A separate organization will be responsible for application of the RCRA cover. Application of the RCRA cover will be addressed in separate safety documentation.

As discussed in Sections 1.1.1, 1.3.1, and 1.3.2, decommissioning and postclosure do not apply to the TRU waste trenches because TRU wastes are not currently permanently disposed of at the Hanford Site. Rather, these wastes are retrievably stored. Once a high-level waste repository can receive TRU wastes for final disposal, the wastes will be removed from the TRU waste trenches of the SWBG and transported offsite for permanent disposal.

At closure, a radiologic site survey will be conducted to characterize the site grounds. This survey will become part of the permanent decommissioning record to be used to judge compliance with applicable radiation standards. Postclosure considerations for SWBG trenches have been discussed in Section 1.3.2.

1.6 CHAPTER CRITERIA

A summary description of the types of information in the chapter is provided along with acceptance criteria derived from appropriate guidance documents.

1.6.1 Summary Description

The contents of this chapter demonstrate conformance with applicable design criteria requirements. The topics discussed include:

- Purpose of the facility
- Structural and mechanical safety criteria
- Safety protection systems
- Safety classification of systems and structures
- Decommissioning.

1.6.2 Acceptance Criteria

The acceptance criteria for this chapter are based on the following:

1. DOE Order 6430.1A, *General Design Criteria*
2. DOE Order 5480.7A, *Fire Protection*
3. DOE Order 5480.11, *Radiation Protection for Occupational Workers*
4. DOE Order 5400.5, *Radiation Protection of the Public and the Environment*
5. DOE Order 5820.2A, *Radioactive Waste Management*
6. DOE Order 5480.28, *Natural Phenomena Hazards Mitigation.*

Specific acceptance criteria are as follows.

1. The chapter should identify and demonstrate compliance with the safety criteria in the applicable DOE orders.
2. The chapter should provide an adequate description of and references to existing reports for the principal design criteria and analyses performed in the evaluations.
3. The conclusions should be supported by the analysis results.
4. Noncompliances should be fully evaluated and justified to demonstrate that the facility can be operated while meeting the intent of the safety requirements established by applicable DOE orders for the proposed operations in protecting the health and safety of the workers, the public, and the environment.

1.7 REFERENCES

1.7.1 Acts, Codes, Regulations, and Standards

- ANSI, 1978, *Radiation Protection Instrumentation Test and Calibration*, ANSI N323-1978 (Reaffirmed 1983), American National Standards Institute, Washington, D.C.
- ANSI, 1982, *Minimum Design Loads for Buildings and Other Structures*, ANSI A58.1-1982, American National Standards Institute, New York, New York.
- ANSI, 1989, *Electric Power Systems and Equipment - Voltage Ratings (60 Hertz)*, ANSI C84.1, American National Standards Institute, New York, New York.
- ANSI, 1990, *National Electrical Safety Code*, ANSI C2-1990, American National Standards Institute, New York, New York.
- Fink, D. G., and H. W. Beaty, 1993, *Standard Handbook for Electrical Engineers*, 13th Edition, McGraw Hill, New York, New York.
- IES, 1981, *IES Lighting Handbook*, Illuminating Engineering Society of North America, New York, New York.
- ICBO, 1988, *Uniform Building Code*, International Conference of Building Officials, Whittier, California.
- IEEE, 1986, *IEEE Recommended Practices for Protection and Coordination of Industrial and Commercial Power Systems*, IEEE 242, Institute of Electrical and Electronics Engineers, Piscataway, New Jersey.
- IEEE, 1990a, *IEEE Recommended Practices for Industrial and Commercial Power Systems Analysis*, IEEE 399, Institute of Electrical and Electronics Engineers, Piscataway, New Jersey.

- IEEE, 1990b, *IEEE Recommended Practices for the Design of Reliable Industrial and Commercial Power Systems*, IEEE 493, Institute of Electrical and Electronics Engineers, Piscataway, New Jersey.
- IEEE, 1993, *Circuit Breakers, Switchgear, Substations, and Fuses*, IEEE C37, Institute of Electrical and Electronics Engineers, Piscataway, New Jersey.
- NFPA, 1990, *Portable Fire Extinguishers*, NFPA 10, National Fire Protection Association, Quincy, Massachusetts.
- NFPA, 1991, *Safety to Life from Fire in Buildings and Structures*, NFPA 101, National Fire Protection Association, Quincy, Massachusetts.
- NFPA, 1993, *National Electrical Code*, NFPA 70, National Fire Protection Association, Quincy, Massachusetts.
- Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq.
- RL, 1991, *Standard Architecture-Civil Design Criteria, Design Loads for Facilities*, SDC-4.1, Rev. 11, U.S. Department of Energy, Richland Operations Office, Richland, Washington.
- WAC 173-303, 1990, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.
- 29 CFR 1910, "Occupational Safety and Health Standards," *Code of Federal Regulations*, as amended.
- 40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

1.7.2 Documents

- DOE, 1986, *Environmental Assessment: Reference Repository Location, Hanford Site, Washington*, DOE/RW-0070, U.S. Department of Energy, Office of Civilian Radioactive Waste Management, Washington, D.C.
- DOE, 1987, *Final Environmental Impact Statement - Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes*, DOE/EIS-0113, U.S. Department of Energy, Washington, D.C.
- DOE, 1988, *Site Characterization Plan: Reference Repository Location, Hanford Site, Washington*, DOE/RW-0164 (Consultation Draft), U.S. Department of Energy, Office of Civilian Radioactive Waste Management, Washington, D.C.
- EPA, 1979, *Design and Construction of Covers for Solid Waste Landfills*, EPA-600/2-79-165, Municipal Environmental Research Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio.

- Hess, A. L., 1994, *Criticality Safety Review for 1978-1990 Burial Ground Emplacements*, CSER 91-003, Westinghouse Hanford Company, Richland, Washington.
- Kennedy, R. P., S. A. Short, J. R. McDonald, M. S. McCann, and R. C. Murry, 1989, *Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards*, UCRL-15910, California Research Laboratory, Lawrence Livermore National Laboratory, Livermore, California.
- Last, G. V., B. N. Bjornstad, M. P. Bergeron, D. W. Wallace, D. R. Newcomer, J. A. Schranke, and M. A. Chamness, 1989, *Hydrogeology of the 200 Areas' Low-Level Burial Grounds - An Interim Report*, PNL-6820, 2 Vols., Pacific Northwest Laboratory, Richland, Washington.
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- WHC, 1990, *Definitive Design Report, Project W-025 Radioactive Mixed Waste Land Disposal Facility Non-Drag-Off*, WHC-SD-W025-FDR-001, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1992a, *Retrievable Storage of Irradiated Fuels in the Solid Waste Burial Grounds*, WHC-SD-WM-SAR-047, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1992b, *Mixed Waste Lined Landfill (Project W025) Preliminary Safety Analysis Report*, WHC-SD-W025-PSAR-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1993, *Hanford Site Solid Waste Acceptance Criteria*, WHC-EP-0063, Rev. 4 (or current revision), Westinghouse Hanford Company, Richland, Washington.

1.7.3 U.S. Department of Energy Orders

- DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, U.S. Department of Energy, Washington, D.C.
- DOE Order 5480.1B, *Environment, Safety, and Health Program for Department of Energy Operations*, U.S. Department of Energy, Washington, D.C.
- DOE Order 5480.5, *Safety of Nuclear Facilities*, U.S. Department of Energy, Washington, D.C.

DOE Order 5480.7A, *Fire Protection*, U.S. Department of Energy, Washington, D.C.

DOE Order 5480.11, *Radiation Protection for Occupational Workers*, U.S. Department of Energy, Washington, D.C.

DOE Order 5480.28, *Natural Phenomena Hazards Mitigation*, U.S. Department of Energy, Washington, D.C.

DOE Order 5820.2A, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C.

DOE Order 6430.1A, *General Design Criteria*, U.S. Department of Energy, Washington, D.C.

1.7.4 Controlled Manuals

WHC-CM-1-3, *Management Requirements and Procedures*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-1-6, *Radiation Protection*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-9, *Radiological Design Criteria*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-11, *ALARA Program Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-12, *Operational Health Physics Practices Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-13, *Health Physics Procedures Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-15, *Radiation Work Requirements and Permits Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-16, *Dosimetry Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-29, *Nuclear Criticality Safety*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-46, *Nonreactor Facility Safety Analysis Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-6-1, *Standard Engineering Practices*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-7-5, *Environmental Compliance*, Westinghouse Hanford Company, Richland, Washington.

Figure 1-1. Radioactive Material EHSC Calculation for LLW.

1. MATERIAL FORM Is the radioactive material dispersible (i.e., other than a consolidated or stabilized solid)? Dispersible materials include: liquids, sludges, gases, powders, and unconsolidated solids. ☐ No Stop. Associated items are safety class 3, other criteria permitting. ☒ Yes Proceed.																												
2. QUANTITY OF MATERIALS RELEASED			MF(2.) = 10,000																									
The following matrix provides multiplying factors which are a function of the total estimated curie content postulated to be released to the environment from the system(s), component(s), and/or structure(s) of interest. Group radioisotopes by half-life ($T_{1/2}$) category and show total amount (in Curies (Ci)) for each category: $T_{1/2} < 1$ yr: Amount = 0 Ci $T_{1/2} = 1$ to 100 yrs: Amount = 3,631,680 Ci $T_{1/2} > 100$ yrs: Amount = 0 Ci Mark the applicable multiplying factors below.																												
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3. TOTAL QUANTITY OF MATERIAL RELEASED [2] = 7.02 gal			MF(3.) = 1																									
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C. DISTANCE TO OFFSITE BOUNDARY [5] = >2500 feet			MF(4.C) = NA																									
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[1] Tritium is included in this category as an exception.

[2] Total quantity of radioactive material postulated to be released to the environment.

[3] 1 gallon = 3.785 liters, 1 gallon = 8.34 lbs (at 4 C, a specific gravity of 1, and atmospheric pressure)

[4] Examples of sensitive surface waters are the Columbia River and West Lake.

[5] Airborne pathways do not apply for this sensitive surface water or offsite boundary criterion (Table 1, criterion 12).

Figure 1-2. Radioactive Material EHSC Calculation for LLMW.

1. MATERIAL FORM Is the radioactive material dispersible (i.e., other than a consolidated or stabilized solid)? Dispersible materials include: liquids, sludges, gases, powders, and unconsolidated solids. ☐ No Stop. Associated items are safety class 3, other criteria permitting. ☒ Yes Proceed.																										
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>10 ⁵	MF=1,000	MF=10,000 ✓	MF=100,000																							
3. TOTAL QUANTITY OF MATERIAL RELEASED [2] = 208 gal <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%;">≤100 gal MF=1</td> <td style="width: 50%;">>1,000-10,000 gal ... MF=10</td> </tr> <tr> <td>>100-1,000 gal ... MF=5 ✓</td> <td>≥10,000 gal MF=100</td> </tr> </table>		≤100 gal MF=1	>1,000-10,000 gal ... MF=10	>100-1,000 gal ... MF=5 ✓	≥10,000 gal MF=100	MF(3.) = 5																				
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[4] Examples of sensitive surface waters are the Columbia River and West Lake.

[5] Airborne pathways do not apply for this sensitive surface water or offsite boundary criterion (Table 1, criterion 12).

Figure 1-3. Radioactive Material EHSC Calculation for TRU Waste.

1. MATERIAL FORM Is the radioactive material dispersible (i.e., other than a consolidated or stabilized solid)? Dispersible materials include: liquids, sludges, gases, powders, and unconsolidated solids. ☐ No Stop. Associated items are safety class 3, other criteria permitting. ☒ Yes Proceed.																										
2. QUANTITY OF MATERIALS RELEASED The following matrix provides multiplying factors which are a function of the total estimated curie content postulated to be released to the environment from the system(s), component(s), and/or structure(s) of interest. Group radioisotopes by half-life ($T_{1/2}$) category and show total amount (in Curies (Ci)) for each category: $T_{1/2} < 1$ yr: Amount = <u>0</u> Ci $T_{1/2} = 1$ to 100 yrs: Amount = <u>6,944.66</u> Ci $T_{1/2} > 100$ yrs: Amount = <u>858</u> Ci Mark the applicable multiplying factors below. <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left; border-bottom: 1px solid black;">Half-life</th> <th style="text-align: center; border-bottom: 1px solid black;">Amount (Ci)</th> <th style="text-align: center; border-bottom: 1px solid black;">< 1 yr. ^[1]</th> <th style="text-align: center; border-bottom: 1px solid black;">1-100 yrs.</th> <th style="text-align: center; border-bottom: 1px solid black;">> 100 yrs.</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">< 1</td> <td>MF=1 MF=10 MF=100</td> <td></td> <td></td> <td></td> </tr> <tr> <td style="text-align: center;">1-1000</td> <td>MF=10</td> <td>MF=100</td> <td>MF=1,000 ✓</td> <td></td> </tr> <tr> <td style="text-align: center;">$> 1000 - 10^5$</td> <td>MF=100</td> <td>MF=1,000 ✓</td> <td>MF=10,000</td> <td></td> </tr> <tr> <td style="text-align: center;">$> 10^5$</td> <td>MF=1,000</td> <td>MF=10,000</td> <td>MF=100,000</td> <td></td> </tr> </tbody> </table> MF(2.) = SUM of circled MFs = 2,000	Half-life	Amount (Ci)	< 1 yr. ^[1]	1-100 yrs.	> 100 yrs.	< 1	MF=1 MF=10 MF=100				1-1000	MF=10	MF=100	MF=1,000 ✓		$> 1000 - 10^5$	MF=100	MF=1,000 ✓	MF=10,000		$> 10^5$	MF=1,000	MF=10,000	MF=100,000		MF(2.) = 2,000
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$> 1000 - 10^5$	MF=100	MF=1,000 ✓	MF=10,000																							
$> 10^5$	MF=1,000	MF=10,000	MF=100,000																							
3. TOTAL QUANTITY OF MATERIAL RELEASED ^[2] = <u>13.4</u> gal																										
<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%;">≤ 100 gal MF=1 ✓</td> <td style="width: 50%;">$> 1,000 - 10,000$ gal ... MF=10</td> </tr> <tr> <td>$> 100 - 1,000$ gal ... MF=5</td> <td>$\geq 10,000$ gal MF=100</td> </tr> </table>		≤ 100 gal MF=1 ✓	$> 1,000 - 10,000$ gal ... MF=10	$> 100 - 1,000$ gal ... MF=5	$\geq 10,000$ gal MF=100																					
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$> 100 - 1,000$ gal ... MF=5	$\geq 10,000$ gal MF=100																									
4. PROXIMITY TO ENVIRONMENTAL RECEIVERS																										
A. DEPTH TO AQUIFER = <u>> 150</u> feet																										
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B. DISTANCE TO SENSITIVE SURFACE WATER ^[4] ^[5] = <u>> 2500</u> feet																										
<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%;">> 2500 feet NA ✓</td> <td style="width: 50%;">$100 - 500$ feet MF=20</td> </tr> <tr> <td>$> 1000 - 2500$ feet MF=9</td> <td>< 100 feet MF=25</td> </tr> <tr> <td>$> 500 - 1000$ feet MF=16</td> <td>Direct discharge to surface water ... MF=50</td> </tr> </table>		> 2500 feet NA ✓	$100 - 500$ feet MF=20	$> 1000 - 2500$ feet MF=9	< 100 feet MF=25	$> 500 - 1000$ feet MF=16	Direct discharge to surface water ... MF=50																			
> 2500 feet NA ✓	$100 - 500$ feet MF=20																									
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C. DISTANCE TO OFFSITE BOUNDARY ^[5] = <u>> 2500</u> feet																										
<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">> 2500 feet ... NA ✓</td> <td style="width: 33%;">$1000 - 2500$ feet ... MF=5</td> <td style="width: 33%;">< 1000 feet ... MF=10</td> </tr> </table>		> 2500 feet ... NA ✓	$1000 - 2500$ feet ... MF=5	< 1000 feet ... MF=10																						
> 2500 feet ... NA ✓	$1000 - 2500$ feet ... MF=5	< 1000 feet ... MF=10																								
5. CALCULATION OF ENVIRONMENTAL IMPACT FOR SAFETY CLASSIFICATION The EHSC is determined as follows where each term is the multiplying factor (MF) from the respective paragraphs above. Terms 4.A, 4.B, and/or 4.C are applied where legitimate pathways to the environment exist. EHSC = (2.)(3.)(4.A)(4.B)(4.C) = (2,000)(1)(1) = 2,000 EHSC = 2,000																										

[1] Tritium is included in this category as an exception.

[2] Total quantity of radioactive material postulated to be released to the environment.

[3] 1 gallon = 3.785 liters, 1 gallon = 8.34 lbs (at 4 C, a specific gravity of 1, and atmospheric pressure)

[4] Examples of sensitive surface waters are the Columbia River and West Lake.

[5] Airborne pathways do not apply for this sensitive surface water or offsite boundary criterion (Table 1, criterion 12).

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Table 1-1. Safety Class Designations.

Safety Class designation	Description	Criteria
1	Environmental and the health and safety of the public	Systems, components, or structures, including portions of process systems, whose failure could adversely affect the health and safety of the public.
2	Onsite worker and the safety of the public	Systems, components, or structures, including portions of process systems, not identified as Safety Class 1, whose failure could adversely affect the health and safety of onsite workers.
3	Health and safety of the facility workers and radioactive, chemical, or thermal releases to the environment	Systems, components, or structures, not identified as Safety Class 1 or 2, whose failure could preclude implementing ALARA principles, prevent monitoring unanticipated releases, and harm workers due to industrial safety hazards.

ALARA = as low as reasonably achievable.

Table 1-2.
Safety Class Criteria.

Safety class	EHSC criteria
1	$\geq 1,000,000$
2	$\geq 500,000$ to $< 1,000,000$
3	$< 500,000$
4	*

*No applicable criteria.

EHSC = environmental hazard safety classification.

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CHAPTER 2.0
FACILITY DESIGN

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LIST OF TERMS

DOE	U.S. Department of Energy
EBR-II	Experimental Breeder Reactor No. 2
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FFTF	Fast Flux Test Facility
HEPA	high-efficiency particulate air (filter)
LLW	low-level waste
MW	mixed waste
RCRA	Resource Conservation and Recovery Act
RH	remote-handled
SRC	submarine reactor compartment
SWBG	Solid Waste Burial Grounds
TRIGA	Training, Research and Isotope production reactor-General Atomics
TRU	transuranic
WHC	Westinghouse Hanford Company

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2.0 FACILITY DESIGN

2.1 SUMMARY DESCRIPTION

Low-level waste (LLW) and low-level mixed waste (MW) are disposed of in excavated trenches on the Hanford Site. Transuranic (TRU) wastes are retrievably stored in trenches at Hanford. Most of the TRU wastes are covered with soil backfill material, but some of the TRU waste packages remain uncovered.

The active Solid Waste Burial Grounds (SWBG) include eight burial grounds comprised of a number of trenches and the Environmental Restoration Disposal Facility (ERDF). Six burial grounds are located in the 200 West Area and two are located in the 200 East Area. The ERDF area burial grounds adjoin the 200 West Area and extend between the 200 West and East Areas. A list of the burial grounds, a current assessment of their status, and a brief assessment of the types of waste in each burial ground is provided in Table 2-1.

2.2 PRINCIPAL DESIGN FEATURES

This section discusses the principal design features of the various elements of the SWBG. These discussions address, where applicable, landfill configuration and support areas (e.g., unloading facility, access ramp), storage/disposal area, backfill, *Resource Conservation and Recovery Act of 1976* (RCRA)- and/or U.S. Department of Energy (DOE)- compliant cover(s), and leachate management systems, which may be installed to mitigate release of leachate to the environment. The latter system includes liners, collection piping and drain field, monitoring system (e.g., leachate level sensors), recessed sump pump, and aboveground facilities to handle collection and temporary storage of leachate material. Separate subsections are provided for discussions regarding LLW (Section 2.2.1), MW (Section 2.2.2) and TRU waste (Section 2.2.3).

The applicable design criteria are those for existing burial ground facilities and equipment. DOE Order 6430.1A, *General Design Criteria*, which includes special nonreactor nuclear facility requirements, has been reviewed for applicability to the burial ground operations addressed in this safety analysis. No special requirements are found to be directly applicable to the waste packages, burial grounds, or handling equipment. A complete description of design requirements is provided in Chapter 1.0.

The principal design criteria described in Chapter 1.0 were reviewed to identify the design features that satisfy the design criteria. The design criteria and corresponding design features relevant to the SWBG are described below:

- **Wind, Tornado Loadings** — The effects of high winds and tornadoes on the trench designs are applicable to only long-term erosion of the trench backfill and RCRA- or DOE-compliant covers. Cover designs will include measures to mitigate wind erosion, such as covering the

backfilled trenches with gravel and/or revegetating the backfill to minimize blowing dust. The effects of long-term erosion on the final covers are not in the scope of this analysis.

- **Floods** — It is concluded in Chapter 1.0 that the SWBG are located well above the elevations expected to be flooded following the probable maximum flood of the Columbia River as well as the 50% breach of the Grand Coulee Dam. As a result, dynamic water forces and flood loads are not a factor in the structural design for the SWBG facilities.
- **Missiles** — It is concluded in Chapter 1.0 that the effects of wind-driven missiles need not be considered in the design of SWBG facilities.
- **Seismic** — The frequencies and consequences of seismic events are addressed in Chapter 6.0, "Accident Safety Analysis."
- **Snow** — The design criteria for snow loadings are determined to be not applicable to trenches in the SWBG because there are no structures associated with the SWBG.
- **Volcanic Ashfall** — The design criteria for volcanic ash loadings are determined to be not applicable because there are no structures associated with the SWBG.
- **Process and Equipment Loadings** — The accident analysis in Chapter 6.0 addresses the frequencies and consequences of process and equipment accidents.
- **Subsurface Water** — In Chapter 1.0, it is shown that, due to the nature of the underlying soil (coarse-grained sand and gravel), the depth of the groundwater, and the absence of aquitards, the effects of subsurface water on the SWBG are negligible. Thus, subsurface water effects on the trenches of the SWBG are not addressed.
- **Other Loads** — Other potential loads that are examined for the SWBG trenches included those from possible aircraft, train, and truck accidents as well as fires. The frequencies of aircraft and train crashes into the trenches are concluded to be incredible and thus are not considered in the design. The frequencies and consequences of potential truck accidents, including mechanical disruption from the crashes as well as thermal loadings induced by potential vehicle fuel fires, are evaluated in Chapter 6.0, "Accident Safety Analysis."

Additional design criteria applicable to confinement systems that are described in Chapter 1.0 include (1) use of low-permeability materials on trench walls and bottoms, (2) minimization of contact

between waste containers and standing water, (3) revegetation of overburden, and (4) confinement after backfilling. These items are addressed below.

- (1) Low-permeability materials: The TRU waste trenches may have an asphalt pad on the bottom of the trench to provide stability during emplacement, storage, and future retrieval operations.
- (2) Minimization of contact: The MW lined landfills may include a leachate collection system which minimizes the risks of releases to the environment.
- (3) Dust control: Operational procedures have been implemented to control dust and minimize wind-borne spread of potentially contaminated material. Methods currently employed at the Hanford Site include revegetation, gravel layers, and spray fixative.
- (4) Confinement after backfilling: An ≈ 1.3 m (≈ 4 ft) layer of backfill material is placed over a filled trench. This effectively protects the wastes from mechanical and thermal accident conditions (e.g., range fires, seismic events). Waste containers also provide a confinement barrier after backfilling. A groundwater monitoring program (see Chapter 1.0) has been established to detect the presence of radioactive materials, which could indicate waste package deterioration.

Some waste packages may require special handling or remote handling because of their weight, dimensions, or other features.

2.2.1 Low-Level Waste

The active LLW disposal burial grounds are classified as a landfill and cover a total area of ≈ 2.1 million m^2 (518 acres; RL 1989, p. 2-5).

LLW is generally received packaged within 208-L (55-gal) steel drums and steel boxes, although concrete burial vaults, other accepted burial containers, and inherently stable waste packages may also be disposed. Concrete drag-off boxes have been used for wastes that exceed 200 mrem/h surface radiation dose rate. The drag-off boxes, which are approximately $61.5 m^3$ ($2,170 ft^3$) in volume, were transported to a trench by a flatbed railroad car or truck. These operations are no longer performed in the SWBG. A listing of LLW received through December 1992 is provided in Table 2-2A.

The principal design criteria described in Chapter 1.0 have been reviewed to identify the design features that satisfy the design criteria. The design criteria and corresponding design features relevant to the LLW disposal trenches include: wind and tornado loadings; floods; missiles; seismic; snow; volcanic ashfall; process and equipment loadings; subsurface water; and other loads. Descriptions of the designs of SWBG disposal trenches are provided in the following paragraphs.

Flat-bottom trenches nominally range from 5.2 m (17 ft) to 24.4 m (80 ft) deep (see Figure 2-1). An engineering analysis is performed for trenches over 6.1 m (20 ft) deep to ensure stable slopes during the operational life. Bottom dimensions range from 4.9 m (16 ft) to over 30 m (100 ft) wide. Trench slopes are normally 1.5H:1V to avoid sloughing of the trench walls. Modifications are made to these trench designs as needed to accommodate a variety of waste packages. Trench bottoms are stabilized to the extent necessary to ensure sound bearing for waste handling equipment. The flat-bottom trenches are routinely backfilled with a minimum of 1.2 m (4 ft) of soil.

Small quantities of remote-handled (RH) (dose rate greater than 200 mrem/h at the waste container surface) LLW are retrievably stored in covered caissons (Figure 2-2). All caissons in the SWBG are located in trench 14 of the 218-W-4B burial ground. Caissons for storage of RH LLW are referred to as beta-caissons. Beta caissons are similar in design to the alpha caissons described in Section 2.2.3.3.

2.2.2 Mixed Waste

The MW disposal trenches are compliant with the requirements of the RCRA or applicable environmental regulations. Principal design features of a MW disposal landfill are discussed in Section 2.2.2.1. In most cases, references are made to the design as outlined in Westinghouse Hanford Company (WHC) document WHC-SD-W025-FDR-001, *Definitive Design Report, Project W-025 Radioactive Mixed Waste Land Disposal Facility Non-Drag-Off* (WHC 1990). To facilitate locating design information in WHC (1990) and to account for direct quotations as appropriate, paragraph references are given in parentheses throughout Section 2.2.2.1. Section 2.2.2.2 presents the design criteria for the submarine reactor compartment (SRC) trench. A listing of MW received through December 1992 is provided in Table 2-2B.

2.2.2.1 Mixed Waste. The MW disposal trenches receive waste that meet the applicable land disposal restrictions. Waste forms are containerized, inherently stable, and/or bulk waste. If approved by the SWBG operating contractor, nonstandard waste packages and miscellaneous equipment waste may also be placed in a MW disposal trench. Less than 5% of the waste is expected to be RH material, which will be shielded or backfilled to minimize worker exposure. The landfill will be filled in balanced layers to ensure the liner is not differentially loaded to the point it is damaged.

The following is a general description of a lined MW trench. Future trenches are likely to vary in size, shape, and other design details. However, from a safety standpoint, they will be identical in that they will be in compliance with the applicable regulations.

Geomembranes incorporated in the design primarily function in this application as a protective barrier to prevent leachate from reaching the environment. Water infiltration is anticipated to be very low, as discussed in this section under water infiltration.

The MW disposal trenches have a liner system that consists of admix, geosynthetic liner materials, and the leachate drainage system. This liner

system will prevent the release of leachate to the environment and prevent migration of any hazardous constituents through the liner during the operational life of the landfill.

The leachate collection system is capable of collecting and removing leachate such that a nominal hydraulic head on the liner is not exceeded. A low-capacity pump will handle the normal, average leachate flow. When adverse precipitation conditions require a higher capacity, such as for the assumed worst-case precipitation event, a high-capacity pump is available. The pumps and associated piping will be resistant to the leachate.

The leachate temporary storage tank will be evacuated using the discharge nozzle from the base of the tank. The discharge piping has been routed such that the discharge is directed back into the tank containment sump in the event the transfer is started without a tanker connected to the discharge (WHC 1990, Section 6.4.1.3).

Leachate level sensors will be used for monitoring both the primary and secondary collection systems. The system consists of a transducer installed next to the pumps, which will transmit a signal, proportional to the water level, to a current-sensitive relay in the control panel. This signal will also be displayed as "inches of water" on the front of the panel. The current-sensitive relays can be used to switch the pumps on and off.

Storage tanks are provided for temporary leachate storage. It has a discharge nozzle on the bottom of the tank at one end and an influent fitting on the top. The tank has a float-actuated mechanical level indicator on one end, and two openings to allow access for inspection and painting. The tank and pressurized piping are protected from freezing by insulation and heat tape.

The design features of the MW disposal trenches that satisfy the general design criteria listed in Chapter 1.0 are as follows:

- Wind, Tornado Loadings — See Section 2.2.
- Floods — See Section 2.2.
- Missiles — See Section 2.2.
- Seismic — See Section 2.2.
- Snow — A very conservative estimate of maximum snowmelt is 3 cm (1.2 in). This would occur if the 25-year snow is assumed to be 0.3 m (12 in) and the water content is 10%. During a 20-minute peak period, the precipitation rate would be 3.8 cm/h (1.5 in/h) or 1.3 cm (0.5 in) total. If the temperature rises from 0 °C (32 °F) to 10 °C (50 °F), the increase in precipitation would be 20%. The landfill is designed to handle these scenarios in maintained ditch systems.
- Volcanic Ashfall — See Section 2.2.

- **Process and Equipment Loadings** — In granular, cohesionless, and drained soils such as those underlying the MW disposal trenches, the stability of the subgrade side slope is primarily related to the maximum slope angle. The results of an infinite slope stability analysis for slopes cut at 3H:1V have been evaluated. The results indicated factors of safety for static and dynamic stability of 2.4 and 1.7, respectively (WHC 1990, Section 5.1.1). The same analyses are performed for the geosynthetic interface liners on the side slope and for the operations layer. Static and dynamic factors of safety are 1.8 and 1.3, respectively (WHC 1990, Section 5.1.2). To assess ramp stability, these analyses are performed on each liner interface using a maximum vehicle weight of 100 tons. In the dynamic analyses, a vehicle braking force equal to 30% of the static vehicle weight is incorporated into the stability equation. The factors of safety for static and dynamic stability are 7.2 and 5.3, respectively; these are well above the U.S. Environmental Protection Agency (EPA) recommendations of 3 and 2, respectively (WHC 1990, Section 5.1.3). Higher loads are permissible subject to engineering evaluation to ensure the EPA-recommended safety factors are not exceeded.

The bearing capacity of the subgrade soil is of primary concern in the foundation design of the leachate collection tank and control building foundations. All structural fill will be moisture conditioned and compacted to at least 95% of the maximum modified Proctor dry density, and all native soils will be compacted before construction. The maximum allowable bearing capacities are summarized as follows (WHC 1990, Section 5.1.6):

- Compacted structural fill in Eolian sand 4,000 lb/ft²
- Dense native sands and gravel 6,000 lb/ft²
- Proof rolled silty sands (Eolian sand) 5,000 lb/ft².

The settlement of foundation soils and the potential for sinkhole or for uplift of protective liners is another consideration in stability of the structure. The subgrade settlement produced by waste loading will be essentially elastic in behavior; it will rebound during the excavation phase of construction and will settle as the landfill is filled. An elastic settlement analysis is performed to determine the magnitude of the total and differential settlement. The maximum subgrade settlement after the landfill is filled will be about 5 cm (2 in) with a maximum differential settlement of approximately 1.3 cm (0.5 in) (WHC 1990, Section 5.2). The admix liner will be placed and compacted to nearly 100% saturation. When the admix liner is loaded with waste, the admix pore water pressure will increase as the liner tries to compress under the load. The pressure gradient that exists between the admix and the surrounding porous soil will drive pore water out of the admix into the surrounding soil. As the pore water leaves the admix, the excess pore water pressure will decrease and the admix will consolidate. The maximum consolidation settlement after the landfill is filled will be about 3.8 cm (1.5 in) with a maximum differential settlement of about 1.3 cm (0.5 in) (WHC 1990, Section 5.2.2). The total settlement (subgrade and admix) will be

about 10 cm (4 in) with a maximum differential settlement of approximately 2.5 cm (1 in). The total and differential settlements of this magnitude are not expected to cause a problem with the design or operation of the landfill.

- **Subsurface Water** — In Chapter 1.0 it is shown that, due to the nature of the underlying soil (coarse-grained sand and gravel), the depth of the groundwater, and the absence of aquitards, the effects of subsurface water on the SWBG trenches are negligible.
- **Other Loads** — Other potential loads that are examined for the MW disposal trenches included those from possible aircraft, train, and truck accidents as well as fires. The frequencies of aircraft and train crashes into the SWBG trenches are concluded to be incredible and thus are not considered in the design. The frequencies and consequences of potential truck accidents, including mechanical disruption from the crashes as well as thermal loadings induced by potential vehicle fuel fires, are evaluated in Chapter 6.0, "Accident Safety Analysis."

Additional design criteria applicable to confinement systems that are described in Chapter 1.0 include (1) use of low-permeability materials on trench walls and bottoms to prevent water infiltration, (2) dust control, (3) confinement after backfilling, and (4) long-term maintenance. These items are addressed below.

- (1) **Low-permeability materials:** Water infiltration is minimized as a result of (1) the multiple layer geomembrane protective barrier, (2) the location of groundwater relative to the bottom of the landfill, (3) the lack of precipitation in the semiarid area, and (4) the characteristics of the sandy soil, which prevent standing water from occurring. On the average, the Hanford Site has approximately 16 cm (6.3 in) of precipitation each year and groundwater levels in the vicinity of the landfill are typically tracked at 82 m (270 ft) below the ground surface. Backfill material will be placed over the top of the uppermost waste package in the landfill. While this is not expected to be the final cover for the site, it will accommodate placement of a RCRA-compliant cover at a future date (WHC 1990, Section 6.6).
- (2) **Dust control:** Operational procedures have been implemented to control dust and minimize wind-borne spread of potentially contaminated material. Generation of fugitive dust will be mitigated by using water sprayers on the tipper trailers or the use of fixatives during the dumping of bulk wastes. Fugitive dust may be minimized with the application of water or a physical fixative along the exposed waste face.
- (3) **Confinement after backfilling:** The liner and leachate collection systems are designed to ensure long-term isolation of the waste and will provide collection and monitoring during emplacement and during postclosure.

A RCRA-compliant cover design will be completed before closure of the landfill disposal site.

The potential for subsidence and sinkhole development and for potential uplift of the composite liner system is negligible. This is because the soil underlying the landfill tends to be coarse-grained sands and gravel, the groundwater is 73 m (240 ft) below the sites, and perched groundwater is unlikely to develop as a result of the absence of aquitards in the coarse-grained sediments. In addition, gas pressures are unlikely to develop as a result of the lack of gas generating sediments and the dissipating nature of the coarse-grained sediments.

- (4) Long-Term Maintenance. Maintenance requirements will exist for the leachate collection system and the general landfill conditions. The leachate storage tank is designed to hold the leachate until it is removed for disposal. Two openings will be provided to allow access for inspections and painting. The tank and pressurized piping will be protected from freezing by insulation and heat tape (WHC 1990, Section 6.4.4.2). To protect the tank from the leachate, a tank coating is selected that will not be reactive with any of the compounds that might be expected to occur in the leachate at high concentrations.

Additional long-term maintenance of the site may include repairs to liners, covers, ditches, utilities, and access roads. The need for maintenance is often established when reviewing results from inspection and monitoring programs. Periodic inspection of ditches for subsidence, settlement, displacement, plant growth, and animal habitation are all important in maintaining the long-term integrity of the site.

2.2.2.2 Submarine Reactor Compartment Trench. The SRC transport and placement operations are performed by the Department of the Navy and its contractors and are outside the scope of this interim safety analysis.

The SRC disposal trench (see Figure 2-2) is designated trench 94 in the 218-E-12B burial grounds located in the northeast corner of the 200 East Area. Trench 94 is managed as a MW disposal unit by agreement with the Washington State Department of Ecology.

The SRC waste is classified as a state-only regulated hazardous waste due to the presence of shielding lead. The waste package is classified as a bulk waste with the characteristics of a U.S. Department of Transportation Type B container carrying highway route controlled quantities of radioactive material (49 CFR 173.403). The Department of the Navy has obtained a certificate of compliance (NRC 1989) with the Type B packaging criteria. This compliance provides a high level of confidence that the SRC waste will not represent a hazard to personnel or the environment.

The SRC unit is a section of a submarine or ship that contains the sealed defueled reactor compartment, associated components, bulkheads, and hull sections. Once placed, the SRCs are managed in the same manner as any other LLW. Because of its structural characteristics, the SRC waste package is impervious to wind, rain, dust, fire, etc. The structural support columns have been designed in accordance with the earthquake standards applicable to the Hanford Site (Figure 2-3).

2.2.3 Transuranic Waste

TRU wastes are retrievably-stored in the SWBG until facilities are available to treat and dispose of these wastes, either onsite or elsewhere. Onsite facilities other than the SWBG that are used for TRU waste storage include the Central Waste Complex and the Transuranic Storage and Assay Facility. All of the retrievably stored TRU wastes are planned to be retrieved, processed through the Waste Receiving and Processing Facility, and transported to the Waste Isolation Pilot Plant for final disposal. A listing of TRU waste packages received through December 1992 is provided in Table 2-2C. The table lists the waste package name, waste type, approximate dimensions, approximate radioactive content, and other important information.

The retrievable storage of TRU wastes in the SWBG requires existing and routinely used equipment.

The principal features of the retrievably stored TRU waste that protect against releases of radioactive and hazardous materials are the strength, containment, and leach resistance provided by the waste packages. To satisfy shipping requirements, the TRU waste packages must meet, at a minimum, the Type A package requirements listed in Table 2-3. Consequently, the waste packages will not release significant quantities of the contained radioactive and hazardous materials except under severe accident conditions. Since the TRU waste packages are planned eventually to be retrieved from the SWBG, their long-term performance (i.e., after the SWBG post-closure care period) under disposal conditions is not applicable.

2.2.3.1 Retrievable Storage of Covered (Backfilled) TRU Waste Packages. The bulk of the retrievably-stored TRU wastes are located in backfilled trenches in the active SWBG in a variety of containers. The trenches have various dimensions, depending upon the specific waste type to be emplaced. Nominal dimensions are approximately 2.4 to 5.5 m (8 to 18 ft) deep, 183 m (600 ft) in length, and 7.6 m (25 ft) wide.

In past practice, TRU waste packages have been stacked up to five layers high in the trenches, with each layer covered with plywood. The retrievably stored TRU waste trenches have been backfilled with a minimum 1.2-m- (4-ft-) thick layer of soil to reduce radiation dose rates and minimize any possible spread of contamination from the trench. A diagram of a typical backfilled TRU waste trench is presented in Figure 2-4.

Operations in backfilled trenches are currently limited to routine maintenance and surveillance activities, including removal of combustible material, repairing subsidence, and groundwater monitoring.

2.2.3.2 Retrievable Storage of Uncovered Contact-Handled Transuranic Waste Packages. The uncovered TRU waste packages are located in the 218-W-04C burial ground in trenches 1, 20, and 29. The trenches are similar in design to those used in the past and incorporate an asphalt pad for waste package stacking stability. The uncovered TRU wastes are packaged in 208-L (55-gal) drums and various boxes and other approved waste packages. No special design features are required for these trenches.

2.2.3.3 Retrievable Storage of Remote-Handled Transuranic Waste Packages. There are two main types of RH TRU waste operations in the SWBG: (1) irradiated fuel wastes and (2) wastes in the alpha caissons. The principal design features for these waste operations are discussed in this section. Irradiated fuel wastes are defined as RH TRU wastes based on DOE Order 5820.2A, *Radioactive Waste Management*, which states that:

"Test specimens of fissionable material irradiated for research and development purposes only and not for the production of power or plutonium may be classified as remote-handled transuranic waste."

All of the irradiated fuel wastes in the SWBG are in compliance with this description.

Irradiated Fuel Waste Retrievable Storage. A number of different types of containers provide shielding and containment of radioactive wastes to meet retrievable storage requirements. The containers also meet the requirements to transport the wastes to the SWBG. Various types of irradiated reactor fuel wastes, including irradiated Training, Research and Isotope production reactor-General Atomics (TRIGA), Light Water Reactor, and Fast Flux Test Facility irradiated fuel wastes have been placed in the SWBG. These wastes, which in many cases are small fragments and pellets, are within sealed containers that are placed within the waste package. The waste packages are contact-handled, but some of the waste materials themselves are highly radioactive. Therefore, they are addressed here as RH TRU wastes. Irradiated fuel waste packages exist in both covered (i.e., backfilled) and uncovered conditions.

The SWBG trenches containing uncovered irradiated fuel wastes are located within the Hanford Site 200 West Area in the 218-W-04C burial ground. The retrievable storage of uncovered Experimental Breeder Reactor No. 2 (EBR-II) waste packages is discussed in WHC-SD-WM-SAR-047, *Retrievable Storage of Irradiated Fuels in the Solid Waste Burial Grounds* (WHC 1992). Uncovered irradiated fuel wastes are placed within either single- or double-encapsulated containers before being placed within the EBR-II casks. The inner containers are constructed of stainless steel pipe and are welded shut and leak tested. The length and diameter of the inner containers are designed for remote loading into the EBR-II cask cavity, stacked to the cavity height, and are supported to prevent movement during transportation and handling activities. The EBR-II cask is a cylindrical steel vessel with outer dimensions of 44.5 cm (17.5 in) in diameter by 151 cm (59.5 in) long. The internal cavity of the cask is 15 cm (6 in) in diameter and 107 cm (42 in) long. The cask is constructed of carbon steel with 12.7 cm (5 in) of poured lead for shielding. The cask closure consists of a bolted lid and gasket.

Irradiated fuel waste packages also have been placed in covered retrievable storage. The EBR-II casks discussed above also have been used for covered storage of irradiated fuels in the 218-W-03A burial ground. The practice of covering irradiated fuel waste packages is no longer performed at the Hanford Site.

Two additional waste package designs have been used for covered retrievable storage of irradiated fuel wastes in the SWBG: shielded 208-L (55-gal) drums and concrete casks. TRIGA reactor fuel wastes are stored in shielded 208-L Department of Transportation 7A steel drums (Martin 1986; see Figure 2-5) in the 218-W-04C burial ground. The drum is constructed of 16-gauge low carbon steel. The external dimensions of the drum are 57.2 cm (22.5 in) in diameter by 85.1 cm (33.5 in) high. The shielding is provided by concrete and a 15.2 cm (6 in) lead liner.

The TRIGA fuel assemblies measure 3.6 cm (1.4 in) in diameter by 72 cm (28.3 in) long. The fuel assemblies are in the form of zirconium-uranium hydride with aluminum cladding. Six to seven assemblies are placed inside a lead-lined inner container within each drum. The inner container is closed with a lead-filled bolted lid. The annular space between the inner container and the drum walls is filled with concrete (≈ 10.2 cm [4 in] thick). The TRIGA fuel elements are low in plutonium content (≈ 1 g/drum) and contain approximately 8 wt% uranium. The contents of the drums that contain TRIGA fuel are limited to a maximum fissile material quantity of 425 g equivalent of ^{239}Pu , maximum TRU content of 0.5 Ci, and maximum of 1,000 Ci of non-TRU radionuclides (Martin 1986). Each drum contains nominally 260 g of ^{235}U . Total fission product content is on the order of 28 Ci/drum.

The other type of waste package used for covered retrievable storage of irradiated fuel wastes are concrete burial containers. These waste packages contain irradiated mixed plutonium oxide and enriched uranium oxide wastes from destructive testing and examination of fuels in the 1960's and 1970's at the General Electric Company. These wastes are placed within aluminum waste liners that are in turn placed within concrete burial containers. The waste liners are gasketed aluminum screw-cap cans. The fuel sections and fragments are prepackaged in sealed metal cans or screw-cap closed containers before loading in the waste liners.

Two concrete burial containers, one for long waste liners (see Figure 2-6) and one for short waste liners (see Figure 2-7), are used for these wastes (VanderCook 1974). Both types of burial containers provide four separate steel vessels, each holding one aluminum waste liner. The steel vessels are schedule 40 pipe, have a soft-iron gasketed 68-kg (150-lb) flange closure, and are hydrostatically tested to 172 kPa (25 lb/in² [gauge]) before the concrete is poured. Shielding on the sides and bottom are provided by 51 cm (20 in) of concrete and on the top by a 7-cm- (2.75-in-) thick lead plug and on 2.5-cm- (1-in-) thick steel flange. Each steel vessel is separated from the others within the burial container by at least 20.3 cm (8 in) of concrete.

The retrievable storage of irradiated fuel wastes in the SWBG requires existing and routinely used equipment. Therefore, the only applicable design criteria are those for existing burial ground facilities and equipment. DOE Order 6430.1A, which includes special nonreactor nuclear facility

requirements, has been reviewed for applicability to the burial ground operations addressed in this safety analysis. No special requirements are found to be directly applicable to the waste packages, burial grounds, or handling equipment.

The basic design features that prevent or mitigate releases to the environment discussed in Section 2.2 are generally applicable to irradiated fuel waste storage (e.g., relatively low groundwater elevation with respect to the landfill, low precipitation, low flood potential, etc.).

TRU Waste Storage Caissons. Underground caissons, referred to as alpha caissons, are used for storage of small packages of TRU wastes with high levels of radiation. The caissons are reinforced-concrete cylinders buried approximately 4 m (13 ft) below grade, as shown in Figure 2-8. The caissons have 1-m- (3-ft-) diameter inlet chutes that have been offset to eliminate direct radiation shine from the stored wastes.

The caissons are provided with exhaust systems that include high-efficiency particulate air (HEPA) filters. Originally, the caissons had been provided with electrically driven exhaust fans to pull air through the inlet chutes into the caisson when the caissons are being loaded. Now, the caissons are being changed to breather filters and the exhaust fans are being removed.

A specially designed, bottom-opening cask is used to load waste materials into the caissons. Waste containers on the caissons include 3.8-, 7.6-, and 18.9-L (1-, 2-, and 5-gal) cans containing RH (high dose rate) irradiated fuel and nonfuel scrap from hot cell examinations. The can lids may not be intact and waste materials may be dispersed within the caissons. No new wastes are anticipated and activities are limited to monitoring and surveillance activities and periodic changeout of the HEPA filters to prevent the filters from becoming highly contaminated. In the future, TRU wastes will be retrieved from the alpha caissons using methods currently being studied.

2.3 SUPPORT SYSTEMS

Support systems are those systems that support the main process and confinement features of the SWBG, as follows:

- LLW — no systems required
- MW — leachate collection pump control and instrumentation
- TRU waste — no systems required.

No additional support systems are identified for SWBG operations.

Pump controls and instrumentation for the MW disposal trenches with leachate collection are housed in a weather enclosure with a lockable door. Only authorized SWBG personnel will have access. The structure is a premanufactured metal enclosure on a concrete slab. Interior lighting is provided. Heating and weather sealing are not provided.

The building includes the electrical service load center, the control panel, electrical outlets, motor starters, pump control boxes, and transformer panel. All electrical parts and enclosures comply with the National

Electrical Manufacturers Associated code and do not represent any unusual risk to personnel or the environment.

The MW leachate collection system for trenches 31 and 34 has the design capability to operate in an automatic mode, as well as a manual mode, to accommodate work schedules and recordkeeping processes. All liquid transport elements of the system are within secondary containment. The high-level cutoff switches ensure that the feed pumps will shut off to prevent overflow of the storage tank. The secondary containment is sized to capture all liquid released from a catastrophic failure of a full leachate storage tank in combination with the precipitation from a 24 hour, 25 year storm event.

2.4 DESCRIPTION OF SERVICE AND UTILITY SYSTEMS

Forced ventilation and offgas systems, compressed air supply, water supply, sewage treatment, steam supply, safety communications, and alarms are not needed for SWBG disposal facilities.

Service and utility systems identified to support SWBG operations are fire protection and maintenance systems.

Service and utility systems identified to support specific SWBG operations include the following:

- LLW — no systems identified
- MW — leachate collection system
- ERDF — decontamination facilities, leachate collection system
- TRU waste — filtered ventilation system.

No additional service and utility systems are identified for SWBG operations.

Decontamination systems are not necessary for routine operation for contaminated waste in the SWBG. Decontamination of the outer surfaces of potentially contaminated waste packages to acceptable levels is performed at the waste generation site or at a central decontamination facility before the packages are loaded onto transport vehicles. Upon receipt of all waste packages, surface dose rates and contamination levels are measured and compared with specified limits. If these measurements exceed the limits, operators are instructed to notify supervision immediately. The disposition of the externally contaminated waste packages will then be determined on a case-by-case basis. Portable decontamination equipment is available and may be used to decontaminate external surfaces.

2.4.1 Building Ventilation

Ventilation systems, including HEPA filters, are provided for the caissons. Forced ventilation is not needed because waste packages are no longer placed in the caissons, and the decay heat generated by the radioactive materials has been reduced to the point where air circulation cooling is no longer required. The HEPA filters are periodically replaced, but the exhaust fans are not operated.

2.4.2 Electrical

Electrical service and lighting are provided to the MW disposal trenches and control buildings. Electrical power is available in the 218-W-5 burial ground via an existing line. Area lighting along the entrance road provides sufficient light for the leachate temporary storage tank and control building area. Lighting of the landfill is not provided or required for operations. All electrical materials and installations meet the requirements of the National Electrical Manufacturers Association code and pose no unknown risks to workers. Adverse effects resulting from loss of electrical power would be loss of power to the leachate pumps.

2.4.3 Safety Communications and Alarms

A safety communication and indicator system is provided for the MW leachate collection system. A rotating light beacon on the roof of the control building is activated by either a pump failure or high collection tank level.

2.4.4 Fire Protection System

The primary fire hazard will most likely be desert range fires that occur during the summer months. Equipment for fire control is available from the Hanford Fire Department. Available equipment includes trucks equipped with hydraulically operated aerial ladders, pumpers, and trucks with chemicals to extinguish fires. Response time within the 200 Areas is less than 10 minutes. The minimum response time to the SWBG is 5 minutes from when the 200 Areas Fire Station is notified. In addition, portable fire extinguishers are provided on motorized vehicles and/or near all storage areas. Personnel are trained in the use of portable fire extinguishers (RL 1989, p. 6-5).

2.4.5 Maintenance Systems

Maintenance requirements exist for the leachate collection system and the general landfill conditions. The leachate storage tank, which is designed to hold the leachate until it is removed for disposal, is described in this section along with maintenance requirements. Two openings in the tank are provided to allow access for inspections and painting. The tank and pressurized piping is protected from freezing by insulation and heat tape. To protect the tank from corrosion by the leachate, a tank coating was selected by comparing the list of chemicals that may be included in the waste disposal facility against the list of chemicals with which the coatings are compatible.

The design elements that require maintenance (the leachate-level sensors and the leachate sump pumps) are designed and located so that they can be maintained with minimal disturbance to the disposal site. Other design elements (such as the geosynthetic liners and the leachate collection pipes) are protected during installation and are designed to withstand weight pressures and other environmental stresses put upon them so that they do not require any further maintenance.

Additional long-term maintenance of the site includes repairs to liners, covers, ditches, utilities, and access roads. The need for maintenance is often established when reviewing results from inspection and monitoring programs. Periodic inspection of ditches for sump leachate levels, leachate flow meters, pumps, level transducers, cover integrity, subsidence, settlement, displacement, plant growth, and animal habitation are all important in maintaining the long-term integrity of the site.

2.5 CHAPTER CRITERIA

A summary description of the information in the chapter is provided with acceptance criteria derived from appropriate guidance documents.

2.5.1 Summary Description

This chapter provides a summary of the plant design including the process building, support systems, and a description of services and utility systems.

2.5.2 Acceptance Criteria

The acceptance criteria for this chapter are based on the following:

1. DOE Order 6430.1A, *General Design Criteria*
2. DOE Order 5480.5, *Safety of Nuclear Facilities*
3. DOE Order 5480.7A, *Fire Protection*
4. DOE Order 5480.11, *Radiation Protection for Occupational Workers.*

Specific acceptance criteria are as follows.

1. Descriptive information on the features of the SWBG should be characterized.
2. The features of the SWBG that serve a confinement function, including special design features employed to withstand environmental and accident forces, should be described.
3. The design bases and industrial codes used for the design of the SWBG should be defined and referenced to the principal design criteria presented in Chapter 1.0.
4. Compliance with national building codes, standards, and DOE orders should be demonstrated.

2.6 REFERENCES

2.6.1 Acts, Codes, and Regulations

NRC, 1989, *Directory of Certificates of Compliance for Radioactive Material Packages*, NUREG-0383, U.S. Nuclear Regulatory Commission, Washington, D.C.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

WAC 173-303, 1990, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

10 CFR 71, 1993, "Packing and Transportation of Radioactive Material," *Code of Federal Regulations*, as amended.

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.

49 CFR 173, "Shippers-General Requirements for Shipments and Packaging," *Code of Federal Regulations*, as amended.

2.6.2 Documents

RL, 1989, *Low-Level Burial Grounds Dangerous Waste Permit Application*, DOE/RL 88-20, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Martin, R. L., 1986, "Disposal of TRIGA Fuel Elements," (WHC Memorandum to L. R. Ogeltree, dated June 24, 1986), Rockwell Hanford Operations, Richland, Washington.

VanderCook, R. E., 1974, *Criticality Safety Analysis, Burial of Waste Liners from General Electric Company*, ARH-3016, Part 2, Atlantic Richfield Hanford Company, Richland, Washington.

WHC, 1990, *Definitive Design Report, Project W-025 Radioactive Mixed Waste Land Disposal Facility Non-Drag-Off*, WHC-SD-W025-FDR-001, Westinghouse Hanford Company, Richland, Washington.

WHC, 1992, *Retrievable Storage of Irradiated Fuels in the Solid Waste Burial Grounds*, WHC-SD-WM-SAR-047, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC, 1993, *Hanford Site Solid Waste Acceptance Criteria*, WHC-EP-0063, Rev. 4, (or current revision), Westinghouse Hanford Company, Richland, Washington.

2.6.3 U.S. Department of Energy Orders

DOE Order 5820.2A, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C.

DOE Order 6430.1A, *General Design Criteria*, U.S. Department of Energy, Washington, D.C.

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Figure 2-1. Illustration of Flat-Bottom Trench.

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SWBG5/94

Figure 2-2. Submarine Reactor Compartment Disposal Landfill.

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SWBG5/94

Figure 2-3. Submarine Reactor Compartment Support Foundations.

Figure 2-4. Diagram of Typical Transuranic Waste Trench.

Figure 2-5. Shielded 208-L Drums for TRIGA Fuel Element Wastes.

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SWBG5/94

Figure 2-6. Concrete Burial Containers for Long Waste Liners.

TOP VIEW

SIDE VIEW

LINER CONTAINER

S9304033.15
SWBG

Figure 2-7. Concrete Burial Containers for Short Waste Liners.

TOP VIEW

SIDE VIEW

LINER CONTAINER

S9304033.16
SWBG

Figure 2-8. Illustration of a Typical Caisson.

Table 2-1. Active Burial Grounds.

Burial ground	Location	Status	Waste types
218-E-10	200 East	Active	MW, LLW
218-E-12B	200 East	Active	MW, LLW, TRU ^a
218-W-3A	200 West	Active	MW, LLW, TRU
218-W-3AE	200 West	Active	MW, LLW
218-W-4B	200 West	Active	MW, LLW, TRU ^b
218-W-4C	200 West	Active	MW, LLW, TRU
218-W-5	200 West	Active	MW, LLW
218-W-6	200 West	Active	Has not received waste
ERDF	Between 200 West/200 East	Active	Has not received waste

^aIncludes submarine compartments in trench 94 of this burial ground.

^bIncludes 12 caissons containing mixed TRU waste.

MW = mixed waste.

LLW = low-level waste.

TRU = transuranic.

Table 2-2A. Low-Level Waste Packages. (6 sheets)

Waste package name	Waste type	Dimensions	Weight (kg)	Rad inventory	Material form	Additional information
Glove boxes	LLW Category 1 Uncovered*	28 glove boxes of various sizes total 3776 ft ³ (107 m ³)	Total weight 15,545 kg (34,200 lb)	6 boxes contain 0.01 g Pu total; 12 boxes contain 0.02 g Pu total; 5 boxes contain 0.03 g Pu 5 boxes contain 0.05 g Pu total: 0.11 g Pu	Stainless steel glove boxes and exhaust tunnel sections; ports and windows covered with plywood; double-plastic wrapped; 97% steel, 1% wood, 2% plastic	Units are bonded to skids and boxed. Units have been decontaminated to non-TRU levels. Placed in 218-W-4C, trench 14 in 1984-85 Source: SWBG records
Steam generator	LLW Category 1 Uncovered*	3.7-m (12-ft) diameter, 13.7 m (45 ft) ₃ long 118.9 m ³ (4,200 ft ³)	Total weight 219,539 kg (484,000 lb)	60 Ci ⁶⁰ Co	10% stainless steel 90% steel	Self-contained cask. Placed in 218-W-4C, trench 14 in 1987 Source: SWBG records
Boxes	LLW Uncovered*	151 boxes 541 m ³ (19,105 ft ³)	Total weight 159,532 kg (351,708 lb)	0.646 Ci, primarily ¹³⁷ Cs, ⁶⁰ Co, and ⁹⁰ Sr	50% combustible 50% noncombustible	Buried in 218-W-5, trench 27 Source: SWBG records
Drums	LLW Uncovered*	446 208-L (55-gal) drums 94 m ³ (3,308 ft ³)	Estimated total weight, 30,345 kg (66,900 lb)	41,0285 Ci, primarily ¹³⁷ Cs and ⁹⁰ Sr	50% combustible 50% noncombustible	Buried in 218-W-5, trench 22 Source: SWBG records
Equipment bulk waste	LLW Uncovered*	9 items of various sizes 38 m ³ (1,342 ft ³)	Total weight 102,377 kg (225,703 lb)	0.095 Ci 30 g depleted U	50% combustible 50% noncombustible	Placed in 218-W-03A, trench 49 Source: SWBG records
Shipping port reactor vessel	LLW Uncovered*	1 cask, 5.4 m (17 ft 8 in) in diameter by 12.4 m (40 ft 7 in) long 9,946 ft ³	Total weight 815,573 kg (1,798,000 lb)	¹⁶ Fe, ⁴⁶⁷ 59Ni, ⁶⁰ 63Ni, ⁶⁰ Co	49% heavy metal 50% concrete 1% lead	Placed in 218-W-04C, trench 14 Source: SWBG records
Pm glovebox hoods in steel boxes	LLW Uncovered*	2 boxes 15.2 m ³ (536 ft ³)	Total weight 4,672.1 kg (10,300 lb)	15,000 Ci, primarily ¹⁴⁷ Pm (as of 9-81)	90% metal 5% plastic 5% glass	Placed in 218-W-04C, trench 14 Source: SWBG records
KAPL Casks	LLW Uncovered*	7 casks, 2.4 m (8 ft) in diameter by 2.6 m (8 ft 8 in) high 81 m ³ (2,859 ft ³)	Total weight 202,305.6 kg (446,000 lb)	28 Ci, primarily ⁶⁰ Co	80% concrete 3% metal 12% resin	Placed in 218-W-04C, trench 14 Source: SWBG records

Table 2-2A. Low-Level Waste Packages. (6 sheets)

Waste package name	Waste type	Dimensions	Weight (kg)	Rad inventory	Material form	Additional information
100 N storage tank	LLW Uncovered*	1 tank, 3.7 m (12 ft) in diameter by 38.1 m ₃ (15 in) high, 48 m ₃ (1,696 ft ₃)	Total weight 1,814.4 kg (4,000 lb)	0.1 Ci tank covered with asbestos insulation	98% metal 2% cloth	Placed in 218-W-04C, trench 14 Source: SWBG records
REDOX tanks	LLW One tank is uncovered*	4 tanks, 7.6 m (25 ft) in diameter by 5.3 m (17.5 ft) high, 945.2 m ₃ (33,380 ft ₃)	Total weight 23,587.2 kg (52,000 lb)	19,051 g Th 9.0 Ci	90% metal 8% silica gel 2% absorbent	Buried in 218-W-04C, trench 14 Source: SWBG records
FFTF casks	LLW Uncovered	3 casks, 2.1 m (7 ft) in diameter by 4.3 m (14 ft) high, 45.8 m ₃ (1,616.3 ft ₃)	Total weight 136,080 kg (300,000 lb)	58,095 Ci, primarily ⁶⁰ Co	95% concrete 5% metal	Placed in 218-W-04C, trench 14 Source: SWBG records
Classified waste Naval core barrels	LLW Covered	65 containers of various sizes 52,336 ft ₃ (1,482 m ³)	Total weight (3,175,456 kg (7,000,682 lb)	1,107,157 Ci, primarily ⁶⁰ Co	100% noncombustible	Buried in 218-W-04C, trench NC Source: SWBG records
Classified waste Naval pumps	LLW Uncovered*	37 containers, 1.1 m (3.5 ft) in diameter by 2.7 m (8 ft, 10 in) long, 333 m ₃ (11,759.7 ft ₃)	Total weight 374,255 kg (825,077.2 lb)	15 Ci, primarily ⁶⁰ Co and ⁵⁵ Fe	39% metal 5% nonmetal 2% plastic 5% absorbent 49% pyrofoam	Placed in 218-E-04C, trench NC Source: SWBG records
Classified waste Naval core baskets	LLW Uncovered*	2 containers, 2.9 m (9 ft 7 in) in diameter by 5 m ₃ (16.5 ft), 68 m ₃ (2,401 ft ₃)	Total weight 320,588 kg (706,763.7 lb)	138,000 Ci, primarily ⁶⁰ Co, ⁶³ Ni, and ⁵⁵ Fe	96% metal 4% absorbent	Placed in 218-W-3AE, trench 08 Source: SWBG records
Classified waste Naval closure heads	LLW Uncovered*	2 containers, 3.1 m (10 ft 1 in) in diameter by 2.2 m (7 ft 4 in) long, 44 m ³ (1,554 ft ³)	Total weight 70,766 kg (156,009.7 lb)	4 Ci, primarily ⁵⁵ Fe	100% metal	Placed in 218-W-3AE, trench 08 Source: SWBG records
TMI casks	LLW Covered	16 liners, 6.34 m ³ (224 ft ³) 16 casks, 184 m ³ (6,496 ft ³)	Weight - liners 8,201 kg (18,080 lb) Weight - casks 477,456 kg (1,052,610 lb)	495,387 Ci, primarily ¹³⁷ Cs and ⁹⁰ Sr	95% concrete 5% metal	Buried in 218-W-03A, trench S7 Source: SWBG records

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Table 2-2A. Low-Level Waste Packages. (6 sheets)

Waste package name	Waste type	Dimensions	Weight (kg)	Rad inventory	Material form	Additional information
Canoga Park HALLAM casks	LLW Covered	3 containers, 12.7 cm (5 in) in diameter by 4.3 m (14 ft) long, 1.03 m ³ (36.3 ft ³)	Total weight, 1,315.4 kg (2,900 lb)	120 Ci, primarily ⁶⁰ Co and ¹³⁷ Cs	98% metal 2% cardboard	Buried in 218-W-03A, trench 51 Source: SWBG records
Ion exchange cylinders from 100-N	LLW Covered	About 41 shipments 1.8 m ³ (64 ft ³) per shipment	Weight, 2,177 kg (4,800 lb) per shipment	18 to 180 Ci per shipment primarily ¹³⁷ Cs and ⁹⁰ Sr	10% metal 90% resins	Buried in 218-W-03A, trenches Source: SWBG records
Drag-off concrete boxes from 100-N (West Burial)	LLW Covered	14 total drag-off boxes, 676 m ³ (23,886 ft ³)	Total weight, 501,673 kg (1,106,000 lb)	Dose rate of 60 to 4,000 mrem/h	3% combustible 97% noncombustible	Buried in 218-W-3AE, trench 02 Source: SWBG records
Samarium ball casks from 100-N	LLW Covered	5 total concrete casks, 16.4 m ³ (580 ft ³)	Total weight, 81,647 kg (180,000 lb)	2,255 Ci primarily ¹⁵⁴ Eu and ¹⁵⁵ Eu	10% metal 90% concrete	Buried in 218-W-03A, trench 40 Source: SWBG records
Reactor fuel cask	LLW Covered	3 total casks, 12 m ³ (405 ft ³)	Total weight, 76,204 kg (168,000 lb)	135 Ci primarily ⁶⁰ Co and Zr/ ⁹⁵ Nb	100% noncombustible	Buried in 218-W-03A, trench 40 Source: SWBG records
Unit 1 caisson	LLW Partial covered and plugged	1 caisson containing 2 shipments, 2 m ³ (53 ft ³)	Total weight, 618 kg (1,362 lb)	123 Ci, primarily ⁶⁰ Co, ¹⁵⁴ Eu, and ¹⁵⁵ Eu	100% noncombustible	Buried in 218-W-04B, trench 14 Caisson unit #1 Source: SWBG records
Graphite blocks in boxes	LLW Covered	1 208-L (55-gal) drum, 0.21 m ³ (7.4 ft ³)	Total weight, 589.7 kg (1,300 lb)	0.05 Ci primarily ¹⁴ C, ⁶⁰ Co, and ¹³⁷ Cs	88% concrete 10% metal 1% graphite block 1% plastic	Buried in 218-W-5, trench 22 Source: SWBG records
Hitman casks	LLW Covered	Hitman liner, 1.4 m (4.6 ft) in diameter by 1.5 m (5.1 ft) high, 30.2 m ³ (1,066 ft ³)	Total weight 71,860 kg (158,424 lb)	17,824 Ci primarily ¹³⁷ Cs and ⁹⁰ Sr dose rates from 8 to 760,000 mrem/h	31% metal 1% plastic 2% rubber 66% grout	Buried in 218-W-3AE, trench 02 Source: SWBG records
Drag-off concrete boxes from 100-N (East Burial)	LLW Covered	31 concrete boxes in various sizes, 373 m ³ (13,175 ft ³)	Total weight, 179,169 kg (395,000 lb)	Dose rate from 4.5 to 9,000 mrem/h, primary isotope is ⁶⁰ Co	100% noncombustible	Buried in 218-E-010, trenches 04, 06, 07, 08, 09, 11, 12, 16 Source: SWBG records

Table 2-2A. Low-Level Waste Packages. (6 sheets)

Waste package name	Waste type	Dimensions	Weight (kg)	Rad inventory	Material form	Additional information
Drag-off concrete boxes from 221 B (East Burial)	LLW Large equipment, filter, and drummed waste Covered	68 concrete boxes in various sizes 3,493 m ³ (123,367 ft ³)	Total weight 1,785,733 kg (3,936,868 lb)	Dose rates from NA to 10,000,000 mrem/h primary isotopes are ¹³⁷ Cs and ⁹⁰ Sr	80% noncombustible 20% combustible	Buried in 218-E-010, trenches 04, 06, 07, 08, 09, 11, 12, 16 Source: SWBG records
Drag-off concrete boxes from 225 B (East Burial)	LLW Large equipment, filter, and drummed waste Covered	8 concrete boxes in various sizes 250 m ³ (8,840 ft ³)	Total weight 159,211 kg (351,000 lb)	Dose rates from 50 to 200,000 mrem/h primary isotopes are ¹³⁷ Cs and ⁹⁰ Sr	100% noncombustible	Buried in 218-E-010, trenches 04, 06, 07, 08, 09, 11, 12, 16 Source: SWBG records
Drag-off concrete boxes from PUREX (East Burial)	LLW Large equipment, filters, and concrete blocks Covered	46 concrete items in various sizes 2,531 m ³ (89,380 ft ³)	Total weight 1,332,509 kg (2,937,680 lb)	Dose rates from NA to 60,000 mrem/h primary isotopes are ¹³⁷ Cs and ⁹⁰ Sr	50% metal 50% concrete	Buried in 218-E-010, trenches 04, 06, 07, 08, 09, 11, 12, 16 Source: SWBG records
Drag-off concrete boxes from Tank Farm (East Burial)	LLW Large equipment, filters, and concrete blocks Covered	14 concrete items in various sizes 495 m ³ (17,484 ft ³)	Total weight 253,177 kg (558,160 lb)	Dose rate from NA to 5,000 mrem/h primary isotopes are ¹³⁷ Cs and ⁹⁰ Sr	100% noncombustible	Buried in 218-E-010, trenches 04, 06, 07, 08, 09, 11, 12, 16 Source: SWBG records
Large equipment burial in concrete boxes from 221TS (cleaned)	LLW Covered	2 concrete boxes in various sizes 79 m ³ (2,800 ft ³)	Total weight 35,562 kg (78,400 lb)	Dose rates from 1 to 5 mrem/h primarily ¹³⁷ Cs	100% noncombustible	Buried in 218-E-010, trenches 04, 06, 07, 08, 09, 11, 16 Source: SWBG records

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Table 2-2A. Low-Level Waste Packages. (6 sheets)

Waste package name	Waste type	Dimensions	Weight (kg)	Rad inventory	Material form	Additional information
Hazardous waste, case-by-case	LLW Covered	72 208-L (55-gal) drums, 35 322-L (85-gal) drums, 1 cask, 1 metal box, 27 m ³ (947 ft ³)	Total weight 31,698 kg (69,882 lb)		Xylene, methanol, tar, mercury, beryllium, naphthylamine tritium, psuedocumene, oil, lead shielding, barium, chromium, naphthalene, cadmium, acetonitrile, toluene, cyclohexane, and lead	Buried in 218-W-03A, trench 16 Source: SWBG records
Hazardous waste, case-by-case	LLW Covered	61 wooden boxes, 49 208-L (55-gal) drums, 15 casks, 2 concrete boxes, 4 metal boxes, 225 cardboard boxes, 20 filters, 296 m ³ (10,452 ft ³)	Total weight 461,620 kg (1,017,700 lb)		Lead, lead shielding, zirconium, chromium, uranium hexafluoride, mercury, vinyl chloride, paint thinner, slaked lime, and asbestos	Buried in 218-W-04C, trenches 48, 53, 58 Source: SWBG records
183H hazardous waste	LLW Covered	3,291 55-gal drums, 693 m ³ (24,459 ft ³)	Total weight 880,514 kg (1,941,200 lb)	126,567 g enriched uranium	10% poly 70% sludge 15% metal 5% plastic	Buried in 218-W-3AE, trench 05 Source: SWBG records
Tank Farm pumps and jumpers	LLW Covered	58 pumps and jumpers, 148 m ³ (5,244 ft ³)	Total weight of items with lengths up to 52 ft, 48,734 kg (107,441 lb)	Dose rate range from 0.5 to 18,000 mrem/h, 4,302 Ci primarily ¹³⁷ Cs and ⁹⁰ Sr	15% noncombustible 85% combustible	Buried in 218-W-03A Buried in 218-E-12B Source: SWBG records
Category 3 waste	LLW or TRU Uncovered	447 208-L (55-gal) drums, 94 m ³ (3,308 ft ³)	Estimated total weight 38,524 kg (84,930 lb)	3.6695 g Pu, 0.02289 g ²³⁸ Pu	50% combustible 50% noncombustible	Stored in 218-W-04C, trench 24 Source: SWBG records
Organic-free liquid	LLW Retrievable Covered	37 208-L (55-gal) drums, 8 m ³ (275 ft ³)	Total weight 3,107 kg (6,850 lb)	0.0002 g Pu	18% oil 1% metal 75% absorbent 6% poly	Stored in 218-W-04C, trench 07 Source: SWBG records
K-3 filters in concrete boxes - grouted (upcoming work)	LLW To be backfilled	2 boxes, 132 m ³ (4,651 ft ³)	Total weight 52,345 kg (115,400 lb)	Dose rate of 3,000 mrem/h, 800 Ci, primarily ¹³⁷ Cs and ⁹⁰ Sr	5% combustible 95% noncombustible	To be buried in 218-E-010, trench 09

Table 2-2A. Low-Level Waste Packages. (6 sheets)

Waste package name	Waste type	Dimensions	Weight (kg)	Rad inventory	Material form	Additional information
Low-level caissons	LLW Covered	6 caissons containing 3.8- to 18.9-L (1 to 5-gal) casks, 29 m ³ (1,021 ft ³)	Total weight 25,471 kg (56,155 lb)	1,748 g Pu, 2,97,465 g U, 66,232 g Th, 109,969 Ci primarily 137Cs, 90Sr, and 60Co	100% noncombustible	Buried in 218-W-04B, trench 14 caissons 1 to 6 Source: SWBG records
Alaska casks	LLW Uncovered*	2 casks, 0.9 m (3 ft) in diameter by 1.2 m (4 ft) high, 2 m ³ (73 ft ³)	Total weight 3,662 kg (8,074 lb)	24 Ci as of 1988, primary isotope is 60Co	100% metal, 2,812-kg (6,200-lb) lead shielding	Placed in 218-W-04C, trench 14 Source: SWBG records
Ion Exchange Modules	LLW Uncovered	11 total cement modules LxWxH 66"x70"x79.9"	42086Lb (19090 Kg)	1,408.4 curies primarily 137Cs and 90Sr	Ion Exchange Resins = 10% Concrete = 50% Metal = 40%	Buried in 218-W-4C Trench 24

*To be backfilled

FFTF = Fast Flux Test Facility

KAPL = Knolls Atomic Power Laboratory.

LLW = low-level waste.

PUREX = Plutonium-Uranium Extraction (Facility).

REDOX = Reduction Oxidation (Facility).

SWBG = Solid Waste Burial Ground.

TMI = Three Mile Island.

TRU = transuranic.

Table 2-2B. Mixed Waste Packages.

Waste package name	Waste type	Dimensions	Weight	Rad inventory	Material form	Additional information
Classified waste Naval submarine reactor compartments	MW Uncovered*	Cylinder container nominal per unit 900 m ³ (32,000 ft ³)	Nominal weight per unit 910,000 kg (2,000,000 lb)	Nominal per unit 12 kg PCB, 12,000 kg asbestos 91,000 kg lead 53,000 Ci MFP primary isotope ⁶⁰ Co	96% metal 1% lead 2% asbestos 1% PCB and absorbents	Placed in 218-E-12B, trench 94 Source: SWBG records
Mixed waste	MW Uncovered*		--	--	--	Placed in 218-W-05 MW disposal trenches 31, 32 (Future operation)

*To be backfilled.

MFP = mixed fission products.

MW = mixed waste.

PCB = polychlorinated biphenyl.

SWBG = Solid Waste Burial Ground.

Table 2-2C. Transuranic Waste Packages. (3 sheets)

Waste package name	Waste type	Dimensions	Weight	Rad inventory	Material form	Additional information
TRIGA fuel waste in shielded drums	TRU Retrievable Covered	13 208-L (55-gal) drums, 2.7 m ³ (96 ft ³)	Total weight, 13,572 kg (29,921 lb)	13 g Pu total, 17,174 g U, 364 Ci MFP	50% concrete 10% metal 40% lead	Stored in 208-L (55-gal) drums in 218-W-4C, trench 07, covered with 1.2 m (4 ft) of dirt Source: SWBG records
Irradiated fuel waste in concrete liners (GE liners)	TRU Retrievable Covered	22 concrete vaults, total 110 m ³ (3868 ft ³)	Total weight, 252,774 kg (558,000 lb)	4,704 g Pu total 1,500 g Nat U 20,900 g Enr U 18,100 g Dep U 237,000 Ci MFP	100% noncombustible	Stored in concrete vaults in 218-W-3A, trench 08, covered with 1.2 m (4 ft) of dirt Source: SWBG records
TRU waste in 416-L (110-gal) drums (two 208-L [55-gal] drums welded end to end)	TRU Retrievable Covered	21 416-L (110-gal) drums, 8.8 m ³ (310.8 ft ³)	Total weight, 3,604 kg (7,945 lb)	7,900 g Pu total	100% noncombustible	Stored in 416-L (110-gal) drums in 218-W-04C, trench 01, covered with 1.2 m (4 ft) of dirt Source: SWBG records
TRU waste in bird cages in 416-L (110-gal) drums [55-gal] drums welded end to end)	TRU Retrievable Covered	15 416-L (110-gal) drums 6.3 m ³ (222 ft ³)	Total weight, 2,041 kg (4,500 lb)	6,287 g Pu total	100% noncombustible	Stored in 416-L (110-gal) drums in 218-W-04C, trench 01, covered with 1.2 m (4 ft) of dirt Source: SWBG records
TRU drums	TRU Retrievable Uncovered	2,056 208-L (55-gal) drums 432 m ³ (15,247 ft ³)	Estimated total weight, 177,191 kg (390,640 lb)	26,199 g Pu total, 73,307 Ci MFP, 15,894 g Dep U, 6,105 g Enr U, 1 g ²⁴¹ Am	50% combustible 50% noncombustible	Stored in 208-L (55-gal) drums in 218-W-04C, trenches 01, 20, 29 Source: SWBG records
TRU boxes	TRU Retrievable Uncovered	24 boxes various sizes, 126 m ³ (4,460 ft ³)	Total weight, 48,560 kg (107,056 lb)	2,023 g Pu total	50% combustible 50% noncombustible	Stored in boxes in 218-W-04C, trenches 01, 20, 29 Source: SWBG records
TRU Caissons (4)	TRU Retrievable Covered	4 caissons containing 3.8-L (1-gal) paint cans, 23 m ³ (824 ft ³)	Total weight, 20,557 kg (45,320 lb)	6,175 g Pu, 87,348 g U, 17,870 g Th, 99,410 Ci (primarily ¹³⁷ Cs, ⁹⁰ Co, and ⁹⁰ Sr)	100% noncombustible	Stored in 218-W-048, trench 14 Caissons Alpha 1 to Alpha 4 Source: SWBG records
EBR-II casks	TRU Retrievable Covered	5 casks, 3.5 m ³ (123 ft ³)	Total weight, 11,315 kg (24,945 lb)	9,811 g Pu, 34,646 g U, 96,908 Ci MFP	100% metal including lead	Stored in 218-W-03A, trench 16 Source: SWBG records

Table 2-2C. Transuranic Waste Packages. (3 sheets)

Waste package name	Waste type	Dimensions	Weight	Rad inventory	Material form	Additional information
EBR-II casks Irradiated fuel waste from INEL, FFTF, and GETR	TRU Retrievable Uncovered	34 casks, 23.6 m ³ (833 ft ³)	Total weight, 84,823 kg (187,000 lb)	32,641 g Pu, 154,278 g U	100% metal including lead	Stored in 218-W-04C, trench 01 Source: SWBG records
Zr Hulls casks	TRU Retrievable Covered	10 casks, 4.2 m ³ (150 ft ³)	Total weight, 2,903 kg (6,400 lb)	16 g Pu 2,000 g enriched U, 38,000 Ci (¹³⁷ Cs)	50% Zr hulls 25% lead 25% metal	Stored in 218-W-04C, trench 01 Source: SWBG records
105 N cask	TRU Retrievable Uncovered	1 cask, 1 m ³ (28.5 ft ³)	Total weight, 3,277 kg (7,225 lb)	48 g ²⁴¹ Am 48 g ²⁴³ Am 4 g ^{242/244} Cm 69 g ²³⁸ Pu 150 Ci MFP	100% noncombustible	12 Am target elements; stored in 218-W-04C, trench 01 Source: SWBG records
Ion exchange drums 100 N	TRU Retrievable Covered	Containers, drums, and boxes 50 m ³ (1,764 ft ³)	Total weight, 22,871 kg (50,422 lb)	9,102 g Pu	Water filters placed in 208-L (55-gal) drums and wooden boxes	Stored in 218-W-03A, trenches 23, 30, 32, 34 Source: SWBG records
PR cans	TRU Retrievable Uncovered	79 containers of various sizes, 13 m ³ (462 ft ³)	Total weight, 9,824 kg (21,658 lb)	22 g Pu	100% metal	Stored in 218-W-04C, trench 20 Source: SWBG records
Z-9 drums	TRU Retrievable Covered	702 208-L (55-gal) drums 147 m ³ (5,195 ft ³)	Total weight, 51,436 kg (113,396 lb)	59,400 g Pu	95% soil 4% metal 1% plastic	Stored in 218-W-04C, trench 01 Source: SWBG records
TRU FRP boxes	TRU Retrievable Covered	112 boxes of various sizes 2,965 m ³ (104,720 ft ³)	Total weight, 1,094,972 kg (2,414,000 lb)	6,925 g Pu	10% combustible 90% noncombustible	Stored in 218-W-03A, trench 17 Source: SWBG records
TRU FRP boxes	TRU Retrievable Covered	73 boxes of various sizes 1,917 m ³ (67,713 ft ³)	Total weight, 343,884 kg (755,930 lb)	8,471 g Pu	10% combustible 90% noncombustible	Stored in 218-W-04C, trench 07 Source: SWBG records
Babcock tanks	TRU Retrievable Covered	22 boxes or tanks, 120 m ³ (4,235 ft ³)	Total weight, 60,643 kg (133,696 lb)	1,372 g Pu	100% noncombustible	Stored in 218-W-04C, trench 20 Source: SWBG records

Table 2-2C. Transuranic Waste Packages. (3 sheets)

Waste package name	Waste type	Dimensions	Weight	Rad inventory	Material form	Additional information
Classified TRU	TRU Retrievable Covered	1,036 208-L (55-gal) drums, 218 m ³ (7,683 ft ³)	Total weight, 122,920 kg (270,993 lb)	2,116 g Pu, 53,005 g Nat U, 13,867,010 g Dep U, 1,026 g Enr U	15% combustible 85% noncombustible	Stored in 218-W-04B, trench 07 Stored in 218-W-03A, trenches 04, 05, 08, 14, 19 Source: SWBG records
Ra-Be neutron source	TRU Retrievable Uncovered	One 208-L (55-gal) drum, 0.21 m ³ (7.5 ft ³)	Total weight, 148 kg (325 lb)	0.25 g ²²⁶ Ra	28% noncombustible 72% combustible (Lead shielding 91 kg)	Stored in 218-W-04C, trench 01 Source: SWBG records
Ra-Be neutron source	TRU Retrievable Covered	One 0.53-m- (1.7-ft-) dia by 0.64-m (2.1-ft) cask 0.57 m ³ (20.1 ft ³)	Total weight, 1,570 kg (3,461 lb)	2.5 g radium 2 Ci radon	100% metal 0.745 kg cadmium 0.165 kg beryllium 1,520 kg lead	Stored in 218-W-03A, trench 16 Source: SWBG records
Pu-Be sources	TRU Retrievable Uncovered	One 208-L (55-gal) drum, 0.21 m ³ (7.5 ft ³)	Total weight, 93 kg (205 lb)	7.9 g Pu 1.14 g ²³⁸ Pu	45% vermiculite 5% plastic 50% metal	Stored in 218-W-04C, trench 04 Source: SWBG records
Category 3 waste	LLW or TRU Retrievable Uncovered	447 208-L (55-gal) drums 94 m ³ (3,308 ft ³)	Estimated total weight, 38,524 kg (84,930 lb)	3.6695 g Pu 0.02289 g ²³⁸ Pu	50% combustible 50% noncombustible	Stored in 218-W-04C, trench 24 Source: SWBG records
Organic-free liquid	TRU Retrievable Covered	30 208-L (55-gal) drums, 6 m ³ (223 ft ³)	Total weight, 3,173 kg (6,995 lb)	161 g Pu	Poly containers with oils absorbed on pads 100% combustible	Stored in 218-W-04C, trench 07 Source: SWBG records

EBR-II = Experimental Breeder Reactor No. 2.
 FFTF = Fast Flux Test Facility.
 FRP = fiberglass-reinforced plastic.
 GE = General Electric.
 GETR = General Electric test reactor.
 INEL = Idaho National Engineering Laboratory.
 LLW = low-level waste.
 MFP = mixed fission product.
 PR = Product Receiver.
 SWBG = Solid Waste Burial Ground.
 TRIGA = Training, Research and Isotope production Reactor-General Atomic.
 TRU = transuranic.

Table 2-3. Type A and Type B Packaging Design Requirements.

General Design Requirements for all Packages (49 CFR 173.411)	Type A Package Design Requirements (49 CFR 173.412)	Type B Package Design Requirements
<ul style="list-style-type: none"> • Ease of handling, either manually or mechanically • Lifting attachment requirements • Ease of decontamination of external surface • Free of pockets or crevices where water might collect. 	<ul style="list-style-type: none"> • General design requirements for all packages • Provisions for sealing packages • External dimension limitations • External surface free from protrusions • Containment and shielding maintained during transport and storage at temperatures between -40 °C to 70 °C • Withstand normal transport conditions, including effects of acceleration, vibration, or vibration resonance • Physical/chemical compatibility of package and associated structures • Containment system retains contents under reduction of pressure to 24.1 kPa (3.5 lb/in²) • Valve protection • Capable of withstanding the following tests (49 CFR 173.465) <ul style="list-style-type: none"> - Water spray - Free drop - Compression test - Penetration test 	<ul style="list-style-type: none"> • General and Type A package design requirements • Capable of withstanding the following hypothetical accident conditions (10 CFR 71) <ul style="list-style-type: none"> - Free drop from 9 m (30 ft) onto an unyielding surface - Puncture from a free drop from 1 m (40 in) onto a cylindrical puncture probe - Exposure to an engulfing fire for 30 minutes at 800 °C (1,475 °F) - Immersion under water for not less than 8 hours

*Additional requirements are applicable to specific types of packages (e.g., fissile material and plutonium packages).

Table 2-4. Comparison of Submarine Reactor Compartment Characteristics and Hanford Mixed Waste Disposal Criteria.

Subject	WHC-EP-0063 requirements	Reactor compartment
Containment	Minimum 2 barriers, NRC/DOT approved	Minimum 3 barriers, NRC/DOT approved
Free liquids	None	None ^a
Fire retardant (combustibles)	Containers constructed of fire-retardant material	Noncombustible (246 °C [475 °F] melts internal lead shielding only)
Absorbents	2 x volume liquid	2 x volume liquid
Radioactive mixed wastes	Co-contaminants or lead shielding; 3 containment barriers	Co-contaminants and lead shielding has 3 containment barriers
Dose rate at 1 m	3 to 5 mrem/h	1.5 mrem/h
Surface contamination	220 dpm/100 cm ² 2,200 dpm/100 cm ² B, γ	<220 dpm/100 cm ² <2,200 dpm/100 cm ² B, γ
Nuclear criticality	Numerous	Not applicable
Asbestos	Minimum 4-mil plastic containment inside outer sealed container	Minimum 2 steel compartments bound in paint
Thermal power	0.1 W/ft ³	0.02 W/ft ³ at burial
Gas generation	Venting or catalyst packs	Hydrogen-oxygen gas recombiner
Void spaces	Shall not exceed 10% of container volume	Acceptable voids ^b
Labeling, marking, and placarding	DOT	DOT

^aSome residual liquids remain within the submarine reactor compartments (SRCs). All systems have been drained to remove liquids to a maximum of 870.6 L (230 gal). Diatomaceous earth is used to absorb remaining free liquids. The amount of sorbent and location applied is recorded on the Solid Waste Storage/Disposal Record.

^bThe U.S. Environmental Protection Agency has designated the SRC as a "bulk waste package," which is exempt from the void space requirements in 40 CFR 265.315 and WAC 173-303-404. The integrity of the package volume will be maintained without filling the SRCs with inert material, thus meeting the intent of these regulations.

DOT = U.S. Department of Transportation.

NRC = U.S. Nuclear Regulatory Commission.

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CHAPTER 3.0
PROCESS SYSTEMS

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LIST OF TERMS

ALARA	as low as reasonably achievable
CH	contact-handled
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EBR-II	Experimental Breeder Reactor No. 2
HPT	health physics technician
LLW	low-level waste
LLWMA	Low-Level Waste Management Area
MW	mixed waste
POP	plant operating procedure
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
RH	remote-handled
RL	U.S. Department of Energy, Richland Operations Office
SRC	submarine reactor compartment
SWBG	Solid Waste Burial Grounds
TRU	transuranic
WAC	<i>Washington Administrative Code</i>

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3.0 PROCESS SYSTEMS

This section describes operations that take place from the first receipt of wastes at the active Solid Waste Burial Grounds (SWBG), through site closure, and through subsequent environmental monitoring and surveillance. These activities are guided by a series of standard operating procedures prepared by the SWBG operating contractor. The operating procedures identify the significant steps and requirements needed to perform SWBG operations. Typically, the content of the procedures includes the following.

- I. SYSTEM DESCRIPTION This section defines the specific actions addressed in the procedure and includes necessary background information, definitions, etc.
- II. PRESTART CONDITION This section defines actions that must occur before receipt of waste at the SWBG and conditions that must be established before the procedure steps are initiated.
- III. SAFETY This section describes important safety-related information personnel should be aware of when handling waste packages and preventive/mitigative features relative to potential hazards. Management information related to safety and applicable safety documents is listed in this section.
- IV. TOOLS AND SUPPLIES This section provides a comprehensive list of the tools and supplies needed to complete the procedure. All necessary paperwork, forms, documents, references, etc., are also provided.
- V. TABLE OF CONTENTS This section provides a list of major sections of the operating instructions.
- VI. PROCEDURE This section provides step-by-step instructions for receiving, unloading, handling, and storing/disposing of waste/containers. The procedures also include safety warnings, waste placement restrictions, and responses to offnormal occurrences. This section may also include drawings of the waste containers as well as appendices for special safety procedures.

Applicable SWBG procedures may be updated or superseded from time to time as required and include at least the following:

- Emergency response
- Facility inspection
- Package inspection
- Waste receipt
- Waste handling
- Surveillance
- Maintenance.

Additional procedures may be required in the future as SWBG operations evolve and as new activities are initiated. In addition to the procedures, work plans are developed which provide general procedures for one-time or nonroutine operations.

Preparation and characterization of waste to Hanford Site requirements (see WHC-EP-0063 [WHC 1993]) is the responsibility of the waste generator. Table 3-1 presents the major waste acceptance criteria for disposal of low-level waste (LLW), mixed waste (MW), and transuranic (TRU) waste at the Hanford Site. It is the responsibility of the SWBG operating contractor to verify that the waste sent to the SWBG complies with the SWBG waste acceptance criteria.

A wide variety of waste package types are received and emplaced at the SWBG. The primary waste container types include 208-L (55-gal) steel drums and metal boxes. Every container that is listed in WHC-SP-0364, *Hazardous Materials Packaging Directory* (WHC 1991); WHC-EP-0558, *Test and Evaluation Document for DOT Specification 7A Type A Packagings*, (WHC 1994); WHC-EP-0063, *Hanford Site Solid Waste Acceptance Criteria* (WHC 1993), and all containers that meet U.S. Department of Transportation (DOT) specifications are authorized for use at the Hanford Site. Alternative waste forms can be accepted provided they meet the waste acceptance criteria applicable to the trench.

Bulk waste is received and procedures ensure that the hazards of waste dispersal are mitigated.

Although most of the waste packages currently in place and anticipated to be used in the future will be packaged in 208-L (55-gal) drums and metal boxes, practical considerations (e.g., weight, dimensions, dose rates) dictate that some wastes be packaged in other containers. A detailed listing and descriptions of waste packages that are currently in place in the SWBG are given in Chapter 2.0, Tables 2-2A, -2B, and -2C. A large variety of waste package types containing a wide range of radionuclide contents, shielding, and other physical, chemical, and radiological characteristics exists. The data in this table are used in the accident analysis to ensure that the risks associated with retrievable storage and disposal of the waste packages are addressed.

3.1 PROCESS DESCRIPTION

This section briefly describes the process for receipt and disposal of solid wastes at the Hanford Site. Detailed descriptions of the processes are provided in Section 3.3.

3.1.1 Narrative Description

The operations associated with the receipt and disposal of waste packages in the SWBG are summarized in this section. Preparation and content of the waste package to Hanford Site requirements (see WHC-EP-0063, current revision) is the responsibility of the waste generator.

In general, most types of waste packages are received, disposed, or retrievably stored in the same manner. Active trenches are backfilled as needed to minimize dose rates to operators and to minimize operator exposures to waste packages. Backfilling trenches also minimizes exposure of waste packages to conditions that could cause package degradation, waste handling accidents, and severe environmental conditions (e.g., fires, water intrusion, earthquakes).

Before a waste shipment is accepted at the SWBG, it is inspected for compliance with the waste acceptance criteria and applicable regulations. Part of the process includes comparing the waste package inventory and packaging with the limits established in the Storage/Disposal Approval Record. Acceptance of waste packages is documented by the signature of the SWBG personnel on the applicable shipping and waste management documents. The inspection ensures that wastes that might compromise the SWBG safety envelope are not accepted into the SWBG.

Before handling of the shipment, waste packages must be surveyed by the health physics technician (HPT) to verify that the dose rate and smearable contamination falls within the SWBG acceptance limits. All waste packages are examined to verify that they are free from visible damage.

Most waste packages are handled by forklift equipment, but heavy waste packages are handled by crane. Waste package placement is guided by the applicable procedure(s). Waste package specific handling requirements are specified in the waste package specific procedures. After the waste packages are received at the trench, inspected, and surveyed, they are removed from the transport vehicle and emplaced in the trenches. Following completion of emplacement operations, the HPT surveys any returnable materials and the transport vehicle before their release from the SWBG.

The MW disposal trenches with liners have loading designs that will ensure that the trench will not be differentially loaded to the extent that the liner integrity will be compromised.

TRU waste is packaged and stored in a manner such that it is retrievable intact and in a contamination-free condition. TRU waste containers may be stored uncovered on TRU asphalt-base trenches per current SWBG procedure. High-activity wastes are stored in single- or double-encapsulated containers within approved shielded waste packages.

3.2 MECHANICAL PROCESS SYSTEMS

This section describes the mechanical processing operations that occur at the SWBG. The four principal categories of operations that occur at the SWBG are as follows:

- Receipt and Inspection of Waste (Section 3.3.1)
- Waste Handling and Interim Storage (Section 3.3.2)

- Waste Disposal Operations (Section 3.3.3)
- Operational Monitoring, Surveillance, and Maintenance (Section 3.3.4).

3.2.1 Receipt and Inspection of Waste

The waste generator is responsible for preparation of waste records and packaging the waste according to DOT regulations for hazardous materials. The generator must comply with those packaging requirements established by law and the SWBG acceptance criteria.

Waste shipments are inspected and surveyed at the SWBG typically for every first-of-a-kind shipment and then randomly on similar shipments. Surveys are also performed on all special-handled and one-time-only shipments. A remote-handled (RH) waste package may be inspected using binoculars to minimize worker exposures per as low as reasonably achievable (ALARA) guidelines. The HPT will determine that the surface dose rate emitted by the waste package and surface contamination are in agreement with the shipping and burial papers and do not exceed restrictions given in WHC-EP-0063 (WHC 1993).

The necessary paperwork for all shipments is checked and verified against the actual waste packages received. Each package must be marked or labeled with the necessary identification information. Where applicable, the waste package must be free of punctures, dents, paint scratches, loose lids or locknuts, bulges, corrosion, and other signs of actual or potential containment breach.

Receiving activities related to a waste package include verification that the documentation accompanying the shipment is complete and accurate. Verification includes cross-checking the shipping and waste management documentation to ensure consistency and accuracy. Instructions for the review and completion of the shipping and waste management documentation are provided in the plant operating procedures (POPs).

A general procedure covers the receipt of commonly used waste packages, such as drums and boxes, on a flatbed truck. Separate procedures are developed for receipt and inspection of various less commonly used packagings that may require some disassembly to gain access to the waste containers and reassembly after the waste containers have been removed.

The following subsections present additional description of the receipt and inspection portions of operating procedures for various waste package types.

3.2.1.1 Low-Level Waste. A general procedure controls the receipt and inspection of commonly used waste packages, such as drums and boxes, on a flatbed truck. Separate procedures have been developed for receipt and inspection of various less commonly used transport packagings that may require some disassembly to gain access to the waste containers and reassembly after the waste containers have been removed.

3.2.1.2 Mixed Waste. A general procedure controls the receipt and inspection of commonly used waste packages such as drums and boxes on a flatbed truck. Separate procedures have been developed for receipt and inspection of various less commonly used packagings that may require some disassembly to gain access to the waste containers and reassembly after the waste containers have been removed.

MWs have been disposed in the non-*Resource Conservation and Recovery Act of 1976* (RCRA) trenches in the SWBG. MW is accepted on a case-by-case basis on the philosophy that due to ALARA considerations, these wastes are safer in the SWBG than in alternative sites. Although, this process remains an option, MW shipments are destined for RCRA-compliant landfill units. Any waste placed in the RCRA-compliant landfill units will have to meet the land disposal restrictions.

3.2.1.3 Transuranic Waste. As discussed previously, TRU wastes are no longer routinely stored in the SWBG. However, in the past TRU wastes were stored in both backfilled and nonbackfilled trenches. POPs for receipt, inspection, and placement of TRU waste containers and casks are available.

TRU wastes may be retrievably stored in a TRU asphalt-base trench per current procedures. The Experimental Breeder Reactor No. 2 (EBR-II) cask waste package must be positioned on a specified minimum spacing to satisfy criticality prevention specifications (see WHC-SD-WM-SAR-047 [WHC 1992]).

TRU waste package configurations of shielded drums and concrete casks have been used in the past but are not anticipated to be used in the future. The risks of the present practice of retrievably storing irradiated fuel waste packages uncovered and on asphalt pads is addressed in the safety analysis.

3.2.2 Waste Handling and Interim Storage

No interim storage requirements are anticipated because shipments from generators can be scheduled to avoid periods when waste is being covered or when other commitments do not permit waste operations at the SWBG.

All handling of waste packages is performed by trained SWBG personnel. Workers have safety training including radiation safety, contamination control, hazardous materials safety, use of protective clothing and equipment, and emergency procedures. They also have job-specific training based on site operating procedures including inspection, material handling, and packaging procedures and requirements. Worker training is discussed in Chapter 7.0.

3.2.3 Waste Disposal/Storage Operations

This section addresses the following SWBG operations:

- Waste emplacement
- Filling of void spaces
- Waste covering
- Locating disposal units

- Closure and stabilization
- Buffer zones.

Many SWBG operations/activities that are performed for general, commonly used waste packages are similar for all waste types. These common activities are addressed where they first occur and are not repeated for subsequent waste types. References are provided to the descriptions of common activities.

Many different types of waste packages may be received at the SWBG for disposal. The most commonly used packages are 208-L (55-gal) steel drums and various sizes of boxes. Such waste packages are typically contact-handled (CH) (i.e., surface dose rate less than 200 mrem/h) and are removed from the transport vehicles and placed in the trench using container handling equipment.

For a shipment of drums, the transport vehicle is usually backed into the trench and offloaded. SWBG personnel have the option to offload the transport vehicle outside the trench when the trench has filled to the point that there is not sufficient space to maneuver the transport vehicle. Stacking heights and spacing vary from trench to trench depending on the waste type and form.

3.2.3.1 Low-Level Waste. A series of POPs has been developed to guide disposal of LLW in the SWBG. Each procedure consists of a number of hold steps and guidance in the event of noted discrepancies. Specific POPs control disposal of less commonly used waste packages that may have special handling requirements, such as disassembly and reassembly of waste packages, shipping containers, etc.; special heavy load considerations; and RH procedures for high dose rate LLW disposal packages. In a typical LLW disposal trench, the drums can be stacked four tiers high before backfilling.

3.2.3.2 Mixed Waste.

MW Trench. The receipt of waste at the MW disposal trenches will not vary in significant detail from the receipt of wastes in other trenches. One difference is the requirement that the trench be loaded in a manner that will not result in damage to the liner integrity. Accordingly, the trench loading and backfill patterns require engineering evaluation. Because the trench may receive RH waste, loading methods must address shielding to protect personnel. The preferred method is the use of concrete barriers because they require comparatively little trench volume to effectively shield the waste. Other shielding is acceptable provided the shielding meets the RCRA landfill regulations.

Bulk waste is placed in the trench as soil fill around containerized waste when appropriate. The soil fill will be compacted around the containers to minimize future subsidence. When the bulk waste is not used as the soil fill it is dumped and spread into layers. Generation of fugitive dust will be mitigated by using water sprayers on the tipper trailers during dumping operations or with the use of fixatives. If water is used the amount will be controlled to maintain the bulk waste soils in a moist condition to minimize dust generation without adding an amount of liquid sufficient to constitute free liquid. Dust generation may also be minimized by application of physical fixatives to exposed bulk soil or adding a layer of clean fill covering the bulk waste.

ERDF. The waste transports arriving at the ERDF transfer their waste containers to dedicated facility tractor/trailers. The dedicated facility tractor/trailers transport the waste containers from the off-loading area to the working face of the trench. Generation of fugitive dust will be mitigated by using water sprayers on the tipper trailers during dumping operations and by periodic operation of water trucks with spray hoses along the exposed waste face. Further process descriptions are contained in WHC-SD-W296-SAD-001, Section 2.4.

SRC Trench. SWBG operations in an unlined MW trench involve disposal of submarine reactor compartment (SRC) units. The SRC unit is welded directly to the metal structure of the support columns in the trench. The support columns have been designed in accordance with code and regulatory requirements with respect to earthquake and wind loading. The SRC unit meets the transportation packaging criteria of the U.S. Nuclear Regulatory Commission (NRC) (10 CFR 71) and the DOT (49 CFR 173) for a Type B packaging carrying "highway route controlled quantities" of radioactive material. The NRC certificate of compliance is given in NUREG 0383 (NRC 1989). The structural characteristics required for a Type B package exceed the packaging requirements of WHC-EP-0063 (WHC 1993). The SRC trench will be backfilled at some point in time. Backfill methods and equipment will be consistent with methods and equipment normally employed by industry and do not represent an unacceptable risk of damage or injury to personnel or the environment.

3.2.3.3 Transuranic Waste.

General. TRU wastes are retrievably stored in the SWBG. Activities related to placement of TRU wastes in the SWBG are similar to the activities during placement of LLW or MW. The principal difference is that TRU waste trenches are not backfilled. TRU waste trenches will remain open until the wastes are retrieved from the trenches for further processing and ultimate disposal. A number of previously covered and uncovered TRU waste packages are currently in the SWBG. The risks of handling and storing these TRU wastes are considered in the safety analysis in Chapter 6.0.

Boxes. RH TRU waste containers typically consist of a waste container inside a disposable overpack. The overpack arrives at the SWBG on a truck trailer or railcar. A crane is then used to lift the waste package off the transport vehicle and place it at the bottom of the trench. The waste package is then covered with soil to reduce the dose rate for subsequent disposal operations.

RH TRU wastes may also be received within nondisposable transportation casks. Specific procedures have been developed to address unloading of this type of waste container from the transportation packaging. The general operational procedure for unloading these kinds of transport casks will be maintained by SWBG personnel. As with RH waste in disposable overpacks, the trench area is backfilled following emplacement to reduce radiation dose rates.

Drums and Casks. Two TRU waste package handling systems are currently in place at the SWBG. One system guides the receipt, handling, and transfer of

waste of sufficiently low activity such that it is compatible with storage in CH 208-L (55-gal) drums. The second guides the receipt, handling, and transfer of waste stored in EBR-II type casks.

Each system consists of a number of hold steps and guidance in the event of noted discrepancies. The minimum staff required to complete these waste operations includes an SWBG supervision representative, an HPT, a transport vehicle driver, two riggers, and a heavy equipment operator.

Though the sequence may vary, each system consists of the following general steps: shipment documentation verification, survey of the container by an HPT before removal from transport vehicle, examination of the container for visible signs of containment breach, removal of the container from the transport vehicle, placement in the burial ground, completion of waste receipt documentation, and survey and release of transport vehicle and/or overpack.

A description of the operating procedure for disposal of Test Reactor Isotope Production General Atomics fuels in shielded 208-L (55-gal) drums is similar to the previous description. Both EBR-II cask and shielded drum activity lists presume placement of container handling equipment at the trench prior to receipt of waste packages.

3.2.4 Operational Monitoring, Surveillance, and Maintenance

This section describes both the environmental monitoring and surveillance activities and the site monitoring and maintenance activities. A large portion of the environmental monitoring and surveillance activities for different waste types are shared or common activities because the different wastes may be stored in adjacent trenches in the same burial ground. Segregation of different waste package types promotes stacking efficiency and stacking stability within the trench. However, there is no safety-related requirement to segregate in this manner so some trenches may contain a variety of different waste package types.

As described in Chapter 5.0 of DOE/RL-88-20, *Low-Level Burial Grounds Dangerous Waste Permit Application*, a groundwater monitoring system consisting of 35 wells has been installed around the SWBG (RL 1989). A total of 16 wells are installed in the 200 East Area and 19 wells in the 200 West Area. These wells, which were drilled and installed from July to October 1987, provide information regarding the hydrogeologic properties of the uppermost aquifer beneath the SWBG and background water quality data. Additional wells may be installed at a later date if a greater well density is warranted.

A total of 11 of the wells in the 200 West Area and all 16 wells in the 200 East Area are installed as single wells. The remaining eight wells in the 200 West Area are drilled as four pairs. Each well of a given pair is drilled 7.6 to 15.2 m (25 to 50 ft) away from the other, with one of each pair being a deep well and the other a shallow well. The deep wells penetrate the uppermost aquifer system to a lower semi-confining unit located $\approx$ 61 to 76 m ($\approx$ 200 to 250 ft) below the water table. The shallow wells penetrate only the upper 6.1 to 9.1 m (20 to 30 ft) of the uppermost aquifer.

Additional design and installation information for these wells is presented in DOE/RL-88-20, Supplement 1, (RL 1990, Chapter 5.0) and Last et al. (1989). Sampling data results from these interim status wells as well as other sample wells on the Hanford Site are published annually in the Hanford Site environmental report (Woodruff et al. 1991).

Groundwater sampling is conducted in accordance with the Part B Permit Application (RL 1989), which also describes the parameters analyzed and the sampling frequency. Groundwater monitoring results for the first quarterly samples taken from the interim status wells are also summarized in RL (1989; p. 5-25). Samples are taken for *Washington Administrative Code* (WAC) 173-303-645(5) (Table 1) drinking water parameters (e.g., arsenic, chromium, mercury, lead) and WAC-173-303-9905 chemical parameters (e.g., pH, specific conductivity, total organic halogen, and total organic carbon). Complete results are contained in Last et al. (1989). Results also are entered in a database and published in quarterly compliance reports (PNL 1989).

Table 3-2, taken from RL (1989, p. 5-26), identifies chemical constituents that are found in concentrations that exceeded drinking water standards during the interim status period. Drinking water standards are listed in 40 CFR 141. Groundwater from four wells in Low-Level Waste Management Area Number 1 (LLWMA-1) exceeded established drinking water standards for tritium (20,000 pCi/L) and one of these four wells exceeded limits for nitrates (45 mg/L) and gross alpha radiation (15 pCi/L). Groundwater from a fifth well exhibited chromium levels that approached the limit (50 μ g/L), but the origin of the chromium is unknown.

In wells installed around LLWMA-2, only the concentration of dissolved chromium approached the standards. An investigation has been launched to determine the source of the chromium; however, the concentrations are being carefully monitored and evaluated (PNL 1989).

In three wells adjacent to LLWMA-3, the concentrations of dissolved chromium exceeded standards. Nitrate levels exceeded 45 mg/L in two wells and approached the standard in two wells. Carbon tetrachloride was detected in five samples and exceeded limits (5 μ g/L) in four of the samples.

In wells at LLWMA-4, samples are shown to be high in coliform bacteria (one well), gross alpha radiation (one well), chromium (five wells), nitrate (two wells), carbon tetrachloride (six wells), and trichloroethylene (one well).

The remainder of this section discusses monitoring and surveillance activities specific to each waste type (i.e., LLW, MW, and TRU waste). It should be noted that monitoring and surveillance activities are, in general, performed for the SWBG as a whole and are not necessarily specific to a particular waste type. The preceding discussion provided a general description of the overall SWBG monitoring and surveillance activities.

3.2.4.1 Low-Level Waste. The general monitoring and surveillance program for the SWBG, described in Section 3.3.4, is applicable to LLWMA-1 and LLWMA-4 in which all the LLW is to be disposed. The scheduled dates for closure of the burial grounds within the scope of the RCRA Part B Permit Application (RL 1989) is presented in Table 3-3. Surveillance and inspection of solid

waste storage/disposal facilities are addressed in an operating procedure that specifies monitoring and surveillance activities and their minimum frequencies. No additional specific monitoring and surveillance requirements are anticipated for the LLW disposal trenches.

3.2.4.2 Mixed Waste.

MW Trench. Two MW lined disposal trenches are now within LLWMA-3. This is a hydrologic unit that includes a group of landfills that are part of the 200 West Area SWBG. Existing groundwater monitoring wells will be used for environmental monitoring and surveillance. Groundwater monitoring will continue throughout the active life of LLWMA-3.

The Part B Permit Application submitted to the Washington State Department of Ecology (RL 1989) includes a groundwater monitoring plan (described in Section 3.3.4). This plan assumes that MW may be buried anywhere in the SWBG and would include future additions of MW disposal trench capacity in the U.S. Department of Energy (DOE) Solid Waste Program. Sampling activity is performed under contract from the DOE.

SRC Trench. The general monitoring and surveillance program for the SWBG, described in Section 3.3.4, is applicable to the SRC landfill. Surveillance and inspection of SWBG units are addressed in an operating procedure that specifies monitoring and surveillance activities and their minimum frequencies. No additional specific monitoring and surveillance requirements are anticipated for the SRC landfill.

3.2.4.3 Transuranic Waste. Uncovered TRU waste packages will be inspected on a weekly basis for signs of corrosion and degradation. It is anticipated that the TRU waste packages will be retrieved at some future time, treated, and/or permanently disposed. Therefore, postoperational activities will consist primarily of visual inspection to detect package degradation. The existing groundwater monitoring programs will be used to identify contamination from failed packagings should a failure occur.

It is anticipated that TRU waste packages buried using past practices will ultimately be exhumed, inspected for package degradation, removed from the burial grounds, and moved to a treatment or disposal facility. In the near term (i.e., until the soil cover is removed from the waste packages), the SWBG environmental monitoring programs (especially the groundwater monitoring network) will be used to detect package failures and radioactive releases should they occur.

Caissons containing TRU wastes no longer are receiving new wastes. Routine monitoring, surveillance, and maintenance of the caissons continues in accordance with existing procedures. TRU waste from the alpha caissons is expected to be retrieved in the future.

3.3 CHEMICAL PROCESS DESCRIPTION

This section is not applicable to the SWBG.

3.4 PROCESS SUPPORT SYSTEMS

Electric power is required to run leachate collection systems in MW disposal trenches and to provide lighting. A loss of power would have no negative impacts on operations. SWBG personnel would have ample time to connect a generator to the system in the event that normal power could not be restored within a few days.

Whereas the trenches are open to the atmosphere, no ventilation or offgas systems are required.

Fire protection is provided by Hanford Fire Department personnel, who are specially trained to respond to fires involving radioactive and hazardous materials. The modern equipment includes trucks equipped with hydraulically operated aerial ladders, pumpers, and trucks with chemicals to extinguish fires. Response time within the 200 Areas is less than 10 minutes. Portable fire extinguishers are provided on motorized vehicles, and personnel are trained in their use. To date, there have been no fires involving wastes in retrievable storage trenches.

Security for the SWBG is provided by the Hanford Patrol. Credit is taken for the 200 Area boundary fences, and the public is not allowed access to the SWBG.

3.5 CONTROL SYSTEM

Overall centralized control of SWBG operations is the responsibility of the SWBG operating contractor management.

Control building(s) for the leachate collection systems in MW disposal trenches are designed to prevent unauthorized access and to protect instrumentation from the elements. Control buildings are not considered occupied structures.

3.6 SAMPLING AND ANALYTICAL

Smear samples from the exteriors of waste packages are taken upon arrival at the Hanford Site to ensure that WHC-EP-0063 (WHC 1993) limits on smearable surface contamination are not exceeded. These samples are analyzed in accordance with existing radiation protection procedures.

3.7 CHAPTER CRITERIA

A summary description of the information in the chapter is provided with acceptance criteria derived from appropriate guidance documents.

3.7.1 Summary Description

This chapter describes the process, process conditions, the equipment and the systems used for the waste package receipt, handling, emplacement, and monitoring activities in the SWBG. The instrumentation and analytical sampling are discussed, where applicable.

3.7.2 Acceptance Criteria

The acceptance criteria for this chapter are based on DOE Order 6430.1A. Specific acceptance criteria are as follows.

1. The chapter should describe the SWBG processes and identify items for safety analysis concern.
2. The chapter should describe the process systems, including major components, safety criteria, and performance requirements.
3. The chapter should describe the process support instrumentation and control systems for normal and accident/abnormal conditions.
4. The chapter should describe design and operations, where applicable to the SWBG.

3.8 REFERENCES

3.8.1 Acts and Codes

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

10 CFR 71, 1993, "Packing and Transportation of Radioactive Material," *Code of Federal Regulations*, as amended.

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

49 CFR 173, "Shippers-General Requirements for Shipments and Packaging," *Code of Federal Regulations*, as amended.

3.8.2 Documents

Last, G. V., B. N. Bjornstad, M. P. Bergeron, D. W. Wallace, D. R. Newcomer, J. A. Schranke, and M. A. Chamness, 1989, *Hydrology for the 200 Areas Low-level Burial Grounds - An Interim Report*, 2 Vols., PNL-6820, Pacific Northwest Laboratories, Richland, Washington.

- NRC, 1989, *Directory of Certificates of Compliance for Radioactive Material Packages*, NUREG-0383, U.S. Nuclear Regulatory Commission, Washington, D.C.
- PNL, 1989, *Resource Conservation and Recovery Act Ground-Water Monitoring Projects for Hanford Facilities: Progress Report for the Period October 1 to December 31, 1988*, PNL-6789, Pacific Northwest Laboratory, Richland, Washington.
- RL, 1989, *Low-Level Burial Grounds Dangerous Waste Permit Application*, DOE/RL-88-20, U.S. Department of Energy, Richland Operations Office, Richland, Washington.
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- WHC, 1991, *Hazardous Materials Packaging Directory*, WHC-SP-0364, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1992, *Retrievable Storage of Irradiated Fuels in the Solid Waste Burial Grounds*, WHC-SD-WM-SAR-047, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1993, *Hanford Site Solid Waste Acceptance Criteria*, WHC-EP-0063, Rev. 4, (or current revision), Westinghouse Hanford Company, Richland, Washington.
- WHC, 1994, *Test and Evaluation Document for DOT Specification 7A Type A Packagings*, WHC-EP-0558, Rev. 2, Westinghouse Hanford Company, Richland, Washington.
- Woodruff, R. K., R. W. Hanf, M. G. Hefty, and R. E. Lundgren, 1991, *Hanford Site Environmental Report for Calendar Year 1990*, PNL-7930, Pacific Northwest Laboratory, Richland, Washington.

3.8.3 U.S. Department of Energy Orders

- DOE Order 6430.1A, 1989, *General Design Criteria*, U.S. Department of Energy, Washington, D.C.

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Table 3-1. Summary Hanford Site Solid Waste Disposal Requirements for Low-Level Waste, Mixed Waste, and Transuranic Waste.^a

Subject	Low-level waste acceptance requirements	Mixed waste acceptance requirements ^b	Transuranic waste acceptance requirements
Free liquids	None ^c	Packaged with approved absorbent material	None
Fire retardancy (combustibles)	Constructed of metal or will be fire retardent	Containers constructed of metal or other noncombustible material	Newly generated waste containers constructed of noncombustible material
Absorbents	2 x volume liquid	2 x volume liquid	2 x volume liquid
Surface dose rates	CH waste: 200 mrem/h RH waste: 3,000 mrem/h at 1 m from side of truck; 5,000 mrem/h at 1 m from railcar	100 mrem/h at surface of container	100 mrem/h at surface of container
Surface contamination	220 dpm/100 cm ² g 2,200 dpm/100 cm ² β,γ	220 dpm/100 cm ² g 2,200 dpm/100 cm ² β,γ	220 dpm/100 cm ² g 2,200 dpm/100 cm ² β,γ
Nuclear criticality	Criticality safety analysis required if package contains >15 g ²³⁵ U	Criticality safety analysis required if package contains >15 g ²³⁵ U. TRU MW containers will not exceed 35 plutonium-equivalent curies	Numerous; e.g., 200 g fissile or fissionable material per 208-L (55-gal) drum
Thermal power	0.1 W/ft ³	0.1 W/ft ³	Calculated/determined for each waste container
Gas generation	Venting or catalyst packs	Catalyst packs	Approved pressure relief device required
Void spaces	Filled; voids shall not exceed 10% of waste container volume	None specified	No limits

^aSpecific waste packages with waste disposal criteria (see WHC-EP-0063).

^bThese requirements are to be used for general guidance and are not intended to replace the U.S. Department of Transportation, U.S. Environmental Protection Agency, and Washington State Department of Ecology regulations.

^cSome residual liquids remain within submarine reactor compartments. All systems have been drained to remove liquids to a maximum of 870 L (230 gal). Diatomaceous earth is used to absorb remaining free liquids. The amount of sorbent and location applied is recorded on the Solid Waste Storage/Disposal Record.

CH = contact-handled.

LLW = low-level waste.

MW = mixed waste.

RH = remote-handled.

TRU = transuranic.

Table 3-2. Chemical Constituents Exceeding Drinking Water Standards During Interim Status Monitoring (October 1988).^a

Constituent	Number of wells exceeding standards			
	LLWMA-1	LLWMA-2	LLWMA-3	LLWMA-4
Gross alpha radiation (15 pCi/L) ^b	1	0	0	1
Carbon tetrachloride (5 ppb) ^b	0	0	4	6
Coliform bacteria (1 MPN) ^b	0	0	0	1
Chromium (50 ppb) ^b	0	0	3	5
Nitrate (45 mg/L) ^b	1	0	2	2
Trichloroethylene (5 ppb) ^b	0	0	0	1
Tritium (20,000 pCi/L) ^b	5	0	0	0

^aSource: RL (1989), p. 5-26.^bDrinking water standards, taken from 40 CFR 141, are provided in parentheses.

LLWMA = Low-Level Waste Management Area.

MPN = most probable number.

ppb = parts per billion.

Table 3-3. Closure Dates for Burial Grounds Containing Low-Level Waste.*

Low-level waste management area	Burial ground	Closure (year)
1	218-E-10	2012 2027
2	218-E-12B	2014-2015 2035-2036 2058-2059
3	218-W-3A and 218-W-3AE	2014-2016
	218-W-5	2029
4	218-W-4B	2011
	218-W-4C	2013-2014 2039
5	218-W-6	2002-2003 2005

*Source: RL (1989), p. 11-75.

CHAPTER 4.0
WASTE CONFINEMENT AND MANAGEMENT

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LIST OF TERMS

HEPA	high-efficiency particulate air (filter)
LLW	low-level waste
MW	mixed waste
SWBG	Solid Waste Burial Grounds
TRU	transuranic
TSD	treatment, storage, and disposal (facility)
WHC	Westinghouse Hanford Company

4.0 WASTE CONFINEMENT AND MANAGEMENT

The purpose of this chapter is to demonstrate that all radioactive and hazardous waste materials generated at the Solid Waste Burial Grounds (SWBG) will be contained and managed safely. This chapter applies to wastes generated during the operation of the SWBG and not to wastes received at the SWBG. Wastes generated elsewhere are subject to waste confinement and management requirements for the waste generating facility.

4.1 WASTE MANAGEMENT CRITERIA

Treatment, handling, and disposal of radioactive wastes generated at the SWBG will be conducted in accordance with applicable federal, state, and local environmental regulations and in accordance with a waste minimization plan. Waste minimization refers to minimizing the volume or quantity and toxicity of wastes generated at the SWBG. A brief description of the regulatory bases and objectives of the SWBG waste minimization plan are found in DOE/RL-88-20 *Low-Level Burial Grounds Dangerous Waste Permit Application* (RL 1989). The objectives of the waste minimization program for the SWBG include the following.

- Minimize the volume of waste being generated.
- Generate nondangerous or less dangerous forms of waste where practical.
- Segregate dangerous waste from nondangerous waste where practical.

The principal requirements that are applicable to facilities on the Hanford Site are contained in WHC-CM-7-5, *Environmental Compliance Manual*.

4.2 RADIOLOGICAL WASTES

The only significant radiological waste to be generated at the SWBG is the leachate collected at the mixed waste (MW) disposal trenches. These wastes are anticipated to be classified as low-level MW. The chemical and physical properties of the leachate are not yet available.

Small quantities of solid radioactive wastes are anticipated to be generated during operation and maintenance of the SWBG. The following types of waste may be generated at the SWBG:

- Process waste — includes secondary MW, secondary nonradioactive waste, and failed equipment
- Decontamination waste — includes decontamination solids, nonrepairable contaminated equipment, and soil solution-absorbing waste
- Maintenance waste — includes lubricating leachate pump oil, antifreeze, oil absorbent, and solvent, if used

- Miscellaneous waste — includes materials contaminated with waste constituents or from offnormal events such as spills or equipment failures.

The key element of waste minimization involves segregation of nondangerous wastes from dangerous wastes to reduce the volume of wastes that must be handled as dangerous wastes. Nondangerous wastes may then be disposed of in the onsite sanitary landfill. Other elements include substitution of nondangerous solvents for dangerous solvents used in decontamination processes and use of the minimum quantities of decontamination solutions necessary to achieve the level of decontamination desired. Most of these wastes are expected to be low-level waste (LLW) and are disposed of in the LLW disposal areas of the SWBG. However, some wastes may be classified as MW and will be disposed of in the MW landfills. Some of the wastes generated at the SWBG may be classified as transuranic (TRU) wastes and will follow the storage/disposal pathway for other TRU wastes generated onsite.

4.3 NONRADIOLOGICAL HAZARDOUS WASTES

No significant quantities of nonradiological hazardous wastes are anticipated to be generated at the SWBG. Nonradioactive nonhazardous wastes, such as paper products and other office-generated wastes, will be kept segregated from radioactive wastes and disposed of appropriately.

4.4 OFFGAS TREATMENT AND VENTILATION

No offgas treatment systems are provided or necessary for most areas of the SWBG. The only elements of the SWBG containing offgas treatment systems are the alpha and beta caissons for remote-handled TRU waste and LLW, respectively. Forced ventilation of the caissons has been stopped because no new wastes are being or will be added to the caissons. However, air from the caissons is still being naturally circulated through the high-efficiency particulate air (HEPA) filters in the caisson exhaust system. The HEPA filters remove radioactive material that may become airborne because of air circulation action. The HEPA filters are monitored and changed out periodically to prevent high radiation levels in the filters. HEPA filter changeout is conducted in compliance with existing SWBG practices.

4.5 LIQUID WASTE TREATMENT AND RETENTION

No liquid wastes, other than the leachate collected from the MW lined trenches, are anticipated to be generated at the SWBG under normal operations. Therefore, liquid waste retention and treatment are applicable to only the MW lined trenches.

The leachate collected from the MW lined trenches is not expected to contain more than trace amounts of radioactive materials. Routine leachate analyses will provide an early indication of loss of integrity of the disposed waste packages.

Leachate production will be about 1,000 m³/yr (20,700 ft³/yr) (WHC 1990). The precipitation falling into a MW lined trench will migrate through the layers of fill, past the containers, and to the liners. The slope of the bottom of the trench will direct the precipitation, now leachate, to the leachate sump. It is pumped to a holding tank from the leachate sump. Precipitation falling on the surrounding area will be directed away from the landfill to the storm drainage system.

The leachate is collected in a tank placed in a secondary containment compliant with federal regulations. The contents are periodically transported to permitted treatment, storage, and disposal (TSD) facilities as operationally required. The liquid waste will be characterized to the extent necessary to meet the receiving TSD facility's waste acceptance criteria.

If radionuclides are found in the leachate samples taken the surface dose rate of the tank will be monitored. If the surface dose rate approaches 100 mrem/h, action will be taken to keep it below 100 mrem/h, such as the following.

- Reduce the allowable quantity of leachate in the tank. (Surface dose rate depends on actual curie content of the tank not the curies per cubic meter.)
- Flush the tank to remove internal surface contamination and precipitated radionuclides. If the tank is badly contaminated, it will be replaced.
- Add shielding to reduce personnel exposures.

Keeping the surface dose rate of the leachate tank below 100 mrem/h also reduces the consequence of a spill should the tank or piping develop a leak. The primary consequence of a spill would be exposure of persons working at the leachate collection basin to clean up the spill. The onsite and offsite dose consequences of a spill would come from wind-borne radionuclides picked up from the surface of the leachate tank collection basin. A spray of leachate into the air from a piping leak would be possible only while the pumps were operating because the leachate collection tank is not pressurized.

The equations from NUREG/CR-1759, Vol. 3 (NRC 1981), intended for wells downstream of a landfill, have been adapted to calculate the leachate reaching the tank, as shown in Table 4-1. The leachate source term is based on the total amount of radionuclides expected in the landfill during its lifetime. The calculation assumed the drums had completely deteriorated and no radioactive decay took place.

The period of time between the emplacement of the last waste package and turning the MW disposal landfill over to custodial care is referred to as the closure period. The placing of a layer of topsoil over the drums will retard the production of leachate until equilibrium is reached between the amount of rainfall and the amount of absorption of moisture by the new fill. A reduction in total leachate flow and subsequent reduction in radionuclides reaching the tank will occur. The topsoil will be graded so as to direct most

of the precipitation to the storm drainage system; therefore, only a small portion of the precipitation will still percolate through to the disposed waste.

The radioactive material reaching the tank will be a fraction of the total curie content of the landfill. As the radioactive material in the landfill is leached away, the inventory in the landfill will decrease. Radioactive decay will also reduce this inventory; however, radioactive decay and the leaching process in reducing the inventory is not considered in making the calculations of radionuclide content of the tank in Table 4-1.

4.6 SOLID WASTES

Small quantities of radioactive solid wastes will be generated during facility operation. Solid wastes may include contaminated clothing, vegetation that has blown or grown into the trenches, and caisson HEPA filters. It is anticipated that only low-level radioactive and low-level MW will be generated at the SWBG. These wastes will be packaged, handled, and disposed of onsite in accordance with WHC-EP-0063, *Hanford Site Solid Waste Disposal Criteria* (WHC 1993) and WHC-CM-7-5.

4.7 CHAPTER CRITERIA

A summary description of the information in the chapter is provided with the acceptance criteria derived from appropriate guidance documents.

4.7.1 Summary Description

This section discusses hazardous and radioactive waste management of the SWBG. Discussions of solid, liquid, and gaseous waste management programs are included in this chapter. A description of the solid and liquid waste streams is provided along with information on the hazardous constituents and radionuclide constituent concentrations.

4.7.2 Acceptance Criteria

The acceptance criteria for this chapter are based on the following:

1. DOE Order 5480.1B, *Environmental, Safety and Health Program for Department of Energy Operations*
2. DOE Order 5480.4, *Environmental Protection, Safety and Health Protection Standards*
3. DOE Order 5400.5, *Radiation Protection of the Public and the Environment*
4. DOE Order 5820.2A, *Radioactive Waste Management*
5. WHC-CM-7-5, *Environmental Compliance Manual*.

The specific criteria used to evaluate this section are as follows.

1. Clear guidelines and references to U.S. Department of Energy orders should be provided so as to fully describe waste management criteria.
2. A clear explanation of waste streams (airborne, liquid, and gaseous) should be provided.
3. A concise description of the hazardous and airborne effluents should be provided.
4. A description of decontamination and waste drainage should be provided.

4.8 REFERENCES

4.8.1 Documents

NRC, 1981, *Data Base for Radioactive Waste Management*, NUREG/CR-1759, U.S. Nuclear Regulatory Commission, Washington, D.C.

RL, 1989, *Low-Level Burial Grounds Dangerous Waste Permit Application*, DOE/RL-88-20, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

WHC, 1990, *Definitive Design Report, Project W-025 Radioactive Mixed Waste Land Disposal Facility Non-Drag-Off*, WHC-SD-W025-FDR-001, Westinghouse Hanford Company, Richland, Washington.

WHC, 1993, *Hanford Site Solid Waste Acceptance Criteria*, WHC-EP-0063, Rev. 4 (or current revision), Westinghouse Hanford Company, Richland, Washington.

4.8.2 U.S. Department of Energy Orders

DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, U.S. Department of Energy, Washington, D.C.

DOE Order 5480.1B, *Environmental, Safety and Health Program for Department of Energy Operations*, U.S. Department of Energy, Washington, D.C.

DOE Order 5480.4, *Environmental Protection, Safety and Health Protection Standards*, U.S. Department of Energy, Washington, D.C.

DOE Order 5820.2A, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C.

4.8.3 ,Controlled Manuals

WHC-CM-7-5, *Environmental Compliance Manual*, Westinghouse Hanford Company,
Richland, Washington.

Table 4-1. Leachate Collection Tank and Basin Content and Surface Dose Rate.*

Isotope	Ci/Tank	Surface dose mrem/h	Ci/Basin	Surface dose mrem/h
⁶⁰ Co	2.1 E-4	9.5 E-2	2.7 E-4	3.1 E-2
⁹⁰ Sr	6.5 E-6	1.4 E-3	8.3 E-6	3.1 E-4
¹²⁹ I	1.6 E-3	9.3 E-7	2.1 E-3	1.6 E-2
¹³⁷ Cs	2.3 E-6	3.3 E-4	2.9 E-6	8.5 E-5
²³⁹ Pu	6.5 E-6	1.1 E-7	8.4 E-6	2.2 E-4
²⁴¹ Am	5.7 E-5	7.1 E-5	7.4 E-5	1.34 E-3
Average for 6 isotopes	3.14 E-4	1.7 E-2	4.1 E-4	5.5 E-2

*The curie amounts are calculated on a spreadsheet using equations from NUREG/CR-1759, Vol. 3. The same source term is used for all the isotopes disregarding the concentration limits imposed by WHC-EP-0063, which would reduce the maximum inventory of radioactive materials in the landfill for some of the radionuclides. Other radionuclide inventories would be limited by the 200 mrem/h surface dose rate per container requirement, the thermal power limit, and the restrictions on long half-lived radioactive wastes given in WHC-EP-0063. The source terms are based on a total inventory of 560,927 Ci.

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CHAPTER 5.0
RADIATION PROTECTION AND INDUSTRIAL HYGIENE

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LIST OF TERMS

ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
CH	contact-handled
DOE	U.S. Department of Energy
LLW	low-level waste
MSDS	material safety data sheet
MW	mixed waste
NAD	nuclear accident dosimeter
OSHA	Occupational Safety And Health Administration
PHA	process hazard analysis
PNL	Pacific Northwest Laboratory
RA	radiation area
RH	remote-handled
RL	U.S. Department of Energy, Richland Operations Office
RWP	radiological work permit
SWBG	Solid Waste Burial Grounds
TRU	transuranic
WHC	Westinghouse Hanford Company

5.0 RADIATION PROTECTION AND INDUSTRIAL HYGIENE

This chapter describes those features of the Solid Waste Burial Grounds (SWBG) that ensure occupational radiation exposures and exposures to hazardous chemicals are maintained as low as reasonably achievable (ALARA) and below applicable standards. Radiation protection features are described in Section 5.1 and industrial hygiene is described in Section 5.2.

5.1 RADIATION PROTECTION

This section describes the key elements of the radiation protection program. Specific policies, standards, and general guidance to administer the Hanford Site radiological control program are followed. These guidelines and/or successor guidance documents may change from time to time.

5.1.1 Occupational Radiation Exposures

Elements of the radiation protection program are included in WHC-CM-1-6, *WHC Radiological Control Manual*, and listed below:

- ALARA Program
- Radiation safety training
- Dose limits and policies
- External dose measurements
- Internal dose measurements
- Radiation posting and labeling
- Radiation work requirements and permits
- Radiological control of materials and equipment
- Surface contamination control
- Controls for personnel survey devices
- Airborne radioactive material evaluations and controls
- Radioactive material storage
- Radioactive material shipping and receiving
- Radiation-generating devices
- Open radiography
- Radiological records
- Radiological reviews and approvals
- Radiological protection and appraisals.

More detail on the ALARA Program is provided in WHC-CM-4-11, *ALARA Program Manual*. The manual outlines the six key elements in the ALARA Program:

- Job planning
- Job monitoring
- Postjob review
- Project design and review (including ALARA reviews of new and backfit facilities)
- ALARA committee
- Training.

5.1.1.1 Policy Considerations. In compliance with the U.S. Department of Energy (DOE) orders and to support radiation protection, the ALARA Program at the Hanford Site applies to the preoperational, operational, and postoperational phases of all projects and facilities. The program goal is to minimize human exposures (occupational and public) to radiological and nonradiological hazards and conditions, commensurate with sound economics, operating practices, and expected benefits from planned activities. The program focuses on those activities with significant risk because of the presence of radiation, toxic substances, or hazardous conditions.

The Hanford Site ALARA Program and policy are established in WHC-CM-1-3, *Management Requirements and Procedures*, MRP 5.37, and described in WHC-CM-4-11. The policy on radiation protection is described in WHC-CM-1-3, MRP 5.38, and WHC-CM-1-6. The policy on industrial safety is described in WHC-CM-1-3, MRP 5.7, and WHC-CM-4-3, *Industrial Safety Manual*. Fire protection is addressed in WHC-CM-4-41, *Fire Protection Program Manual*. The ALARA Program, as described in these documents, complies with the requirements of the following:

- DOE Order 5480.10, *Contractor Industrial Hygiene Program*
- DOE Order 5480.11, *Radiation Protection for Occupational Workers*
- RLIP 5480.11, *Radiation Protection for Occupational Workers*
- PNL-6577, *Health Physics Manual of Good Practices for Reducing Radiation Exposures to As Low As Reasonably Achievable (ALARA)* (Munson 1988).

DOE Order 5480.10 requires an effective industrial hygiene program designed to preserve employee health and well-being. DOE Order 5480.11 requires that exposures to radiation resulting from DOE operations be maintained as far below all limiting values as reasonably achievable.

5.1.1.2 Design Considerations. The basic design objective for the SWBG is to provide an environmentally safe land disposal/retrievable storage system for low-level waste (LLW), low-level mixed waste (MW), and transuranic (TRU) waste. Waste disposal and storage facilities are designed and constructed in accordance with applicable federal and state requirements. General design criteria for the SWBG are addressed in Chapter 1.0. SWBG facility designs, including descriptions of design elements that satisfy the general design criteria, are provided in Chapter 2.0. Radiation protection design criteria and design features are included in these chapters. Operational considerations related to radiation protection are provided in Chapter 3.0.

5.1.1.3 Operational Considerations. A number of administrative controls are in place to ensure safety during all activities. In particular, WHC-CM-4-3, Standard A-7, provides for a job hazards analysis and the dual function of providing a responsible review of the work scope and zone.

Each procedure includes a safety section that identifies specific precautions and/or safety requirements applicable to the task at hand. Warnings are also provided in the text of the procedure to alert operators to safety concerns associated with particular steps.

Activities that involve radiological exposure must be performed following the requirements of WHC-CM-1-6. Entry into, and the work performed in, any radiologically controlled area is governed by the provisions of the radiological work permit (RWP) that is issued for that job or area. The Health Physics organization issues RWPs with the review and concurrence signature of SWBG operating management.

The general policy is that all occupational radiation exposures shall be kept ALARA. This policy is reflected in the design objective that occupational internal and external radiation doses should be ALARA and shall not exceed 20% of the maximum value of 5 rem/yr (i.e., 1 rem/yr) effective dose equivalent permitted in DOE Order 5480.11. Administrative control levels established in WHC-CM-1-6 are well below the DOE limits (see Table 5-1). It is also a goal to design the facility such that occupational extremity doses are less than 10 rem/yr. In addition, the design of the SWBG will not result in the occupational workers being exposed in excess of the values listed in 10 CFR 20, "Standards for Protection Against Radiation." This is in accordance with the radiation protection requirements of DOE Order 6430.1A, *General Design Criteria* (Division 13, Paragraph 1324-4), for this type of facility. There is no person-rem offsite dose anticipated from normal operation of the SWBG. Offsite doses are addressed in Chapter 6.0 for different accident scenarios.

Numerous special and routine studies of radioactivity in the Hanford Site environs have been conducted since the beginning of Hanford Site operations. These surveys will continue to be made in compliance with DOE Order 5484.1, *Environmental Protection, Safety, and Health Protection Information Reporting Requirements*, Chapter III, "Effluent and Environmental Monitoring and Reporting," and Chapter IV, "Occupational Radiation Exposure Information." Effluent monitoring instrumentation is designed, calibrated, and maintained in accordance with American National Standards Institute (ANSI) N42.18-1980, *Specifications and Performance of Onsite Instrumentation for Continuously Monitoring Radioactivity in Effluents* (ANSI 1980).

There is no gaseous effluent release anticipated from the SWBG. No instrumentation to measure effluent gases will be required. In addition, there is no liquid effluent generated by normal operations of the SWBG, except for the MW lined trenches discussed below. Any liquid wastes collected from the trenches are anticipated to result from rainwater. However, because the waste packages are free of external contamination and are expected to retain their containment capabilities for the foreseeable future, rain runoff from the trenches is expected to contain insignificant levels of radioactive contamination. Furthermore, the soil will absorb and trap nearly all of the radioactive material near the trench so groundwater contamination is anticipated to be minimal.

Rain runoff is confined within the MW lined landfill by the leachate management system. The leachate is pumped into the leachate collection tank, sampled, characterized, and then transported either to an interim storage or treatment facility.

5.1.2 Radiation Sources

The sources of radiation used as the bases for radiation protection are described in this section. Compositions of the different waste types are provided in Chapter 6.0. Information on the radionuclides contributing to radiation source streams in the SWBG is provided in Chapter 6.0. Characterization of the isotopic composition or gamma ray energy groups, strength (curie content), and geometry of the waste are derived from historical waste characterization data. Where there is insufficient data, this information is based on bounding source terms set by regulatory limits and criteria.

During normal operation of most trenches, including trenches containing LLW, TRU waste, submarine reactor compartments, and irradiated fuel wastes, there is no process equipment or piping that contains radioactive materials. Contained sources within these trenches are limited to the waste packages. Radioactive material will be limited to contact-handled (CH) waste in acceptable containers with approved manifests, and remote-handled (RH) wastes controlled in accordance with WHC-CM-2-14, *Hazardous Material Packaging and Shipping*.

During normal operation of MW lined trenches, all process equipment and piping containing potentially radioactive fluids are provided with secondary containment to prevent any leaks or spills of radioactive and hazardous material from being released into the environment. The secondary leachate containment consists of a concrete-walled foundation for the aboveground primary leachate collection system piping, piping components, and tank. Primary containment of the solid waste form is provided by the waste container; secondary and tertiary containment is provided by the use of geomembranes in the liner system.

Contained sources in the MW lined trenches are limited to the wastes and the leachate collection system components and piping. Radioactive material will be limited to approved bulk wastes, CH waste in certified containers with approved manifests, and RH wastes controlled in accordance with WHC-CM-2-14.

5.1.3 Radiation Protection Design Features

This section details radiation protection design features applicable to the SWBG.

5.1.3.1 Solid Waste Burial Grounds Design Features. The following SWBG equipment and design features help ensure that occupational radiation exposures are ALARA and confinement is maintained.

- The layouts of the trenches are designed to provide proper traffic flow of personnel and materials, to provide work areas appropriate for the operational activities, and to satisfy WHC-CM-4-9, *Radiological Design*, Section 2.0, "Facility Layout."
- Leachate detection systems will be installed with leachate collection systems.

- Leachate pumping systems will be installed as required.
- Active trenches are backfilled when the radiation dose rate at the lip of the trench exceeds 100 mrem/h.
- Shielding is provided in the trenches for high dose-rate waste packages.

Several design features are used to keep exposures and contamination ALARA. The waste packages used in the SWBG will meet the requirements of the applicable safety analysis report for packaging and WHC-EP-0063, *Hanford Site Solid Waste Acceptance Criteria* (WHC 1993), specifications. Considering the integrity of the packaging and the waste contents concentration limits, in the event that a small amount of radioactive material is released from a container during normal operations there would be negligible consequences other than localized contamination around the waste container. Sampling, characterization, and decontamination would be completed before resuming normal operations. For MW lined trenches, all leachate in the landfill area will be contained within the landfill and leachate collection system.

The SWBG areas are posted and treated as radiologically controlled areas. Only those areas where RH waste is emplaced in appropriately prepared trenches will be treated as radiation areas.

5.1.3.2 Shielding. The SWBG is designed and operated such that the combination of shielding attenuation and task time requirements maintains the worker dose to less than 0.5 rem/yr effective dose equivalent. It is also a goal to operate the SWBG such that the extremity dose is less than 15 rem/yr.

Shadow shielding and distance are used to minimize dose rates to operators when placing RH wastes in LLW or TRU waste trenches. In some cases, specially designed waste disposal packages incorporating shielding will be used during emplacement of RH wastes.

The RH waste emplacement areas within MW disposal trenches will provide shielding for the side adjacent to the landfill interior, possibly concrete blocks. Using a conservative transmission factor of 0.005 for the 0.6-m- (24-in.-) thick concrete block barrier wall, the potential dose to workers operating in areas adjacent to the RH waste behind the wall is estimated to be less than 1 mrem/h. Tools such as drum handlers attached to forklifts will be used when practical to maximize the distance between workers and waste drums.

Liquid waste from the leachate collection system will be sampled and characterized. Results of the sample analyses will be evaluated in determining its end destination. Contingency plans are required to address the dispositions of leachate anticipating different sample analysis results.

5.1.3.3 Ventilation. Caissons are the only area of the SWBG in which ventilation is needed. The caissons are provided with high-efficiency particulate air filter systems to remove radioactive material from the caisson exhaust air. The caisson exhaust filtration systems are being changed over from a forced-exhaust concept (i.e., requiring operation of an exhaust fan) to one incorporating "breathable" filters. The exhaust fans are not required for the breathable filter designs.

5.1.3.4 Area Radiation and Airborne Radioactivity Monitoring Instrumentation. This section provides details regarding the area and airborne radiation monitoring programs that are provided for the SWBG. The design, installation, and operation of both the area and airborne radiation monitoring systems, as required, will be in accordance with WHC-CM-4-9, *Radiological Design*, Section 10.0, "Sampling and Monitoring;" WHC-CM-7-5, *Environmental Compliance Manual*, Section D, "Radioactive Airborne Emissions;" WHC-CM-1-6, *WHC Radiological Control Manual*, Section 12.0, "Airborne Radioactive Materials, Evaluation and Controls;" and ANSI N323-1978, *Radiation Protection Instrumentation Test and Calibration* (ANSI 1978).

Site-wide radiation monitoring devices and environmental air samplers are placed at the perimeters of facilities and at various designated locations throughout the Hanford Site, as defined in WHC-CM-7-5. The purpose of these devices and systems is to measure radioactivity in the Hanford Site environment, confirm safe facility operations, and allow assessment of impacts of site operations on the environment and, ultimately, to humans. As a result of the limits on the radionuclide inventories imposed by the waste acceptance criteria, the total radionuclide inventory limit, and packaging requirements for radioactive materials to be placed in this facility, neither an installed air monitoring or area radiation monitoring system is required for the SWBG.

Air sampling will be performed as required by the operations being conducted under the criteria put forth in WHC-CM-1-6.

The Hanford Site nuclear accident dosimeter is a stationary device containing various thermoluminescent materials, activation analysis foils, and shields that permit accurate characterization of radiation spectra in the event of a criticality. Fixed nuclear accident dosimeters in the SWBG will be used in accordance with WHC-CM-4-16, *Dosimetry Manual*, and WHC-CM-1-6.

5.1.4 Estimated Person-Rem Onsite Dose Assessment

Radiation exposures to onsite personnel will not be quantified because of the wide variety of packaging used and emplacement strategies/activities that occur in the SWBG. Occupational exposures will vary widely among different waste types (CH versus RH), waste packages (boxes of various sizes, drums, special-handled waste packages, and bulk wastes), waste emplacement strategies (forklift versus crane), special shielding needs, the number of personnel in the trench when waste packages are being emplaced, and the amounts and types of wastes already emplaced in the trenches. Because there are a great number of variables involved in estimating onsite doses, a general approach to demonstrating that occupational exposures will be controlled below the levels allowed by DOE Order 5480.11 is needed.

The format and content of RWP is described in WHC-CM-1-6. RWPs are the most detailed level of radiation protection documentation. They are written to specifically describe radiation protection requirements for a unique operation, activity, or location. The RWP provides instruction to workers and the health physics technician regarding unique radiological control requirements and ALARA practices for specific tasks.

The *ALARA Program Manual*, WHC-CM-4-11, outlines the ALARA Program in more detail than WHC-CM-1-6. The goal of the ALARA Program is to "minimize human and environmental exposures to radiation and hazardous substances and conditions, commensurate with sound economics and operating policies." This program, in addition to the RWP requirements for specific activities and operations in the SWBG, effectively ensures that all types of occupational exposures are within DOE guidelines and that exposures are ALARA.

5.1.5 Radiation Protection Program

This section provides information on the radiation protection program.

5.1.5.1 Organization. The management and operations contractor has the overall responsibility for the radiation protection program. These functions include principal responsibility for support and overview of the radiation protection, ALARA, and industrial safety programs, and nuclear safety. The nuclear safety function develops and administers programs to control and minimize nuclear safety hazards; performs independent nuclear safety reviews; supports appraisals and surveillances; investigates nuclear safety occurrences; and provides engineering support to ensure compliance with applicable nuclear safety standards, directives, and recognized good practices. The Health Physics organization develops and administers programs to control and minimize radiological hazard exposures, monitors radiological protection experience to provide performance and trend reports, and ensures that employee health and safety records are properly maintained.

5.1.5.2 Equipment, Instrumentation, and Facilities. The following sections provide information on the various health physics-related equipment, instrumentation, and facilities available to support the radiation protection program. The design, installation, operation, and calibration of health physics instrumentation will be in accordance with WHC-CM-1-6.

Portable radiation monitoring and surveillance instruments are provided to all Hanford Site contractors from a central Hanford Site instrument pool operated by a DOE contractor. The frequency and method of calibrations of portable surveillance instruments are defined in WHC-CM-1-6, *WHC Radiological Control Manual*, and PNL-MA-0562, *Radiation Protection Instrumentation Manual* (PNL 1989).

Health Physics uses portable air samplers. These devices usually operate on alternating current line voltage, but a few are battery powered. Personnel contamination monitors that detect alpha and beta radiation will be located near the access control stations. These counters provide a contamination check of personnel leaving the radiation area.

Two dosimetry programs are used to monitor personnel dose. The major program uses a thermoluminescent dosimeter badge device that provides the legal record of an individual's radiation dose history. A supplementary dosimetry program uses self-reading gamma pencil dosimeters to provide a real-time tracking system for individuals to note and control their exposure totals on a short-term basis. The use of dosimeters is described in WHC-CM-1-6. Specific dosimetry information is provided in WHC-CM-4-16.

The SWBG will have surveys conducted on a routine basis for penetrating whole-body radiation and for alpha and/or beta contamination in accordance with WHC-CM-1-6, Section 10, paragraph 5.5. Instruments to be used for these surveys are identified in PNL-MA-0562 (PNL 1989). Most portable surveillance instruments are maintained, repaired, and calibrated at the central Hanford Site instrument pool.

Protective clothing (often referred to as special work procedure clothing) available for routine use at the SWBG includes cloth coveralls, laboratory coats, caps, shoe covers, boots, and gloves. Specific clothing requirements for each job are listed in the RWP for each job. Supplies of appropriate types of respiratory protective equipment maintained in the 200 West Area are described in WHC-CM-1-6.

Personnel decontamination stations are provided in T Plant for 200 West Area personnel. All stations are equipped and supplied as required to provide initial skin decontamination services. All stations have sinks, showers, nasal irrigation equipment, and all necessary supplies for skin and hair decontamination. For more severe contaminations, the individual may be transported to Kadlec Medical Center in Richland, Washington, which has a special decontamination facility. In vivo whole body and lung measurements for internal depositions are also done in Richland at the Pacific Northwest Laboratory (PNL) lung and whole body counters.

5.1.5.3 Procedures. A number of documents have been developed that describe requirements and procedures relative to radiological and environmental protection. A brief overview of relevant documents is provided below. Health Physics-related procedures, applicable to the SWBG and other Hanford facilities, are contained in WHC-IP-0718, *Health Physics Procedures Manual*.

5.1.5.4 Physical and Administrative Measures for Controlling Access and Stay Time in Radiation Areas. Both physical and administrative measures for controlling access to radiation areas have been developed (see WHC-CM-1-6). Physical measures include building structures, temporary zoning, and radiological posting. Administrative measures are developed where physical measures are inadequate. The RWP, operating procedures, "need-for-entry" requirements, training, and checking in and out with the Health Physics office for entry into and leaving radiation areas are included as administrative measures and controlled through the implementation of the Radiation Area Management System.

Stay-time control is incorporated in written work plans and is part of radiation worker training. The RWP, operating procedures, work plans, and emergency procedures are developed with personnel exposure in mind. Radiological conditions such as dose rates, contamination levels, and potential airborne radioactivity levels are discussed in these operating documents and are used to determine radiological stay times. Physical and administrative measures for controlling access and stay times for radiation areas are discussed in WHC-CM-1-6.

5.1.5.5 Bases and Methods for Monitoring and Controlling Contamination of Personnel, Equipment, and Surfaces. Bases and methods to control contamination are discussed in WHC-CM-1-6. Actions to be taken if defined limits of contamination control are exceeded address personnel contamination

and subsequent decontamination and documentation, along with control of equipment and surfaces that exhibit contamination. The basic policy is to preclude contamination by design with mechanical constraints. Should an individual become contaminated, equipment and supplies are in place to remove or minimize its effects. Methods of personnel decontamination available include washing, scrubbing, chemical reacting, chelating, and surgery. Equipment to monitor residual personnel and internal contamination is available.

5.1.5.6 Radiation Protection Training Programs. The site-wide Hanford training program consists of courses in general safety awareness, nuclear safety, and hazardous materials and waste. The safety training program includes a multitiered radiation protection training program that provides a level of training commensurate with an individual's classification as a radiation worker/nonradiation worker, as well as the individual's specific work assignment. Requirements for radiation protection training are stated in WHC-CM-1-6 and are consistent with the requirements stated in DOE Order 5480.11.

5.1.5.7 Methods for Personnel Monitoring. Procedures require that all employees, visitors, and vendors be issued and use an assigned record dosimeter at all times when in the SWBG facility. These dosimeters provide an official measurement of an individual's radiation exposure. All record dosimeters used at the Hanford Site are accredited by DOE's Laboratory Accreditation Program.

Exposure to internally deposited radionuclides is assessed by in vitro (excreta analysis) or in vivo (whole body or chest count) bioassay measurements. A baseline bioassay determination of internal radionuclides is performed for employees, visitors, and vendors as a prerequisite to any work assignment that involves the potential for internal deposition of radioactive material. Based on a review of the radionuclides and activity levels involved, Health Physics Dosimetry determines the appropriate type of surveillance and establishes a routine internal exposure surveillance schedule.

Supervisors are required to notify Health Physics of any changes in an employee's work assignment that may affect the potential for internal exposure. In the event that there is reason to suspect that an intake of radioactive material has occurred, employees are required to notify their supervisor and Health Physics, and an appropriate evaluation is scheduled. Any injuries that occur in a radiologically controlled area must be reported to Health Physics for evaluation of possible internal contamination through wounds. Guidelines for indication of internal contamination and emergency response procedures are described in WHC-CM-4-16, Section 5.1. Sampling programs for all workers will be performed in accordance with WHC-CM-4-16.

Control of airborne radioactivity concentrations will be accomplished by implementing the control criteria of WHC-CM-1-6 and operating waste receipts in accordance with WHC-EP-0063 (WHC 1993). Minimizing the actual amount of surface smearable contamination and maintaining good housekeeping are two effective controls used to minimize the potential for airborne radioactive concentrations.

5.1.5.8 Policy, Methods, Frequencies, and Procedures for Conducting Radiation Surveys. The methods, frequencies, and procedures for conducting radiation surveys are determined based on the materials handled (form, element, isotope) and the radiological condition and type of operations conducted (dose rate, contamination level, or airborne potential). Survey instrumentation is selected based on the materials handled to ensure that appropriate equipment is used. Survey frequencies are based on the potential for changes that would expose operators, as well as the items discussed above. As operating experience is accumulated, it is factored into the frequency and rigor required for each survey. Each routinely performed radiation survey is documented on a report form that specifies the survey frequency, instruments to be used, and type of survey (contamination, radiation, or air activity) to be performed. The SWBG will have surveys conducted on a routine basis for penetrating whole-body radiation and for alpha and/or beta contamination as described in Section 5.3.5.

5.1.6 Estimated Person-Rem Offsite Dose Assessment

Offsite doses from operation of the SWBG are negligible relative to natural background radiation and other radiation sources on the Hanford Site. Airborne radioactive release from the SWBG is expected to be minimal because of strict adherence to the surface contamination acceptance criteria, good handling practices, prompt cleanup of spills, and repackaging of breached containers. The majority of waste accepted at the SWBG is packaged in CH containers. However, waste requiring remote handling because of high container surface dose rate will be shielded to minimize occupational exposures.

Waterborne dispersion or discharge of radioactivity via groundwater paths is improbable for the following reasons.

- There is an average of only 16 cm (6.3 in) of precipitation per year for the Hanford Site.
- The vadose zone below the SWBG contains only 2% to 6% moisture.
- Groundwater levels are typically found at 82 m (270 ft) below ground surface in the vicinity of the SWBG.
- The SWBG trenches are 51.8 to 61 m (170 to 200 ft) above the flood level.
- For a MW lined trench, geomembrane barriers with separate leak detection and collection systems keep leachate from penetrating nearby soil and flowing into the groundwater. The secondary leachate collection sump has sensors that detect leakage through the top liner. The admix layer, with a permeability of less than 1×10^{-7} cm/s, will further retard leachate from reaching groundwater.
- All storm water falling on adjacent areas is directed away from the trenches by using drainage ditches constructed as part of the access road system.

- The SWBG trenches will be covered with topsoil as a backfill cover, which may also be a part of the final *Resource Conservation and Recovery Act of 1976*-approved cover to retard water infiltration. The infiltration estimates are expected to be small (RL 1989).

5.2 INDUSTRIAL SAFETY

The industrial safety and industrial hygiene programs, described in WHC-CM-4-3, *Industrial Safety Manual*, and WHC-CM-4-40, *Industrial Hygiene Manual*, are designed to "...ensure that exposures to harmful chemical, physical, and biological agents and ergonomic stresses are maintained ALARA and within all limits prescribed by the DOE." The industrial safety program implements the relevant requirements given in the following list of DOE-Headquarters and DOE Richland Operations Office (RL) directives:

<u>Number</u>	<u>Title</u>
RL 5480.1A	<i>Environmental Protection, Safety, and Health Protection Program for Department of Energy Operations for Richland Operations</i>
DOE 5480.1B	<i>Environment, Safety, and Health Program for DOE Operations</i>
DOE 5480.4	<i>Environmental Protection, Safety, and Health Protection Standards</i>
RLIP 5480.4C	<i>Environmental Protection, Safety, and Health Protection Standards for RL</i>
DOE 5480.8A	<i>Contractor Occupational Medical Program</i>
RLID 5480.8	<i>Contractor Occupational Medical Program</i>
DOE 5480.10	<i>Contractor Industrial Hygiene Program</i>
RLIP 5480.10	<i>Industrial Hygiene Program</i>
DOE 5482.1B	<i>Environment, Safety, and Health Appraisal Program</i>
RL 5482.1B	<i>Environment, Safety, Health, and Quality Assurance Appraisal and Surveillance Program</i>

DOE 5483.1A *Occupational Safety and Health
Program for DOE Contractor Employees
at Government-Owned Contractor
Operated (GOCO) Facilities*

RL 5483.1B *Occupational Safety and Health
Program for DOE Contractor Employees
at Government-Owned Contractor-
Operated (GOCO) Facilities*

DOE 6430.1A *General Design Criteria*

When complete, WHC-CM-4-40, will establish the detailed program requirements and procedures that are necessary to implement these directives.

The WHC-CM-4-40 industrial hygiene program elements include the following:

- **ALARA and Safety Awareness** — An ongoing program that promotes high levels of employee recognition and understanding about safe practices and principles through a variety of initiatives.
- **"Best Practices" Focus** — The industrial hygiene program reflects the commitment to identify and use the best practices derived from industrial and governmental experience, whether such practices are mandatory requirements or not.
- **Directives Review and Assessment** — One of the program's primary objectives is ensuring compliance with all DOE occupational health requirements. To that end, the DOE directives and prescribed standards are reviewed to ensure that the relevant requirements are known and implemented.
- **Hazardous Material Controls** — The program establishes requirements for controlling hazardous materials from "cradle to grave." This includes controls on purchasing, storing, and handling chemical substances and preparing hazardous wastes for disposal.
- **Hazard Communication** — The hazard communication program helps ensure that employees are provided with product information that enables them to recognize hazards and take appropriate actions to ensure their own safety.
- **Industrial Hygiene Expertise** — An industrial hygiene group is established and staffed with personnel knowledgeable of the range of industrial hygiene activities and concerns. These personnel assist management in applying the best industrial hygiene principles at the lowest cost.
- **Industrial Hygiene Manual** — This manual is to provide managers, supervisors, job planners, and employees with clear, usable, and correct documentation necessary to meet the program objectives.

- **Monitoring** — Industrial hygiene is integrated into the management and operations contractor self-assessment processes (audits, surveillances, facility management walkthroughs, on-the-job supervision, etc.) so that industrial hygiene practices are continually reinforced and reemphasized.
- **Training** — All employees are trained on recognizing and minimizing job-related hazards, from the initial general employee training to in-depth, facility-specific training. Refresher training is provided as necessary.

The specific requirements established for the industrial safety program are described briefly in the following sections.

The Industrial Health, Safety, and Fire Protection organization has the overall responsibilities in this area. This function reviews external standards, statutory regulations, and DOE health and safety directives for applicability and incorporates appropriate requirements into policy, standards, and programs; reviews and approves safety-related documents, facilities, operations, programs and activities; provides health, safety, and technical fire protection services and engineering support to line management and DOE; and conducts safety assessments and surveillances to assess compliance to established standards and requirements.

5.2.1 Hazard Communication Program

The hazard communications program ensures that managers know the hazards from chemical and physical agents in the workplace, and that the employees are informed of these hazards and are provided with adequate information and training to know and understand the use of the necessary protective control measures. This program conforms to the Occupational Safety and Health Administration's (OSHA's) "Hazard Communication Standard," (29 CFR 1910.1200) and DOE Order 5480.10, *Contractor Industrial Hygiene Program*.

The hazards communications program involves several elements, including identification of hazardous materials, determination of hazards, development of facility-specific hazard communication program, chemical labeling, training, and documentation. Identification of hazards begins with initial procurement of hazardous chemicals. Employees requisitioning chemicals must evaluate the hazards associated with the chemicals to be used before they are brought in the workplace. Employees must attach the material safety data sheet (MSDS) to the procurement requisition for each hazardous chemical requested. The Industrial Hygiene organization must approve hazardous material requisitions and sign the purchase requisition to indicate approval before the material is purchased. Chemical hazards in each work place must also be identified through the preparation and maintenance of a list of all hazardous materials and physical agents in the work area. Monitoring for workplace hazards will also be performed by the Industrial Hygiene organization.

The industrial safety program requires each facility or work function group (as appropriate) to develop, implement, and maintain a facility- (or group-) specific, written hazard communication program for their work areas

that establishes how the requirements of this program are met. The written programs must include each major facility or group function and provide the following:

- The list of hazardous chemicals and physical agents known to be present in the work area (including the appropriate MSDS number for the chemical hazards)
- The labels and other forms of warning signs posted
- The file location of MSDSs for chemicals found in the work place and the work areas
- The methods used to inform employees of the hazards of nonroutine tasks
- The method used to give employees information and how the training will be met (to include facility- or job-specific training)
- The responsible personnel for each of the above descriptions
- The method that will be used to inform and provide MSDSs to other contractor employees of the hazards associated with their work areas within management and operations contractor-operated facilities.

5.2.2 Carcinogen Control Program

The purpose of the carcinogen control program is to ensure a safe and healthy work environment by effectively reducing or eliminating employee exposure to chemical carcinogens to ALARA. This program is motivated by DOE Order 5480.10 and establishes the minimum requirements and guidance for the purchase, use, storage and handling of OSHA-regulated carcinogens, and the known human and suspect human carcinogens. The major focus of the program is to use carcinogen products only when no other practical substitute can be found and to make every effort to minimize exposure if carcinogens are used. Each facility containing carcinogen products is required to have a written program describing the carcinogen control implementation procedures. This includes handling, storage, and use of the carcinogen products, and how procedures will be updated to reflect chemical and or process changes involving carcinogen products. Proper procedural controls are also required to be developed for all work involving carcinogens, including purchasing and receiving, posting and labeling, packaging and storage, inventory, decontamination, and disposal. The carcinogen control program also establishes requirements for proper training and adequate medical surveillance for work involving the use of carcinogens.

5.2.3 Asbestos Control Program

The purpose of the asbestos control program is to reduce or eliminate exposure to asbestos fibers, to both meet the legal limits and to achieve levels that are ALARA. This program is established in accordance with

RLIP 5480.10, *Industrial Hygiene Program*, Part B, "Asbestos Material." This program establishes the minimum requirements and guidance for the purchase, use, storage, and handling of asbestos containing materials.

The asbestos control program has three major elements:

- **Programmatic Controls** — Ongoing controls set up to ensure that asbestos containing materials are properly identified, controlled, and documented
- **Personnel Protection** — Requirements for training, medical examinations, and protective clothing and equipment
- **Work Controls** — Requirements and practices necessary for safe work on or around asbestos containing materials.

Transportation, hauling, and disposal requirements are covered more extensively in WHC-CM-7-5, *Environmental Compliance*.

Programmatic controls include establishing the following:

- General asbestos control program requirements
- Asbestos management plan
- Facility assessment requirements
- Asbestos hazard communication requirements
- Asbestos notification requirements
- Asbestos recordkeeping requirements.

Personnel protection requirements include establishing the following:

- Personal protective equipment and respiratory protection
- Asbestos training
- Medical examination requirements.

The third element of the asbestos control program involves establishing work controls, including the following:

- Requirements for pre-job inspection and planning
- Engineering controls
- Monitoring and sampling
- Housekeeping
- Negative pressure-control systems
- Removal, demolition, and renovation operations
- Reporting of spills and releases
- Disposal of asbestos-containing materials.

Specific requirements in each of these areas are presented in WHC-CM-4-40.

5.2.4 Chemical Storage and Handling

The chemical storage and handling standard provides the requirements and guidance for safe storage and handling of hazardous chemicals and chemical

products, as directed in DOE Order 5480.10. The standard establishes general requirements for chemical container labeling, hazard communication, and storage (including segregation of storage areas from processing areas and segregation of incompatible chemicals). The standard also establishes special requirements for peroxide storage.

Specific requirements are established in the standard to ensure that hazardous chemicals are properly and safely stored and handled. Some examples of these requirements are as follows.

- Maintain manufacturer's labels intact and attached to containers.
- Manager's must ensure that employees are familiar with the hazards of chemical materials being used, stored, or handled. Facility-specific or job-related hazard training must be provided.
- Incompatible kinds of chemicals must be stored separately. The following groups of chemicals must be stored separate from each other:
 - Oxidizers
 - Flammable and combustible chemicals
 - Unstable chemicals
 - Acids
 - Alkalis.
- All chemical stocks are routinely inspected for condition and expiration dates (when provided).

5.2.5 Process Safety Management

The purpose of the process safety management standard is to establish requirements for managing highly hazardous chemicals. This standard seeks to decrease the incidence of catastrophic releases and to ensure that processes involving these chemicals are conducted safely.

Facility-specific written programs are required to be prepared for facilities containing chemicals in quantities above specified thresholds. The facility-specific programs are intended to provide employees and subcontractors with information about the following:

- Employee participation in process safety management
- Governing process operating procedures
- Procedures used to control modifications to processes or facilities
- The process equipment maintenance program
- Process safety information.

A process hazard analysis must be prepared for each process involving highly hazardous chemicals. The process hazard analysis is used to identify, evaluate, and control process hazards.

The standard specifies that only trained operators, maintenance workers, and subcontractors are permitted to work on or near the involved process. Initial training includes the following:

- An overview of the process
- Process operating procedures
- Process safety information
- Health and safety hazards
- Emergency procedures
- Emergency shutdown procedures
- Safe work practices
- Facility safety rules.

The standard also specifies retraining and training documentation requirements for affected workers.

The standard also specifies that investigations will be performed of incidents that result in (or could have resulted in) a catastrophic release of a highly hazardous chemical in the workplace. The investigation must comply with procedures WHC-CM-1-3, MRP 5.14, "Occurrence Reporting and Processing of Operations Information," and be started within 48 hours of the incident.

5.2.6 Respiratory Protection

The purpose of the respiratory protection standard is to implement the requirements of the OSHA respiratory protection standard (29 CFR 1910.134) that defines the requirements governing the use of respirators for protection against harmful air contaminants and/or oxygen deficient atmospheres. Respirators are to be used only if preferred controls, including engineering and/or administrative controls (such as enclosures, ventilation, or the substitution of less hazardous materials) are not available. Only approved respirators are to be used. Employees are to be medically screened and trained to use the respirators. The standard establishes requirements for selection, testing, storage, cleaning, and inspections of respirators.

5.2.7 Laboratory Safety Standard

The laboratory safety standard implements the requirements of the OSHA Lab Safety Standard (29 CFR 1910.1450). Special safety requirements are also defined, including the requirements for a chemical hygiene plan for laboratories that use, handle, or store hazardous chemicals. This standard is applicable only to laboratory facilities and is not applicable to production facilities, such as the SWBG.

5.3 CHAPTER CRITERIA

A summary description of the information in the chapter is provided with acceptance criteria derived from appropriate guidance documents.

5.3.1 Summary Description

This chapter describes the radiation protection program involving design considerations, operational procedures, and all factors related to limiting and controlling the radiation exposure to workers within the facility, the general public, and the environment. The principal subjects in this chapter include the following:

1. Consideration of occupational radiation exposures including application of ALARA principles, facility design, and operational factors
2. Consideration of radiation exposure areas including containment of radioactive wastes and possible airborne radioactive material.
3. Radiation protection design features including shielding, ventilation, and the appropriate area radiation and airborne radioactivity monitoring instrumentation.
4. Overall health physics program including organization, equipment, instrumentation, facilities, and procedures.

5.3.2 Acceptance Criteria

Acceptance criteria for this chapter are based on the following:

1. DOE Order 5480.11, *Radiation Protection for Occupational Workers*
2. DOE Order 5400.5, *Radiation Protection of the Public and the Environment*
3. WHC-CM-4-10, *Radiation Protection Manual*.

Specific acceptance criteria are as follows.

1. The adequacy of the radiation protection program should be demonstrated.
2. The facility design should demonstrate that ALARA principles are properly applied.
3. The radiation monitoring system should be sufficiently described so that its adequacy can be determined.
4. The adequacy of the health physics program, including organization, training, equipment, and instrumentation, should be demonstrated.

5.4 REFERENCES

5.4.1 Acts, Codes, Regulations, and Standards

ANSI, 1978, *Radiation Protection Instrumentation Test and Calibration*, ANSI N323-1978, American National Standards Institute, Washington D.C.

ANSI, 1980, *Specifications and Performance of Onsite Instrumentation for Continuously Monitoring Radioactivity in Effluents*, ANSI N42.18-1980, American National Standards Institute, Washington D.C.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

10 CFR 20, "Standards for Protection Against Radiation," *Code of Federal Regulations*, as amended.

29 CFR 1910, "Occupational Safety and Health Standards," *Code of Federal Regulations*, as amended.

5.4.2 Documents

Munson, L. H, 1988, *Health Physics Manual of Good Practices for Reducing Radiation Exposures to As Low As Reasonably Achievable (ALARA)*, PNL-6577, Pacific Northwest Laboratory, Richland, Washington.

PNL, 1989, *Radiation Protection Instrumentation Manual*, PNL-MA-0562, Pacific Northwest Laboratory, Richland, Washington.

RL, 1989, *Low-Level Burial Grounds Dangerous Waste Permit Application*, DOE/RL-88-20, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

WHC, 1993, *Hanford Site Solid Waste Acceptance Criteria*, WHC-EP-0063, Rev. 4 (or current revision), Westinghouse Hanford Company, Richland, Washington.

5.4.3 U.S. Department of Energy Orders

DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, U.S. Department of Energy, Washington, D.C.

DOE Order 5480.1B, *Environment, Safety, and Health Program for DOE Operations*, U.S. Department of Energy, Washington, D.C.

DOE Order 5480.4, *Environmental Protection, Safety, and Health Protection Standards*, U.S. Department of Energy, Washington, D.C.

DOE Order 5480.8A, *Contractor Occupational Medical Program*, U.S. Department of Energy, Washington, D.C.

DOE Order 5480.10, *Contractor Industrial Hygiene Program*, U.S. Department of Energy, Washington D.C.

DOE Order 5480.11, *Radiation Protection for Occupational Workers*, U.S. Department of Energy, Washington D.C.

DOE Order 5482.1B, *Environment, Safety, and Health Appraisal Program*, U.S. Department of Energy, Washington, D.C.

DOE Order 5483.1A, *Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned Contractor Operated Facilities*, U.S. Department of Energy, Washington, D.C.

DOE Order 5484.1, *Environmental Protection, Safety, and Health Protection Information Reporting Requirements*, U.S. Department of Energy, Washington D.C.

DOE Order 6430.1A, *General Design Criteria*, U.S. Department of Energy, Washington, D.C.

5.4.4 U.S. Department of Energy, Richland Operations Office
Orders and Implementing Procedures and Directives

RL Order 5480.1A, *Environmental Protection, Safety, and Health Protection Program for Department of Energy Operations for Richland Operations*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

RL Order 5482.1B, *Environment, Safety, Health, and Quality Assurance Appraisal and Surveillance Program*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

RL Order 5483.1B, *Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned Contractor-Operated (GOCO) Facilities*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

RLID 5480.8, *Contractor Occupational Medical Program*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

RLIP 5480.4C, *Environmental Protection, Safety and Health Protection Standards for RL*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

RLIP 5480.10, *Industrial Hygiene Program*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

RLIP 5480.11, *Radiation Protection for Occupational Workers*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

5.4.5 Controlled Manuals

WHC-CM-1-3, *Management Requirements and Procedures*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-1-6, *Radiological Control Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-2-14, *Hazardous Material Packaging and Shipping*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-3, *Industrial Safety Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-9, *Radiological Design*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-10, *Radiation Protection Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-11, *ALARA Program Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-16, *Dosimetry Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-40, *Industrial Hygiene Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-41, *Fire Protection Program Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-7-5, *Environmental Compliance Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-IP-0718, *Health Physics Procedures Manual*, Westinghouse Hanford Company, Richland, Washington.

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Table 5-1. Administrative Control Levels for Facility Workers
(WHC-CM-4-41).

TEDE	Skin and extremity ^a	Lens of eye ^a	Any organ ^a	Approval required to exceed this level ^{b,c}
Maximum dose equivalent (annual), mrem				
500	15,000	4,500	15,000	Level 3 line manager and RCM ^d
750	22,500	6,750	22,500	Level 2 line manager and RCM
1,000	30,000	9,000	30,000	Contractor senior site executive
2,000	--	--	--	DOE PSO
Age x 1,000 = lifetime TEDE				Level 1 line manager and RCM

^aThe values are based on the nonstochastic limit and are calculated as committed doses.

^bSee Table 1-2 in WHC-CM-1-6, Chapter 1, for comparable position titles.

^cApprovals are sequential. See Form 54-3000-XXX in WHC-CM-1-6, Exhibit 2-1. Westinghouse Hanford Company addendum - personnel shall use Form A-6001-153.

^dApproval may be delegated within the radiological control organization.

DOE = U.S. Department of Energy.

RCM = radiological control manager.

PSO = program secretarial officer.

TEDE = total effective dose equivalent.

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CHAPTER 6.0
ACCIDENT SAFETY ANALYSIS

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LIST OF TERMS

CH	contact-handled
DBE	design basis earthquake
DOE	U.S. Department of Energy
HLW	high-level waste
HPT	Health Physics Technician
LLMW	low-level mixed waste
LLW	low-level waste
MW	mixed waste
NRC	U.S. Nuclear Regulatory Commission
OHA	Operation Hazard Analysis
PHA	Preliminary Hazards Analysis
RF	release fraction
RH	remote-handled
SAR	Safety Analysis Report
SRC	submarine reactor compartment
SWBG	Solid Waste Burial Grounds
SWITS	Solid Waste Information Tracking System
TRU	transuranic
TSR	Technical Safety Requirements
WHC	Westinghouse Hanford Company

6.0 ACCIDENT SAFETY ANALYSIS

6.1 INTRODUCTION

6.1.1 Purpose of Accident Safety Analysis

The purpose of the accident safety analysis is to:

- Provide technical justification for the conclusion that the facility can be operated without undue risk to the employees, the public, or the environment.
- Provide a basis for the facility Technical Safety Requirements (TSR).

6.1.2 Scope of Accident Safety Analysis

The scope of this accident safety analysis addresses concerns of potential accidents involving the following activities as applicable in the active Solid Waste Burial Grounds (SWBG) and the ERDF Area Burial Grounds:

- Low-level waste (LLW) — The disposal of LLW.
- Low-level mixed waste (LLMW) — The disposal of LLMW.
- Transuranic (TRU) waste — The retrievable storage of TRU waste and irradiated fuel waste.

6.1.3 Methodology of Accident Safety Analysis

Steps taken in the preparation of this safety analysis are as follows:

- **Hazards identification** — Abnormal operations and potential accidents are identified. Abnormal operations are defined as events that may be expected to occur during the operation of the facility but will not have any significant consequences beyond the facility boundary. Accidents are defined as infrequent events that may occur during the operation of the facility. Accidents are the set of events that are postulated because their consequences may result in a potential impact to the maximum onsite receptor or maximum offsite receptor and include natural phenomena and man-induced low probability events.

An Operation Hazard Analysis (OHA) is performed to identify the complete range of accidents posed in the conduct of operations in the SWBG. The outcome of the form driven OHA is reported in tabular format on a Preliminary Hazards Analysis (PHA) table. The purpose of the PHA is to identify the broad range of potential event sequences and to assign a measure of perceived risk to each sequence. The PHA tables are found in Appendix 6A. The last three

entries in the PHA table show, for each event sequence or category of event sequences, the barriers (engineered and/or administrative) within the facility which prevent or mitigate the consequences of the accident, the estimated likelihood of the event sequence occurring as stated, and a rough estimate of the magnitude of consequences of the accident assuming that the listed preventive barriers fail.

Each event listed in the PHA is given a qualitative estimated likelihood of occurrence and consequence severity based on engineering judgement and using the categories defined in WHC-CM-4-46 (WHC 1992a). These categories are shown in Tables 6-1 and 6-2.

- **Accident sequence development** — Those potential accidents that are determined to adequately represent the complete range of credible accidents (from anticipated to extremely unlikely) are selected from the PHA table. These accidents are then examined in greater detail to determine the probability of occurrence as accurately as possible, using the fault-tree analysis found in (Appendix 6B).
- **Source term definition** — The maximum radionuclide concentrations are derived from Hanford Site Radioactive Solid Waste Acceptance Criteria (WHC 1993a) and existing burial ground records. The respirable source term is calculated by applying the release fractions (RFs) discussed in Appendix 6C.
- **Consequence analysis** — The "Unit Releases For The Solid Waste Burial Ground Interim Safety Basis" report, found in Appendix 6D, provides the methodology for calculating the dose consequences from accidents at the SWBG. It provides the X/Q values and baseline unit release doses that are multiplied together to find unit release values corresponding to numerous release points and receptor locations. The X/Q values in this report are based on acute releases and are calculated by the GXQ code in accordance with the methodology outlined in U.S. Nuclear Regulatory Commission (NRC) Guide 1.145 (NRC 1982). The baseline unit release doses are calculated by the GENII dosimetry code (Napier et al. 1988).
- **Risk determination** — The probability of those accidents identified for sequence development are plotted against the consequences from the consequence analysis and compared to the risk comparison guidelines of WHC-CM-4-46 as illustrated in Figures 6-1 and 6-2. The risk comparison guidelines are taken from WHC-CM-4-46, Chapter 7.0, Figure 7-1.

6.1.4 Conclusion of the Accident Safety Analysis

Risk assessments have been performed for each activity in the SWBG involving LLW, mixed waste (MW), and TRU waste receiving and disposal operations. The results of the risk comparison are compared to the appropriate risk comparison guidelines as shown in Figures 6-1 and 6-2. Those accidents that fall below the risk comparison guidelines are considered to be

acceptable. All accidents analyzed in this risk assessment of SWBG operations fall below the risk comparison guidelines as shown in Figures 6-1 and 6-2 and are therefore acceptable.

6.2 RISK ASSESSMENT FOR LOW-LEVEL WASTE

LLW, as defined in U.S. Department of Energy (DOE) Orders 5820.2A and 5400.3, is waste that contains radioactivity that is not classified as high-level waste (HLW), TRU waste, spent nuclear fuel, or byproduct material. Radioactive waste may be classified as LLW, provided the concentration of TRU radionuclides is less than 100 nCi/g of the waste matrix.

6.2.1 Low-Level Waste Inventory

All LLW will be characterized with sufficient accuracy to permit proper identification, minimization, segregation, transportation, treatment, storage, and disposal. This characterization will ensure that, upon or immediately after generation and before packaging, the actual physical and chemical characteristics and radionuclide content of the waste are known and recorded for use during all subsequent stages of the waste management process.

LLW is classified according to Waste Category 1, Waste Category 3, and greater than Waste Category 3 concentration limits defined in the Hanford Site Solid Waste Acceptance Criteria (WHC-EP-0063) and summarized as follows:

Waste Category 1 — Low activity waste with very low concentrations of long-lived radionuclides whose concentrations do not exceed the value in Table 3-1, Column 1 of the *Hanford Site Solid Waste Acceptance Criteria* (WHC-EP-0063).

Waste Category 3 — Moderate and high activity waste with low to moderate concentrations of long-lived radionuclides whose concentrations exceed the values in Table 3-1, Column 1 but do not exceed the values in Table 3-1, Column 2 of the *Hanford Site Solid Waste Acceptance Criteria* (WHC-EP-0063).

Greater Than Waste Category 3 (GTWC3) — Waste that has radionuclide concentrations greater than Category 3 and must be handled as special cases. Disposal systems for such waste must be justified by a specific performance assessment through the National Environmental Policy Act of 1969 (NEPA) as specified in WHC-EP-0063.

6.2.1.1 Radiological Inventory. It is not feasible to generate an expected radionuclide level for individual waste packages that may be involved in postulated accidents. Therefore, for worst-case conditions, it is assumed that all containerized wastes meet the upper radiological acceptance criteria for each category in Table 6-3. The curie concentration limits in Table 6-3 are taken from the Category 1 and 3 activity limits for disposal found in Table 3-1 of the *Hanford Site Solid Waste Acceptance Criteria*, WHC-EP-0063 with the exception of ^3H , ^{151}Sm , and ^{210}Pb . The concentration limits (Ci/m^3) for these three isotopes are reduced to restrict their dose (rem/m^3) to less than ^{60}Co and ^{90}Sr . The baseline unit release doses are taken from Table 4 of

attachment 1 of the Baseline Unit Release Doses and X/Q Values internal memo found in Appendix 6D. The dose concentration limits are the product of the baseline unit release dose times the curie concentration limit. The concentration limits in Table 6-3 will be used as waste package inventory to provide a conservative estimate of package curie content when calculating potential releases.

Some of the concentrations exceed the surface dose rates and thermal limits imposed by WHC-EP-0063, therefore, in many cases the waste concentration limit will not be reached. Concentrations greater than Waste Category 3 will be accepted only on an item by item basis, after approval of the SDAR.

WHC-EP-0063 does not give ^{60}Co a Ci/m^3 limit for Category 3 but gives practical considerations such as external radiation and internal heat generation as limiting the concentrations. Acceptance criteria for any package with the potential to generate greater than 3.53 W/m^3 (0.1 W/ft^3) are required to be included in the SDAR applicable to the waste package. The power factor for ^{60}Co is 1.54 E-02 W/Ci , from Table D-7, WHC-EP-0063, Appendix 6D (WHC 1993a).

$$3.53 \text{ W/m}^3 \div 0.0154 \text{ W/Ci} = 229 \text{ Ci/m}^3$$

The radiological constituents in bulk soils and bulk solid wastes received for emplacement in the LLW trenches and the ERDF (WHC 1994) will not exceed the limits summarized in Section 6.3.2 and shown in Tables 6-4, 6-5, and 6-6.

6.2.1.2 Low-Level Waste Form. Waste form and waste package criteria are considered in the following subsections.

6.2.1.2.1 Waste Form Criteria. Low-level radioactive waste forms capable of generating toxic gases, vapors, fumes, or liquids that would be harmful to personnel handling the waste will not be accepted (DOE Order 5820.2a, Chapter III, Section 3.i.[5] [d]). Wastes with this capability must be reacted or otherwise stabilized in an approved manner. Specific waste form criteria dealing with liquid waste, tritiated waste, asbestos, ion exchange resins, alkali metals, long-term radioactive waste, explosives, compressed gases, pyrophoric materials, radioactive animal carcasses, classified waste, and infectious waste are to meet the criteria defined in WHC-EP-0063.

6.2.1.2.2 Waste Package Criteria. The waste package includes the waste, internal packaging, waste container, and any disposable overpack. All LLW packages accepted at Hanford are to meet the criteria listed in WHC-EP-0063 as applicable for waste container, containment, surface dose rate, surface contamination, thermal power, gas generation, interior void space, and nuclear criticality.

6.2.2 Hazards Identification for Low-Level Waste

Hazards associated with normal operations in the LLW landfill are similar to those in ERDF Safety Assessment in WHC (1994) and summarized in Section 6.3.2. Hazards associated with abnormal operations and accidents in the LLW operation are identified by an OHA process. The outcome of the OHA is reported in tabular format on a PHA table found in Appendix 6A, Table 6A-1. Those potential events that are determined to adequately represent the complete range of credible events are listed as follows:

- Normal Operations
 - Bulk Waste Dispersion
- Abnormal Operations
 - Backfill Subsidence
 - Receipt of LLW Container(s) Having Surface Contamination
 - Receipt of LLW Container(s) Having High Surface Dose Rates
- Accidents
 - Drum(s) rupture
 - Drum(s) fire
 - Drum explosion.

6.2.2.1 Normal Operations Analysis for Low-Level Bulk Waste. Normal operations involve receipt and emplacement of bulk soils and solid wastes in the trench. Unloading of bulk soils into the trench and spreading and compacting of soils within the trench provides a mechanism for generation of fugitive dust and release of contaminants.

As the contents of bulk soils are unloaded in the trench, a potential plume of fugitive dust is released. Spreading and compacting of the waste soil will also produce fugitive dust in the immediate area. Soil stabilization treatment will be provided through use of water spray nozzles and by mobile truck sprayers. Normal bulk waste operations will be conducted only at windspeeds of below 24 km/h (15 mi/h).

The inventory and consequences of this analysis are bound by the ERDF safety assessment found in WHC (1994) and summarized in Section 6.3.2. Therefore, the radiological dose to the maximum onsite and offsite receptors is less than $8.24\text{E-}02$ rem EDE and $9.47\text{E-}04$ rem EDE respectively. The radiological consequences of this event are within the risk comparison guidelines found in WHC-CM-4-46, Chapter 7.0, Figure 7-1 given a probability of one and are therefore acceptable for normal operations.

6.2.2.2 Abnormal Operations Analysis for Low-level Waste Drums and Boxes. Three abnormal events are analyzed; backfill subsidence, receipt of LLW containers having a high surface dose rate, and receipt of LLW containers having surface contamination. Any one event could potentially increase the radiation exposure to the SWBG operator but would have no effect on the maximum onsite or maximum offsite receptors.

6.2.2.2.1 Backfill Subsidence. Of concern in the SWBG is the occurrence of subsidence or collapse of the burial trenches.

Scenario description: This may be caused by voids generated by container deterioration or settling of backfill. Although no accurate historical records have been maintained of instances of settling, it is known to occur, varying from a relatively slight degree of settling to a collapse. Collapse could result in the partial uncovering of waste containers, the generation of pathways for the dispersal of radioactive material, and the intrusion of ground water.

Detection: Subsidence is detected by routine surveillance performed by SWBG personnel.

Consequences: The consequences of this event, if undetected, are expected to be increases in radiation exposure and possible personal injury to SWBG personnel.

Recovery: Should routine surveillance reveal areas which are subsiding or have collapsed, these areas will be promptly investigated, backfilled with approved fill material, compacted, and re-stabilized.

6.2.2.2.2 Receipt of Low-Level Waste Container Having High Surface Dose Rates and/or Surface Contamination. This postulated abnormal event involves operator and/or monitoring equipment failures at the waste generator facility and at the trench to detect surface contamination and/or excessive surface dose rates.

Scenario Description: Administrative controls and operating procedures have been implemented at the waste generator facility that require radiation monitoring and measurement of surface contamination on the external surfaces of LLW containers before they can be released from a facility. Procedural checklists are used to ensure that this monitoring activity occurs. Failure of an Health Physics Technician (HPT) to perform these monitoring activities or failure of the monitoring equipment could potentially result in release from the facility of a container having excessive surface contamination levels.

It is possible that excessive quantities of radioactive material could be loaded into the containers, resulting in a surface dose rate in excess of the 200 mrem/h maximum limit. Operating limits and procedures at the waste generator facility are in place to ensure that loading limits are not exceeded. In addition, the dose rate at the surface of the container is measured before it is released from the facility. Failure of an HPT to perform these monitoring activities or failure of the monitoring equipment could potentially result in release from the facility of a container having excessive surface dose rates.

Detection: The SWBG operating procedures require radiation monitoring of the container surface before emplacement in the trench. Therefore, failure to detect excessive surface dose rates or excessive surface contamination levels at the SWBG is very unlikely.

Consequences: The consequences of this event, if undetected, are expected to be increases in radiation exposures to SWBG operators. However, because the LLW containers are radiation monitored both by the waste generators and HPTs before emplacement in the trench, the excessive

radiation levels are likely to be detected before any major handling activities occur, and the increased personnel exposures will be minimized.

Recovery: If excessive surface dose rates or surface contamination levels are present, SWBG personnel and a Health Physics supervisor are to be notified immediately. A decision will then be made on the appropriate action to be taken to resolve the situation or to implement standard recovery plans.

6.2.2.3 Accident Analysis For Low-Level Waste. Potential accidents are analyzed using a fault tree analysis. The fault tree analysis in Appendix 6B shows the minimal cut sets that could potentially result in a radiological release from uncovered containers. The preliminary hazards analysis in Appendix 6A identifies plausible accidents expected to result in radiological releases and are incorporated into the fault tree. The fault tree analysis in Appendix 6B shows the minimal accident event sequence (cutsets) that could potentially result in a radiological release from the LLW containers. The fault tree analysis is plotted using CAFTA (WHC 1990a). The accident events shown to be credible are summarized as follows:

- Events in which one or more containers are breached
 - Vehicle crashing into container(s)
 - Dropped container
 - Corrosion
 - Seismic activity
 - High-wind projectile
 - Over pressurization
- Events in which the content of one or more containers burn in an ensuing fire
 - Ignited vehicle crash
 - Lightning
 - Spontaneous combustion
- Events in which one or more drums explode
 - Solar radiation
 - Vehicle crash.

The minimal cutsets range from accidents with smaller consequences (one or two drums) and higher annual frequencies to accidents with larger consequences and lower annual frequencies. Accidents involving one or two drums include drum handling accidents such as a fork lift accident or natural events such as wind driven missiles. Accidents involving a large number of drums include a heavy equipment accident such as a bulldozer, crane, or truck crashing into the drum stack or natural events such as a seismic activity that topples the drum stack.

Those potential accidents determined to adequately represent the complete range of credible accidents are examined in greater detail in the following subsections.

6.2.2.3.1 Vehicle Accident With Fire Involving 66 Drums. Among those credible accidents identified in the PHA table and quantified in the fault tree resulting in a fire release are lightning, spontaneous combustion, range fires, and an ignited vehicle crashing into the containers and igniting the exposed contents of the breached containers. Lightning and spontaneous combustion would only involve one drum. Range fires are prevented from affecting the burial grounds by surveillance requirements which remove combustible debris from the trenches. The Hanford Fire Department also minimizes the potential impacts of range fires on the trenches. The maximum credible fire release accident would involve an ignited vehicle crashing into the drum stack. The number of drums impacted in the accident would depend on the cross section of the vehicle. A vehicle crash with ensuing fire is analyzed in the following subsections.

Scenario description: It is postulated that a bulldozer catches on fire while covering the drums with overburden and rolls onto uncovered waste containers. The potential for such a rollover is very low as a result of the bulldozer's low center of gravity.

Assumptions: The following assumptions are made in this analysis.

- The following bulldozer characteristics are assumed:

Type: D8-L, 180-gal diesel fuel capacity

Weight: 96,000 lb (48 ton)

Blade width: 3.6 m (12 ft)

Vehicle length: 6.7 m (22 ft)

Cross section: 3.6 m by 6.7 m (12 ft by 22 ft) = 24 m² (264 ft²).

- As many as 66 drums could be breached by the rolling bulldozer.
- 100% of the breached drums contents are consumed in the fire. This assumption is very conservative considering the average combustible drum content is 65% (Anderson 1989), thermal shielding by the noncombustible materials, packaging methods, energy dissipation paths, and that many of the ruptured drums will not have all contents ejected and directly available for burning.
- ⁹⁰Sr at maximum Category 3 concentration limit is 1.5 E+04 Ci/m³ (see Table 6-3)
- Drum volume is 0.208 m³.
- The RF for a waste Category 3 fire is 1.25 E-05 (NUREG-0782).

Source term development: The source term for a 66 drum accident with ensuing fire is calculated as follows:

$$\begin{aligned} \text{source term} &= \left(1.5\text{E}+04 \frac{\text{Ci}}{\text{m}^3}\right) * \left(0.208 \frac{\text{m}^3}{\text{drum}}\right) * (66 \text{ drums}) * (1.25\text{E}-05) \\ &= 2.57 \text{ Ci } ^{90}\text{Sr} \end{aligned}$$

Consequences: Dose consequences for a fire release, induced by a vehicle accident, are determined by using the "Unit Releases For The Solid Waste Burial Ground Interim Safety Basis" report, found in Appendix 6D. The appropriate X/Q value selected from Table 3 is multiplied by the appropriate baseline unit release dose in Table 4. This is then multiplied by the amount of material released in the accident (source term) to determine the dose consequence. The equation is as follows:

$$\left(\frac{X}{Q}\right) * (\text{Baseline Unit Release Dose}) * (\text{source term}) = \text{dose consequences}$$

Table 3, in Appendix 6D, shows the maximum onsite receptor to be located 100 m east-southeast. The maximum offsite receptor is the site boundary located 11.1 km west of the SWBG. Using Table 4 baseline unit release in Appendix 6D, the dose consequence of a 66 drum accident with fire is calculated as follows:

$$\text{maximum onsite dose} = \left(5.20\text{E-}03 \frac{\text{s}}{\text{m}^3}\right) * \left(8.0\text{E+}02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (2.57 \text{ Ci})$$

$$= 1.07 \text{ E+}01 \text{ rem maximum organ bone surface (BS)}$$

$$\text{maximum offsite dose} = \left(3.31\text{E-}06 \frac{\text{s}}{\text{m}^3}\right) * \left(8.0\text{E+}02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (2.57 \text{ Ci})$$

$$= 6.81 \text{ E-}03 \text{ rem BS}$$

Annual frequency: The frequency of a DOE reportable truck accident resulting from a vehicle fire during operation on the Hanford Site of a magnitude that could breach drums is calculated to be 3.6E-08 per mile (WHC-SD-TP-RPT-007 Rev. 0, 1993). Annual mileage for a truck at the low level burial grounds is conservatively assumed to be 15,000 miles. The annual frequency of this event is calculated as follows:

$$3.6 \text{ E-}08/\text{mile} \times 15,000 \text{ miles} \times = 5.4 \text{ E-}04.$$

Conclusions: The maximum onsite and offsite dose consequences of 1.07 E+01 rem BS and 6.81 E-03 rem BS respectively are plotted with the annual frequency of 5.4 E-04 on the radiological risk comparison guidelines found in WHC-CM-4-46, Chapter 7.0, Figure 7-1 to determine if the risk is acceptable. As illustrated in Figures 6-1 and 6-2, the risk is acceptable.

At an annual frequency of 5.4 E-04 the onsite risk acceptance curve is not exceeded until the dose consequences exceed 12.97 rem EDE. This equates to the contents of 80 drums released in a fire.

Bounding Fire Analysis: Based on the vehicle and the storage array the above analysis examined a fire with 66 drums. However, it is not known how far a worst case fire might propagate once initiated. This propagation is the subject of a Fire Hazards Analysis (FHA) currently in work. The FHA will more fully examine fire propagation and other events.

6.2.2.3.2 Vehicle Accident Without Ensuing Fire. Among those credible accidents identified in the PHA table and quantified in the fault tree resulting in a mechanical release are a dropped container, corrosion, over pressurization, and a vehicle crash.

- During the drum handling operation a drum could be dropped and breached or pierced.
- Corrosion could occur from corrosive chemicals being in the container resulting in corrosion from the inside. Corrosion could also occur from drums placed in the open environment and corroding from the outside. Either way the corrosion could compromise the container and expose the contents to the environment. The amount of material made airborne is expected to be small. The amount of material made airborne is further reduced due to the absence of an energy source other than the wind. Little of the LLW material is expected to be in the form of easily dispersed liquid or powder. The drums are inspected periodically and a corroded drum would be noticed and repackaged before total confinement is lost.
- Over pressurization would be detected when the first drums become compromised. Corrective action would limit the number of drums to one or two.
- The maximum mechanical release accident would involve a vehicle crashing into the drum stack. The number of drums impacted in the accident would depend on the cross section of the vehicle. A vehicle crash accident is analyzed in the following subsections.

Scenario description: The accident analyzed in this scenario is the same accident described in Section 6.2.2.2.1 without a fire.

Assumptions: The assumptions are the same as those listed in Section 6.2.2.2.1 with the following exceptions:

- The RF for a waste Category 3 mechanical release is 1.0 E-06 (NUREG\CR-1759).

Source term development: The source term for a 66 drum accident with out a fire is calculated as follows:

$$\begin{aligned}\text{source term} &= \left(1.5\text{E}+04 \frac{\text{Ci}}{\text{m}^3}\right) * \left(0.208 \frac{\text{m}^3}{\text{drum}}\right) * (66 \text{ drums}) * (1.0\text{E}-06) \\ &= 2.06 \text{ E}-01 \text{ Ci } ^{90}\text{Sr}\end{aligned}$$

Consequences: Using the same methodology applied in Section 6.2.2.2.1, the maximum onsite and offsite receptor dose for a fire release are calculated. Table 3 in Appendix 6D, shows the maximum onsite receptor to be located 100 m ESE. The maximum offsite receptor is the site boundary located 11.1 km W of the SWBG. Using Table 4 baseline unit release in Appendix 6D, the dose consequence of a 66 drum accident with mechanical release is calculated as follows:

$$\begin{aligned}\text{maximum onsite dose} &= \left(3.44\text{E}-02 \frac{\text{s}}{\text{m}^3}\right) * \left(8.0\text{E}+02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (2.06\text{E}-01 \text{ Ci}) \\ &= 5.67 \text{ E}+00 \text{ rem BS}\end{aligned}$$

$$\begin{aligned}\text{maximum offsite dose} &= \left(1.88\text{E}-05 \frac{\text{s}}{\text{m}^3}\right) * \left(8.0\text{E}+02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (2.06\text{E}-01 \text{ Ci}) \\ &= 3.10 \text{ E}-03 \text{ rem BS}\end{aligned}$$

Annual frequency: The frequency of a DOE reportable truck accident occurring on the Hanford Site of a magnitude that could breach drums is calculated to be $8.9\text{E}-07$ per mile (WHC-SD-TP-RPT-007 Rev. 0, 1993). Annual mileage for a truck at the low level burial grounds is conservatively assumed to be 15,000 miles; therefore, the annual frequency of an accident is calculated to be $1.3 \text{ E}-02$.

Conclusions: The maximum onsite and offsite dose consequences of $5.67 \text{ E}+00 \text{ rem BS}$ and $3.10 \text{ E}-03 \text{ rem BS}$ respectively are plotted with the annual frequency of $1.3 \text{ E}-02$ on the radiological risk comparison guidelines found in WHC-CM-4-46, Chapter 7.0, Figure 7-1 to determine if the risk is acceptable. As illustrated in Figure 6-1 and 6-2, the risk is acceptable.

6.2.2.3.3 Drum Explosion. Hydrogen gases are known to be generated in waste containers containing certain radioactive materials. Vent clips or catalyst packs are used on waste drums to mitigate the hazards of combustible gases. The fault tree in Appendix 6D evaluates the likelihood of a hazardous material release resulting from a drum explosion.

Annual frequency: The cutset report in Addendum B shows the basic event requirements for a drum explosion. The frequencies assigned to the basic events are also found in Appendix 6B and generalized as follows:

1. **Hydrogen is generated in the drum** — In closed systems containing organic or wet radioactive materials, the buildup of flammable mixtures of hydrogen-oxygen can be expected and has been observed (Henrie 1986). The most important source of hydrogen-oxygen generation is radiolysis. This is an anticipated event ($1.00 \text{ E}+00$).
2. **Gas is not vented from or recombined in the container** — If the waste matrix is capable of gas generation, the containers are to be vented.

Vent clips are fabricated from 26-gauge stainless-steel sheets, with three 0.003 in. grooves on the surface. They are installed between the drum-lid gasket and the drum rim. Because gases readily diffuse and the limited ways in which the simple design of the vent clip could fail, it is unlikely the vent clip will fail to vent gases. It is more likely the operator fails to install a vent clip. Based on standard human reliability, the probability of an operator failing to install a vent clip is $1.00\text{E}-03$ (Swain and Guttman 1983).

3. **Hydrogen reaches explosive concentration with oxygen** — Hydrogen is flammable in concentrations of 4.1 to 74.2 vol% in air. It requires an oxidizing agent (usually oxygen, minimum 5.0%) to be flammable. Detonations can occur at higher concentrations (18.3 to 59 vol% hydrogen in air) (EG&G 1987). An INEL study (EG&G 1985) shows that out of 184 suspect Rocky Flats drums and 33 Los Alamos drums, only 1 drum (an 8-mo-old drum) had an explosive mixture. This data gives this event a frequency of $4.60 \text{ E}-03/\text{drum}$.
4. **Hydrogen/Oxygen mixture is ignited** — Listed below are four different ignition sources that are evaluated in the fault tree.
 - **Over pressurization** — The drums are not covered and are exposed to the solar rays of the sun. The hot summer months are, July, August, and September. July is the hottest with a daily normal maximum temperature of 95°F . Since the hot months constitute one fourth of the year, the annual frequency for this basic event is $2.5 \text{ E}-01$.
 - **Static charge** — Annual frequency of $5.0 \text{ E}-03$.
 - **Seismic** — Annual frequency of $1.0 \text{ E}-03$.
 - **Vehicle crash** — Annual frequency of $3.7 \text{ E}-02$.

The annual frequency per drum for this event is calculated using the most likely ignition source (over pressurization) as follows:

$$(1.00\text{E}+00)(1.00\text{E}-03)(4.60\text{E}-03/\text{drum})(2.5\text{E}-01) = 1.15\text{E}-06/\text{drum}$$

Assumptions: Assumptions for this analysis are as follows:

- Only one drum explodes
- Drum volume is 0.208 m^3
- Strontium-90 at maximum Category 3 concentration limit is $1.5 \text{ E}+04 \text{ Ci/m}^3$
- A respirable RF of $1.5 \text{ E}-03$ for an explosion is estimated as follows:
 - 10% waste volume is directly released from the drum and dispersed. Of this 10%, $1.0 \text{ E}-03$ becomes respirable (Mishima 1993).
 - 100% of material not made airborne burns. Of the 10% released from the drum, $1.0 \text{ E}-02$ becomes respirable (Mishima 1993). Of the 90% remaining in the drum, $5.0 \text{ E}-04$ becomes respirable (Mishima 1993).

Source term development: The source term for a single drum explosion is calculated as follows:

$$\begin{aligned} \text{source term} &= \left(1.5\text{E}+04 \frac{\text{Ci}}{\text{m}^3}\right) * \left(0.208 \frac{\text{m}^3}{\text{drum}}\right) * (1.5\text{E}-03) \\ &= 4.68 \text{ E}+00 \text{ Ci } ^{90}\text{Sr} \end{aligned}$$

Consequences: Using the same methodology applied in Section 6.2.2.2.1, the maximum onsite and offsite receptor dose for a single drum explosion is calculated. Table 3 in Appendix 6D, shows the maximum onsite receptor to be located 100 m ESE. The maximum offsite receptor is the site boundary located 11.1 km W of the SWBG. Using Table 4 baseline unit release in Appendix 6D, the dose consequence of a single drum explosion with fire is calculated as follows:

$$\begin{aligned} \text{maximum onsite dose} &= \left(1.80\text{E}-02 \frac{\text{s}}{\text{m}^3}\right) * \left(8.0\text{E}+02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (4.68\text{E}+00 \text{ Ci}) \\ &= 6.74 \text{ E}+01 \text{ rem BS} \\ &= 6.96 \text{ E}-02 \text{ rem BS} \end{aligned}$$

$$\text{maximum offsite dose} = \left(1.86\text{E-}05 \frac{\text{s}}{\text{m}^3} \right) * \left(8.0\text{E+}02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}} \right) * (4.68\text{E+}00 \text{ Ci})$$

Conclusions: The maximum onsite and offsite dose consequence of $6.74 \text{ E+}01 \text{ rem BS}$ and $6.96 \text{ E-}02 \text{ rem BS}$ respectively, correspond to an annual frequency of $4.0 \text{ E-}03$ on the radiological risk comparison guidelines found in WHC-CM-4-46, Chapter 7.0, Figure 7-1. To exceed the risk comparison guidelines the number of LLW drums directly exposed to solar radiation from the sun (top drums and southern exposed drums) is calculated as follows:

$$\left(\frac{4.0\text{E-}03 \text{ [annual frequency]}}{1.15\text{E-}06 \text{ [annual frequency]}} \right) \frac{\text{drum}}{\text{drum}} = 3,478 \text{ drums}$$

6.2.2.3.4 Aircraft Events — Uncovered Containers. Events in which an aircraft crashes into uncovered trenches are examined in this section. The likelihood of an aircraft crashing into a burial ground trench is considered incredible.

6.2.2.3.4.1 General Aviation Aircraft. Two possibilities exist: (1) Hanford Patrol helicopter crash and (2) commercial aircraft crash. With regard to the latter, the WNP-2 final safety analysis report examined the probability of a commercial aircraft crash into the WNP-2 reactor building. The results of this analysis indicated the annual frequency of such an event was less than $1 \text{ E-}07$, based on formulae given in NUREG-0800 (NRC 1981) that considered distances from the WNP-2 site to airports, aircraft accident data, annual aircraft traffic volumes, airway and airport approach characteristics (i.e., widths of airways and their distances from the plant), and building areas. Based on the WNP-2 analysis, it is concluded that the probability of a commercial aircraft crash into an uncovered trench is incredible.

6.2.2.3.4.2 Hanford Patrol Aircraft. A second concern with aircraft crashes is the possibility that a future Hanford Patrol helicopter may crash into a burial ground trench. The Hanford Patrol helicopter mission has been terminated but the following analysis is provided in case this mission is reinstated and bounds casual aircraft activity over the Hanford Site. The

annual frequency of such a crash was estimated using the formula in the *Standard Review Plan* (SRP; NRC 1981), Section 3.5.1.6. The annual frequency of an aircraft crash was calculated using the following expression:

$$P_a = \sum_{i=1}^L \sum_{j=1}^M C_j N_{ij} A_j$$

where:

- M = Number of different types of aircraft using the airport
- L = Number of flight trajectories affecting the site
- C_j = Probability per square mile of a crash per aircraft movement, for the jth aircraft
- N_{ij} = Number (per year) of movements by the jth aircraft along the ith flight path
- A_j = Effective plant area (in square miles) for the jth aircraft.

For this analysis, it was assumed that all helicopter flights travel over the SWBG. Typically, two flights per day are made. Therefore, $N_{ij} = 2/d * 365 \text{ d/yr} = 730 \text{ operations/yr}$. The effective plant area is approximately the area of a typical trench 182.9 m by 7.6 m (600 ft by 25 ft). Therefore, $A_j = 5.3 \text{ E-04 mi}^2$. The aircraft crash probability per square mile per aircraft movement was taken from NRC (1981). The highest probability given was $1.1 \text{ E-08 crashes/mi}^2$ per aircraft movement. Using these values, the annual frequency of the Hanford Patrol helicopter crashing into a storage cask within a trench in the SWBG is estimated at about 4 E-09/yr . This is significantly below the 1 E-06/yr guideline for credible accidents to be considered in safety analyses. For this scenario to be credible, the contents of over 230 trenches would have to be exposed.

6.2.2.3.5 Natural Phenomena Events. The impact of an earthquake, high wind, and flood are evaluated to find potential activity release scenarios and their consequences in this section.

6.2.2.3.5.1 Earthquake. The fault tree analysis and the cut-set report in Appendix 6B, demonstrate a seismic event resulting in breached drums to be credible in the uncovered low level trenches (see Appendix 6B, "LLW MECHANICAL RELEASE IN SWBG" fault tree and the cut-set report following the fault tree).

Assumptions: The following assumptions are made:

- Total contents available for release is postulated to be ^{90}Sr at the maximum limit of 1.5 E+04 Ci/m^3
- 100% of the contents of the breached drums are released
- The RF for respirable radionuclides in this scenario is a mechanical release of 1.0 E-06 as discussed in Appendix 6C
- Drums falling a distance of more than 4 ft to the trench floor or landing on other drums are assumed to rupture and expose their contents.

Source term development: The source term for an earthquake without a fire is calculated as follows:

$$\begin{aligned}\text{source term} &= \left(1.5\text{E}+04 \frac{\text{Ci}}{\text{m}^3}\right) * \left(0.208 \frac{\text{m}^3}{\text{drum}}\right) * (1.0\text{E}-06) \\ &= 3.12 \text{E}-03 \text{ Ci } ^{90}\text{Sr/drum}\end{aligned}$$

Consequences: Using the same methodology applied in Section 6.2.2.2.1, the maximum onsite and offsite receptor dose for a mechanical release per drum is calculated. Table 3 in Appendix 6D, shows the maximum onsite receptor to be located 100 m ESE. The maximum offsite receptor is the site boundary located 11.1 km W of the SWBG. Using Table 4 baseline unit release in Appendix 6D, the dose consequence of a single drum rupture is calculated as follows:

$$\begin{aligned}\text{maximum onsite dose} &= \left(3.44\text{E}-02 \frac{\text{s}}{\text{m}^3}\right) * \left(8.0\text{E}+02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (3.12\text{E}-03 \text{ Ci}) \\ &= 8.59 \text{E}-02 \text{ rem BS/drum}\end{aligned}$$

$$\begin{aligned}\text{maximum offsite dose} &= \left(1.88\text{E}-05 \frac{\text{s}}{\text{m}^3}\right) * \left(8.0\text{E}+02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (3.12\text{E}-03 \text{ Ci}) \\ &= 4.69 \text{E}-05 \text{ rem BS/drum}\end{aligned}$$

Annual frequency: The design basis earthquake (DBE) is taken to have a return period of 1,000 yr, which means the annual frequency of occurrence is 1.0 E-03.

Conclusions: The maximum onsite dose consequence on the risk comparison guideline when the frequency is 1.0 E-03 is approximately 100 rem BS. The maximum onsite dose consequence due to a mechanical release is 8.59 E-02 rem BS/drum; therefore, the maximum number of drums that could rupture without exceeding the risk comparison guideline can be calculated as follows:

$$\text{Number of drums} = \left(\frac{1 \text{ drum}}{8.59\text{E}-02 \text{ rem}}\right) * (100 \text{ rem}) = 1,164 \text{ drums}$$

The maximum onsite receptor is bounding when compared to the maximum offsite dose resulting from a 1,164 drum mechanical release as shown in the following calculation:

$$\begin{aligned} \text{maximum offsite dose} &= \left(1.88\text{E-}05 \frac{\text{s}}{\text{m}^3}\right) * \left(8.0\text{E+}02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (3.63\text{E+}00 \text{ Ci}) \\ &= 5.46 \text{ E-}02 \text{ rem BS} \end{aligned}$$

Therefore, up to 1,164 drums could breach due to the earthquake without exceeding the risk comparison guideline. To allow either number of drums or volume of waste to be tracked by SWBG personnel to ensure these quantities are not exceeded, the equivalent volume in cubic meters is provided. 1,164 drums x .208 m³/drum = 242 m³ would be allowed uncovered without exceeding the risk comparison guideline.

Drums falling from the top two levels of the outer 2 rows of the two sides and front are breached for drums stacked four high (approximately 22%). 242m³ x 22%=1100 m³ would be allowed uncovered and stacked in each burial ground.

6.2.2.3.5.2 Earthquake With Ensuing Fire. A seismic event with ensuing fire is considered to be extremely unlikely if not incredible. Therefore a bounding analysis is performed to show the maximum number of drums that can burn in an ensuing fire after an earthquake without exceeding the risk comparison guidelines at an annual frequency of 1.0 E-06 or 1000 rem BS.

Assumptions: The same assumptions used in the earthquake scenario in subsection 6.2.2.3.5.1 are assumed here with the following exceptions:

- The respirable release fraction for a waste Category 3 fire is 1.25 E-05 (NUREG-0782).

Source Term Development: The source term for an earthquake with ensuing fire is calculated as follows:

$$\begin{aligned} \text{source term} &= \left(1.5\text{E+}04 \frac{\text{Ci}}{\text{m}^3}\right) * \left(0.208 \frac{\text{m}^3}{\text{drum}}\right) * (1.25\text{E-}05) \\ &= 3.9 \text{ E-}02 \text{ Ci } ^{90}\text{Sr/drum} \end{aligned}$$

Consequences: Using the same methodology applied in Section 6.2.2.2.1, the maximum onsite and offsite receptor dose for a fire release per drum is calculated. Table 3 in Appendix 6D, shows the maximum onsite receptor to be located 100 m ESE. The maximum offsite receptor is the site

boundary located 11.1 km W of the SWBG. Using Table 4 baseline unit release in Appendix 6D, the dose consequence of a single drum fire is calculated as follows:

$$\text{maximum onsite dose} = \left(5.20E-03 \frac{\text{S}}{\text{m}^3}\right) * \left(8.0E+02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{S}}{\text{m}^3}}\right) * (3.9E-02 \text{ Ci})$$

$$= 1.62 \text{ E-01 rem BS/drum}$$

$$\text{maximum onsite dose} = \left(3.31E-06 \frac{\text{S}}{\text{m}^3}\right) * \left(8.0E+02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{S}}{\text{m}^3}}\right) * (3.9E-02 \text{ Ci})$$

$$= 1.03 \text{ E-04 rem BS/drum}$$

Conclusions: The maximum onsite dose consequence on the risk comparison guideline when the frequency is 1.0E-06 is 1000 rem BS. The maximum onsite dose consequence due to a fire release is 1.62 E-01 rem BS/drum; therefore, the maximum number of drums that could burn without exceeding the risk comparison guideline can be calculated as follows:

$$\text{Number of drums} = \left(\frac{1 \text{ drum}}{1.62E-01 \text{ rem BS}}\right) * (1000 \text{ rem BS}) = 6,172 \text{ drums}$$

The maximum offsite dose resulting from 6,172 drums is calculated as follows:

$$(6,172 \text{ drums}) * (1.03 \text{ E-04 rem BS/drum}) = 6.36 \text{ E-01 rem BS}$$

6.2.2.3.5.3 High Wind Missile. Based on the design basis wind criteria of SDC-4.1, Rev. 11 (DOE-RL 1989), a potential missile penetration of different containers and the stability of a four 208-L (55-gal) drum bundle is evaluated by Goldberg (1989). The evaluation determined that the 100 mi/hr missile would penetrate three walls of 16-gauge metal (208-L [55-gal] drums or boxes) or five walls of 18-gauge metal (114-L [30-gal drums]). This correlates to the missile passing through one 208-L (55-gal) drum or one box and lodging in a second drum or box, or passing through two 18-gauge 114-L (30-gal) drums and lodging in a third 114-L (30-gal) drum. High winds will disperse rapidly and dilute the release reducing the consequences to the maximum onsite and offsite receptor.

The annual frequency of high winds exceeding 86 mi/h at the Hanford Site is small (1.0×10^{-2}). House keeping practices in the SWBG reduces the availability of potential projectiles and because the drums are below grade, the impact annual frequency is also small (1.0 E-02). The annual frequency of this event is calculated to be 1.0 E-04 .

The consequences are well below those for a seismic event discussed in Section 6.2.2.3.5.1 shown to be acceptable. Therefore, further analysis of impacts from a highwind missile is bounded by a seismic event.

6.2.2.3.5.4 Flood. The 200 Area plateau is immune from the probable maximum flood postulated by the U.S. Army Corps of Engineers (ERDA 1975) for the Columbia River Basin. Local onsite flooding, however, is credible as a result of heavy rains and runoff. The local flooding in an area of exposed contamination could result in the spread of contaminated materials.

Should local flooding occur before the site can be protected from the heavy rains and runoff, a small amount of contamination could spread to the soil column and possibly outside the trench boundary. Such small consequences combined with the low annual frequency equate to an insignificant risk with no consequences to maximum onsite and offsite receptors (WHC 1991).

- Annual frequency of flooding $\sim 10^{-1}$
- During a contamination incident $10^{-2} \times 10^{-1} = 10^{-3}$
- Consequences are minor site contamination that require cleanup action.

6.2.3 Analysis For Miscellaneous Low-Level Waste Packages

A list of miscellaneous LLW packages is illustrated in Table 6-7. Location, inventory, and waste form is identified with each waste package in the table. Each waste package is analyzed with regard to its inventory and waste form under abnormal and accident conditions. The results are listed in the last column of Table 6-7.

6.2.3.1 Abnormal Operations for Miscellaneous Low-Level Waste Packages. The abnormal operations for miscellaneous LLW packages would be similar to those already discussed in Section 6.2.2.1.

6.2.3.2 Accident Analysis for Miscellaneous Low-Level Packages. Only packages that are uncovered and capable of being compromised by a credible accident are analyzed in this section. For simplicity, each suspect waste package in Table 6-7 is analyzed under extreme conditions without consideration to scenario sequence development. One hundred percent of all the isotopic contents are released to the atmosphere by either a mechanical release (a respirable RF of 1.0 E-05) or a fire (a respirable RF of 5.0 E-04). An uncovered ion exchange module explosion is analyzed in more detail in Section 6.2.3.3.

Consequences: Using the same methodology applied in Section 6.2.2.2.1, the maximum onsite and offsite receptor dose for a mechanical release or a fire is calculated. Table 3 in Appendix 6D, shows the maximum onsite receptor to be located 100 m ESE. The maximum offsite receptor is the site boundary located 11.1 km W of the SWBG.

The total dose consequences associated with waste packages are the sums of the dose consequences from the contributing isotopes. Unknown MFP are considered to be ^{90}Sr . The dose consequences are illustrated in the last column in Table 6-7.

Conclusions: The maximum acceptable dose without exceeding the risk comparison guidelines when the annual frequency is 1.0 is as follows:

- Maximum onsite receptor dose: 1.0 rem EDE or 10.0 rem maximum organ
- Maximum offsite receptor dose: 0.01 rem EDE or 0.1 rem maximum organ.

Only the maximum onsite dose consequences from the classified waste core basket from Table 6-7 exceed the limits. However, due to the engineered container the core baskets are in, this event is considered extremely unlikely. The likelihood of occurrence for an extremely unlikely event, as defined in Table 6-1, falls in a range of $1.0 \text{ E-}04$ to $1.0 \text{ E-}06$. For the purpose of determining risk acceptance, the more conservative end of the range ($1.0 \text{ E-}04$) is assigned to this event. Therefore, the maximum onsite and offsite risks are acceptable.

6.2.3.3 Analysis of Ion Exchange Modules. Eleven ion exchange modules (IXM) are stored, uncovered, in the SWBG 218-W-4C Trench 24. The IXMs were used to remove radioactive salt contamination from the KW and KE Storage Basins, where spent N-Reactor fuel is stored. Each IXM consists of six spent ion exchange columns encased in concrete. The six ion exchange columns are connected together with piping that allows the columns to vent radiolytically generated gases through a common header and filter.

The bounding accident for the IXMs is postulated to be a hydrogen explosion, which is caused by the buildup of hydrogen and oxygen in the IX columns.

Scenario Description. Although the ion exchange columns were drained before storage in the SWBG, residual water remains in the columns, absorbed in the ion exchange media. Through radiolysis of the residual water and radiolytic decay of the organic resin beads in the ion exchange columns, hydrogen, oxygen and other gases are generated. Normally, these gases vent through the filtered vent path provided in the IXM.

The radiolysis of water is assumed to produce a stoichiometric ratio of hydrogen and oxygen, which is further assumed to fill the freeboard space of the ion exchange columns, the connecting piping, and the vent header. Dilution by carbon dioxide and other gases likely to be produced from radiolytic decay of the organic resin is conservatively neglected. It is postulated that the mixture of hydrogen and oxygen gas is ignited by a spark induced internally by mechanical contact, such as might occur should the IXM be moved or impacted by equipment. The ignition causes an explosion which breaches the vent header, and suspends a portion of the radioactive material bound to the resin media and dissolved in any residual liquid in the columns into the atmosphere.

Source Term Development. It is unlikely that the explosion would significantly compromise the containment provided by the concrete block encasing the IX columns and piping. The radioactive release would be mitigated somewhat in flowing out the vent piping, because of the tortuous path the vented gases, along with any entrained liquids or solids, would have to follow. However, for the purposes of this analysis, it is conservatively assumed that the release is not mitigated by any of these factors.

The unmitigated fraction of material fragmented in an explosion and made airborne can be estimated from the following equation (Ayer et al. 1988):

$$2.783(MR)^{0.3617} \text{ g aerosol/g explosive (TNT)} \quad \text{Eqn. 1}$$

The MR, or "Mass Ratio," expresses the relationship between the mass of material fragmented and the energy in the explosive charge (expressed as equivalent weight of TNT). The above equation applies to both solids and liquids.

The estimated volume of the six columns and interconnecting piping in each module is 0.85 m^3 (30 ft^3). The estimated volume of ion exchange media in each module is 0.59 m^3 (21 ft^3). Assuming a void volume of 50% for the ion exchange media, the free volume that can be occupied by radiolytically generated gases is: $0.85 \text{ m}^3 - (0.59 \text{ m}^3)(0.5) = 0.56 \text{ m}^3$ (20 ft^3).

From the ideal gas law, at 1 atm and 25 C, 0.56 m^3 corresponds to 23 moles of gas. Assuming a stoichiometric ratio of hydrogen to oxygen of 2:1, the number of moles of hydrogen is $(2/3)(23 \text{ moles}) = 15 \text{ moles}$. From Ayer et al. (1988), the TNT equivalent weight to 1 g of hydrogen is 28.65 g. Therefore, the total TNT equivalent for this accident scenario is:

$$\begin{aligned} \text{TNT equivalent} &= (15 \text{ mol H}_2)(2 \text{ g/mol})(28.65 \text{ g TNT/g of H}_2) \\ &= 860 \text{ g TNT} \end{aligned}$$

From the IXM module disposal records the mass of ion exchange resins (including absorbed liquid) in each module is approximately 2,000 kg. Conservatively assuming the energy of explosion is only absorbed by the ion exchange media (e.g., not absorbed in part in the metal columns, piping and concrete block), the MR is 2330 ($2,000 \text{ kg}/0.860 \text{ kg}$).

Applying Eqn. 1, the unmitigated aerosol release is:

$$2.783(2330)^{0.3617} = 46.0 \text{ g aerosol/g TNT}$$

Only a fraction of this aerosol material is in the respirable size range. Appendix C of Ayer et al. (1988), provides particle size distributions for MRs up to 1000. At an MR of 1000 the respirable fraction ($<10 \text{ um}$) is reported to be 3.1% of the total airborne. As the MR goes up, the respirable fraction is found to decrease, because a larger mass is harder to fragment (for any given TNT equivalent) into small particles. The 3.1% respirable fraction value is thus judged to be conservative for this case.

The respirable release fraction (RRF) for the hydrogen explosion is the product of the calculated aerosol release and the respirable fraction, divided by the total material subject to fragmentation (in this case, assumed to be only the IX media with its absorbed liquid):

$$\text{RRF} = (46.0 \text{ g aerosol/g TNT})(860 \text{ g TNT})(0.031)/(2 \text{ E}+06 \text{ g}) = 6.1 \text{ E}-04.$$

The radionuclide inventory of the IXM with the highest quantity of TRU material is provided as follows:

⁹⁰ Sr	71.8 Ci
¹³⁷ Cs	48.6 Ci
²³⁸ Pu	0.217 Ci
²³⁹ Pu	1.09 Ci
²⁴⁰ Pu	0.144 Ci.

This worst-case inventory was determined from the storage/disposal records for the 11 IXMs. The amount of respirable radioactive material released in the explosion is calculated by multiplying the inventory values above by the above RRF, as follows:

$$^{90}\text{Sr release} = (71.8 \text{ Ci})(6.1 \text{ E}-04) = 4.60 \text{ E}-02 \text{ Ci}$$

$$^{137}\text{Cs release} = (48.6 \text{ Ci})(6.1 \text{ E}-04) = 2.96 \text{ E}-02 \text{ Ci}$$

$$^{238}\text{Pu release} = (0.217 \text{ Ci})(6.1 \text{ E}-04) = 1.32 \text{ E}-04 \text{ Ci}$$

$$^{239}\text{Pu release} = (1.09 \text{ Ci})(6.1 \text{ E}-04) = 6.65 \text{ E}-04 \text{ Ci}$$

$$^{240}\text{Pu release} = (0.144 \text{ Ci})(6.1 \text{ E}-04) = 8.78 \text{ E}-05 \text{ Ci}.$$

Dose Consequences. The dose consequences are calculated as before (see Section 6.2.2.2.1) by multiplying the above source terms by the appropriate X/Q and the baseline unit release dose factors provided in Appendix 6D. The maximum onsite receptor for LLW is assumed to be located 100 m to the east, with a X/Q of $1.8 \text{ E}-02 \text{ s/m}^3$. The maximum offsite receptor is located 11.1 km to the west, with a X/Q of $1.86 \text{ E}-05 \text{ s/m}^3$. The baseline unit release dose factor for ²³⁹Pu is conservatively applied to the ²³⁸Pu and ²⁴⁰Pu releases.

Maximum Onsite Receptor Dose

$$^{90}\text{Sr dose} = \left(1.80\text{E-}02 \frac{\text{S}}{\text{m}^3}\right) * \left(70 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{S}}{\text{m}^3}}\right) * (4.60\text{E-}02 \text{ Ci})$$

$$= 5.8 \text{ E-}02 \text{ rem EDE}$$

$$^{137}\text{Cs dose} = \left(1.80\text{E-}02 \frac{\text{S}}{\text{m}^3}\right) * \left(10 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{S}}{\text{m}^3}}\right) * (2.96\text{E-}02 \text{ Ci})$$

$$= 5.3 \text{ E-}03 \text{ rem EDE}$$

$$^{238}\text{Pu dose} = \left(1.80\text{E-}02 \frac{\text{S}}{\text{m}^3}\right) * \left(1.4\text{E+}05 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{S}}{\text{m}^3}}\right) * (1.32\text{E-}04 \text{ Ci})$$

$$= 3.3 \text{ E-}01 \text{ rem EDE}$$

$$^{239}\text{Pu dose} = \left(1.80\text{E-}02 \frac{\text{S}}{\text{m}^3}\right) * \left(1.4\text{E+}05 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{S}}{\text{m}^3}}\right) * (6.65\text{E-}04 \text{ Ci})$$

$$= 1.7 \text{ E+}00 \text{ rem EDE}$$

$$^{240}\text{Pu dose} = \left(1.80\text{E-}02 \frac{\text{S}}{\text{m}^3}\right) * \left(1.4\text{E+}05 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{S}}{\text{m}^3}}\right) * (8.78\text{E-}05 \text{ Ci})$$

$$= 2.2 \text{ E-}01 \text{ rem EDE}$$

Total Dose: 2.3 rem EDE

Maximum Offsite Receptor Dose

The maximum offsite receptor dose can be calculated by multiplying the onsite receptor dose (above) by the ratio of the offsite X/Q to the onsite X/Q. The total offsite receptor dose is thus $(2.3 \text{ rem})(1.86 \text{ E-05}/1.8 \text{ E-02}) = 2.4 \text{ E-03 Rem EDE}$.

Frequency Assessment. The IXM hydrogen explosion accident is judged to be well below $10^{-2}/\text{yr}$. The explosion requires an ignition source be generated after flammable gases have built up in the column. The probability of an ignition source being generated is difficult to estimate, but is judged to be an "unlikely" event in itself, with a frequency well below $10^{-2}/\text{yr}$. The IXM hydrogen explosion is thus an "unlikely" event, according to the frequency categories defined in WHC-CM-4-46, Section 4.0.

Risk Assessment. The onsite dose of 2.3 rem EDE falls below the risk acceptance guideline of 5 rem corresponding to a frequency estimate of $10^{-2}/\text{yr}$. The offsite dose estimate of 2.5 E-03 rem is below the risk acceptance guidelines for any frequency category. The accident is judged to have a frequency well below $10^{-2}/\text{yr}$. Given the conservatism in the analysis and the low probability of occurrence, the risk of this accident is judged to be acceptable.

6.3 RISK ASSESSMENT FOR LOW-LEVEL MIXED WASTE

LLMW is waste containing both LLW and hazardous or dangerous waste. LLW is discussed in Section 6.2. Dangerous wastes are those solid wastes designated in WAC 173-303-070 through -103 as dangerous or extremely hazardous wastes. It is also classified according to Waste Category 1, Waste Category 3, and greater than Waste Category 3 concentration limits as discussed in Section 6.2.1.

The risk assessment for MW considers:

- MW disposal landfill located in the 218-W-5 burial ground. The information presented in this analysis covers two MW disposal trenches of the same design and location in the same burial grounds.
- Environmental Restoration Disposal Facility (ERDF) located between the 200 West and 200 East Areas, approximately 14.5 km east and north of the Hanford Site boundary.
- Submarine reactor compartments located in the 218-E-12B burial ground.

6.3.1 Mixed Waste Disposal Landfill

A RCRA-compliant MW disposal landfill is located in the 218-W-5 burial ground. The information presented in this analysis covers two MW disposal trenches of the same design and location in the same burial grounds.

6.3.1.1 Mixed Waste Disposal Landfill Inventory. The MW disposal landfill will accept only LLMW meeting the requirements of WHC-EP-0063, 10 CFR 61, 40 CFR 268, and WAC 173-303-070. The radiological inventory and waste form is the same as that discussed in Section 6.2.1.1.

The quantities and types of chemicals and compounds that will be placed in a MW landfill are limited. The Hanford Site Solid Waste Acceptance Criteria in WHC-EP-0063 (WHC 1993a) and the current environmental regulations (40 CFR 268) require that hazardous wastes meet treatment standards before land disposal. This treatment mitigates the toxicological hazards; therefore, the potential toxicological consequences are minor as compared to the potential radiological consequences.

Uranium bearing solid waste will be limited to 1% ^{235}U enrichment or less to be acceptable for disposal in the MW lined trenches. Higher enrichments of ^{235}U may be accepted on a case-by-case basis if the disposal documentation shows that the uranium waste is in an insoluble or stabilized form.

The radiological and toxicological constituents in bulk soils and bulk solid waste received for emplacement in the LLMW trench will not exceed the limits of the ERDF Safety Assessment in WHC (1994), summarized in Section 6.3.2 and shown in Tables 6-4, 6-5, and 6-6.

6.3.1.2 Hazards Identification for Mixed Waste Disposal Landfill. Hazards associated with normal operations in the MW landfill are similar to those in ERDF Safety Assessment found in WHC (1994), and summarized in Section 6.3.2. Hazards associated with abnormal operations and accidents in the MW landfill operations are similar to those in the LLW operation and are identified by an OHA process. The outcome of the OHA is reported in tabular format on a PHA table found in Appendix 6A, Table 6A-2. Those potential events that have been determined to adequately represent the complete range of credible events are listed as follows:

- Normal Operations
 - Bulk waste dispersion
- Abnormal Operations
 - Backfill subsidence
 - Receipt of MW container(s) having surface contamination
 - Receipt of MW container(s) having high surface dose rates
- Accidents
 - Drums(s) rupture
 - Drums(s) fire
 - Drum explosion
 - Leachate collection system spray release.

6.3.1.3 Normal Operations Analysis for Bulk Waste in Mixed Waste Disposal Landfill. Normal operations involve receipt and emplacement of bulk soils and solid wastes in the trench. Unloading of bulk soils into the trench and spreading and compacting of soils within the trench provides a mechanism for generation of fugitive dust and release of contaminants.

As the contents of bulk soils are unloaded in the trench, a potential plume of fugitive dust is released. Spreading and compacting of the waste soil will also produce fugitive dust in the immediate area. Soil stabilization treatment will be provided through use of water spray nozzles and by mobile truck sprayers or the application of affixitive. If water is used it will be applied so as to minimize dust without introducing free liquid. Normal bulk waste operations will be conducted only at windspeeds of below 24 km/h (15 mi/h).

The inventory and consequences of this analysis are bound by the ERDF safety assessment found in WHC (1994) and summarized in Section 6.3.2. Therefore, the radiological dose to the maximum onsite and offsite receptors is less than $8.24\text{E-}02$ rem EDE and $9.47\text{E-}04$ rem EDE respectively. The radiological consequences of this event are within the risk comparison guidelines found in WHC-CM-4-46, Chapter 7.0, Figure 7-1 given a probability of one. Acute concentrations for all nonradiological constituents are also within the permissible exposure limits. The radiological and nonradiological risks are therefore acceptable for normal operations.

6.3.1.4 Abnormal Operations Analysis for Mixed Waste Disposal Landfill. Scenario descriptions, detection, consequences, and recovery of abnormal operations for MW are the same as the LLW discussed in Section 6.2.2.2.

6.3.1.5 Accident Analysis for Mixed Waste Disposal Landfill. The preliminary hazards analysis in Appendix 6A, Table 6A-2 identifies plausible accidents expected to result in radiological releases. In addition to a postulated leachate collection system spray release, potential accidents in the MW disposal landfill are similar to the LLW accidents discussed in Section 6.2.2.3.

6.3.1.5.1 Bulldozer Accident With Ensuing Fire. After examining the PHA table in Appendix 6A, it has been determined that a bulldozer accident resulting in a fire in a MW disposal trench is the bounding accident.

The scenario description, assumptions, source term, and annual frequency are the same as the LLW discussed in Section 6.2.2.3.1. However, the consequences are not the same due to the difference in the maximum onsite receptors.

Consequences: Using the same methodology applied in Section 6.2.2.3.1, the maximum onsite and offsite receptor dose for a fire release are calculated. Table 3 in Appendix 6D, shows the maximum onsite receptor to be 241-T located 730 m ESE of the MW landfill. The maximum offsite

receptor is the site boundary located 11.1 km W of the MW landfill. Using Table 4 baseline unit release in Appendix 6D, the dose consequence of a 66 drum accident with fire are calculated as follows:

$$\begin{aligned} \text{maximum onsite dose} &= \left(2.94\text{E-}04 \frac{\text{s}}{\text{m}^3} \right) * \left(8.0\text{E+}02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}} \right) * (2.57 \text{ Ci}) \\ &= 6.04 \text{ E-}01 \text{ rem BS} \end{aligned}$$

$$\begin{aligned} \text{maximum offsite dose} &= \left(3.31\text{E-}06 \frac{\text{s}}{\text{m}^3} \right) * \left(8.0\text{E+}02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}} \right) * (2.57 \text{ Ci}) \\ &= 6.81 \text{ E-}03 \text{ rem BS} \end{aligned}$$

Conclusions: The maximum onsite and offsite dose consequences of 6.04 E-01 rem BS and 6.81 E-03 rem BS respectively, are plotted with the annual frequency of 5.4 E-04 on the radiological risk comparison guidelines found in WHC-CM-4-46, Chapter 7.0, Figure 7-1 to determine if the risk is acceptable. As illustrated in Figures 6-1 and 6-2, the risk is acceptable.

At an annual frequency of 5.4 E-04 the onsite risk acceptance curve is not exceeded until the dose consequences exceed 12.97 rem EDE. This equates to the contents of 1,413 drums released in a fire.

Bounding Fire Analysis: Based on the vehicle and the storage array the above analysis examined a fire with 66 drums. However, it is not known how far a worst case fire might propagate once initiated. This propagation is the subject of a Fire Hazards Analysis (FHA) currently in work. The FHA will more fully examine fire propagation and other events.

6.3.1.5.2 Bulldozer Accident Without Ensuing Fire. The scenario description, assumptions, source term, and annual frequency are the same as the LLW discussed in Section 6.2.2.3.2. However, the consequences are not the same due to the difference in the maximum onsite receptors.

Consequences: Using the same methodology applied in Section 6.2.2.3.1, the maximum onsite and offsite receptor dose for a mechanical release are calculated. Table 3 in Appendix 6D, shows the maximum onsite receptor to be 241-T located 730 m E of the MW landfill. The maximum offsite receptor is the site boundary located 11.1 km W of the MW landfill.

Using Table 4 baseline unit release in Appendix 6D, the dose consequence of a 66 drum accident with mechanical release is calculated as follows:

$$\begin{aligned} \text{maximum onsite dose} &= \left(1.16\text{E-}03 \frac{\text{s}}{\text{m}^3}\right) * \left(8.0\text{E+}02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (2.06\text{E-}01 \text{ Ci}) \\ &= 1.91 \text{ E-}01 \text{ rem BS} \end{aligned}$$

$$\begin{aligned} \text{maximum offsite dose} &= \left(1.88\text{E-}05 \frac{\text{s}}{\text{m}^3}\right) * \left(8.0\text{E+}02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (2.06\text{E-}01 \text{ Ci}) \\ &= 3.10 \text{ E-}03 \text{ rem BS} \end{aligned}$$

Conclusions: The maximum onsite and offsite dose consequence of 1.91 E-01 rem BS and 3.10 E-03 rem BS respectively, are plotted with the annual frequency of 1.3 E-02 on the radiological risk comparison guidelines found in WHC-CM-4-46, Chapter 7.0, Figure 7-1 to determine if the risk is acceptable. As illustrated in Figures 6-1 and 6-2, the risk is acceptable.

6.3.1.5.3 Drum Explosion. The annual frequency, assumptions, and source term are the same as the LLW discussed in Section 6.2.2.3.3. However, the consequences are not the same due to the difference in the maximum onsite receptors.

Consequences: Using the same methodology applied in Section 6.2.2.3.1, the maximum onsite and offsite receptor dose for a single drum explosion are calculated. Table 3 in Appendix 6D, shows the maximum onsite receptor to be 241-T located 730 m E of the MW landfill. The maximum offsite receptor is the site boundary located 11.1 km W of the MW landfill. Using Table 4 baseline unit release in Appendix 6D, the dose consequence of a drum explosion is calculated as follows:

$$\begin{aligned} \text{maximum onsite dose} &= \left(1.05\text{E-}03 \frac{\text{s}}{\text{m}^3}\right) * \left(8.0\text{E+}02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (4.68\text{E+}00 \text{ Ci}) \\ &= 3.93 \text{ E+}00 \text{ rem BS} \end{aligned}$$

$$\text{maximum offsite dose} = \left(1.86\text{E-}05 \frac{\text{s}}{\text{m}^3} \right) * \left(8.0\text{E+}02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}} \right) * (4.68\text{E+}00 \text{ Ci})$$

$$= 6.92 \text{ E-}02 \text{ rem BS}$$

Conclusions: The maximum onsite dose consequence of 10.0 rem BS correspond to an annual frequency of 1.0 E-01 on the radiological risk comparison guidelines found in WHC-CM-4-46, Chapter 7.0, Figure 7-1. For this event to exceed the risk guidelines, the dose consequence of 3.90 E+00 would need to be increased by a factor of 2.5 and the number of LLMW drums directly exposed to solar radiation from the sun (top drums and southern exposed drums) would need to exceed 86,956 as shown in the following calculation:

$$\left(\frac{1.0\text{E-}01 \text{ [annual frequency]}}{1.15\text{E-}06 \text{ [annual frequency]}} \right) = 86,956 \text{ drums}$$

6.3.1.5.4 Leachate Collection System Spray Release.

Inventory: The inventory in the 10,000 gal (37.85 m³) tank is the leachate reaching the tank from a MW disposal trench. The equations from NUREG/CR 1759 VOL 3 for precipitation moving through the soil have been adapted to calculate the leachate reaching the tank. The results are tabulated in Table 6-8. The isotopic leachate inventory is based on the total amount of radionuclides (560,927 Ci) expected in a MW trench during operation. The calculations assume the containers have completely deteriorated and no radioactive decay took place.

Respirable Spray Release: To determine the spray release for the leachate collection system, a computer model is used to estimate the release rate of aerosol droplets from pressurized liquid leaks, WHC-SD-GN-TI-30003, Rev 0. Assuming a pump head of 15.2 m, an optimum orifice/slit size is predicted by the model. Table 6-9 shows the largest release is from a 6.00 E-03 cm slit. The 6.00 E-03 cm slit yields a total flow of 9.35 E+01 c³/sec and a RF of 6.00 E-01. This produces a 56.1 c³/sec spray of droplets less than 50 microns. The spray is assumed to go undetected for an 8 h work shift. The respirable release of an 8 h spray is calculated as follows:

$$5.61 \text{ E-}05 \text{ m}^3/\text{sec} \times 60 \text{ sec/min} \times 60 \text{ min/h} \times 8 \text{ h} = 1.62 \text{ m}^3$$

Source Term Development: The source term is the individual contribution of each isotope in the 8 h respirable spray. For each isotope, the curie content in the tank (37.83 m^3) is multiplied by the 8 h respirable spray release (1.62 m^3) as shown below.

$$^{60}\text{Co} = 2.1 \text{ E-04 Ci}/37.85 \text{ m}^3 \times 1.62 \text{ m}^3 = 8.988 \text{ E-06 Ci}$$

$$^{90}\text{Sr} = 2.3 \text{ E-05 Ci}/37.85 \text{ m}^3 \times 1.62 \text{ m}^3 = 9.844 \text{ E-07 Ci}$$

$$^{129}\text{I} = 1.6 \text{ E-03 Ci}/37.85 \text{ m}^3 \times 1.62 \text{ m}^3 = 6.848 \text{ E-05 Ci}$$

$$^{137}\text{Cs} = 2.3 \text{ E-06 Ci}/37.85 \text{ m}^3 \times 1.62 \text{ m}^3 = 9.844 \text{ E-08 Ci}$$

$$^{239}\text{Pu} = 6.5 \text{ E-06 Ci}/37.85 \text{ m}^3 \times 1.62 \text{ m}^3 = 2.782 \text{ E-07 Ci}$$

$$^{241}\text{Am} = 5.7 \text{ E-05 Ci}/37.85 \text{ m}^3 \times 1.62 \text{ m}^3 = 2.440 \text{ E-06 Ci}$$

Consequences: Using the same methodology applied in Section 6.2.2.3.1, the maximum onsite and offsite receptor dose for a spray release are calculated. Table 3 in Appendix 6D, shows the maximum onsite receptor to be 241-T located 730 m E of the MW landfill. The maximum offsite receptor is the site boundary located 11.1 km W of the MW landfill. Using Table 4 baseline unit release in Appendix 6D, the dose consequence of a spray release is calculated.

The radiological dose to the maximum onsite receptor is calculated as follows:

$$^{60}\text{Co dose} = \left(1.16\text{E-03} \frac{\text{s}}{\text{m}^3}\right) * \left(6.60\text{E+01} \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (8.99\text{E-06 Ci})$$

$$= 6.88 \text{ E-07 rem EDE}$$

$$^{90}\text{Sr dose} = \left(1.16\text{E-03} \frac{\text{s}}{\text{m}^3}\right) * \left(7.00\text{E+01} \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (9.84\text{E-07 Ci})$$

$$= 7.99\text{E-08 rem EDE}$$

$$^{129}\text{I dose} = \left(1.16\text{E-03} \frac{\text{s}}{\text{m}^3}\right) * \left(5.00\text{E+01} \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (6.85\text{E-05 Ci})$$

$$= 3.97 \text{ E-06 rem EDE}$$

$$^{137}\text{Cs dose} = \left(1.16\text{E-}03 \frac{\text{s}}{\text{m}^3}\right) * \left(1.00\text{E+}01 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (9.84\text{E-}08 \text{ Ci})$$

$$= 1.14 \text{ E-}09 \text{ rem EDE}$$

$$^{239}\text{Pu dose} = \left(1.16\text{E-}03 \frac{\text{s}}{\text{m}^3}\right) * \left(1.40\text{E+}05 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (2.78\text{E-}07 \text{ Ci})$$

$$= 4.52 \text{ E-}05 \text{ rem EDE}$$

$$^{241}\text{Am dose} = \left(1.16\text{E-}03 \frac{\text{s}}{\text{m}^3}\right) * \left(1.50\text{E+}05 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (2.44\text{E-}06 \text{ Ci})$$

$$= 4.25 \text{ E-}04 \text{ rem EDE}$$

The dose to the maximum onsite receptor is the sum of the individual dose contribution of each isotope; therefore:

$$\text{maximum onsite dose} = 4.75 \text{ E-}04 \text{ rem EDE}$$

The radiological dose to the maximum offsite receptor is calculated as follows:

$$^{60}\text{Co dose} = \left(1.88\text{E-}05 \frac{\text{s}}{\text{m}^3}\right) * \left(6.60\text{E+}01 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (8.99\text{E-}06 \text{ Ci})$$

$$= 1.12 \text{ E-}08 \text{ rem EDE}$$

$$^{90}\text{Sr dose} = \left(1.88\text{E-}05 \frac{\text{s}}{\text{m}^3}\right) * \left(7.00\text{E+}01 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (9.84\text{E-}07 \text{ Ci})$$

$$= 1.29\text{E-}09 \text{ rem EDE}$$

$$^{129}\text{I dose} = \left(1.88\text{E-}05 \frac{\text{s}}{\text{m}^3}\right) * \left(5.00\text{E+}01 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (6.85\text{E-}05 \text{ Ci})$$

$$= 6.44 \text{ E-}08 \text{ rem EDE}$$

$$^{137}\text{Cs dose} = \left(1.88\text{E-}05 \frac{\text{s}}{\text{m}^3}\right) * \left(1.00\text{E+}01 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (9.84\text{-}08 \text{ Ci})$$

$$= 1.85 \text{ E-}11 \text{ rem EDE}$$

$$^{239}\text{Pu dose} = \left(1.88\text{E-}05 \frac{\text{s}}{\text{m}^3}\right) * \left(1.40\text{E+}05 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (2.78\text{E-}07 \text{ Ci})$$

$$= 7.32 \text{ E-}07 \text{ rem EDE}$$

$$^{241}\text{Am dose} = \left(1.88\text{E-}05 \frac{\text{s}}{\text{m}^3}\right) * \left(1.50\text{E+}05 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (2.44\text{E-}06 \text{ Ci})$$

$$= 6.88 \text{ E-}06 \text{ rem EDE}$$

The dose to the maximum offsite receptor is the sum of the individual dose contribution of each isotope; therefore:

$$\text{maximum offsite dose} = 7.69 \text{ E-}06 \text{ rem EDE}$$

Conclusions: The consequence of this event fall below the radiological risk comparison guidelines for onsite and offsite receptors as defined in WHC-CM-4-46, Chapter 7.0, Figure 7-1 regardless of the frequency. Therefore, the associated risk is acceptable and further analysis to determine accident sequences and frequency is unnecessary.

6.3.1.5.5 Natural Phenomena Events. Natural phenomena events are the same as the LLW discussed in Section 6.2.2.3.5. However, the consequences for a seismic event are not the same due to the difference in the maximum onsite receptors.

Earthquake Consequences: Using the same methodology applied in Section 6.2.2.3.1, the maximum onsite and offsite receptor dose for a mechanical release per drum is calculated. Table 3 in Appendix 6D, shows the maximum onsite receptor to be 241-T located 730 m E of the MW

landfill. The maximum offsite receptor is the site boundary located 11.1 km W of the MW trenches. Using Table 4 baseline unit release in Appendix 6D, the dose consequence of a single drum rupture is calculated as follows:

$$\text{maximum onsite dose} = \left(1.16\text{E-}03 \frac{\text{s}}{\text{m}^3}\right) * \left(8.0\text{E+}02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (3.12\text{E-}03 \text{ Ci})$$

$$= 2.90 \text{ E-}03 \text{ rem BS per drum}$$

$$\text{maximum offsite dose} = \left(1.88\text{E-}05 \frac{\text{s}}{\text{m}^3}\right) * \left(8.0\text{E+}02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (3.12\text{E-}03 \text{ Ci})$$

$$= 4.69 \text{ E-}05 \text{ rem BS per drum}$$

Conclusions: The maximum onsite dose consequence on the risk comparison guideline when the frequency is 1.0 E-03 is approximately 100 rem BS. The maximum onsite dose consequence due to a mechanical release is 2.90 E-03 rem BS/drum; therefore, the maximum number of drums that could rupture without exceeding the risk comparison guidelines can be calculated as follows:

$$\text{Number of drums} = \left(\frac{1 \text{ drum}}{2.90\text{E-}03 \text{ rem}}\right) * (100 \text{ rem}) = 34,482 \text{ drums}$$

The maximum onsite receptor is bounding when compared to the maximum offsite dose resulting from a 34,482 drum mechanical release shown in the following calculation:

$$\text{maximum offsite dose} = \left(1.88\text{E-}05 \frac{\text{s}}{\text{m}^3}\right) * \left(8.0\text{E+}02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (1.08\text{E+}02 \text{ Ci})$$

$$= 1.62 \text{ E+}00 \text{ rem BS}$$

Therefore, up to 34,482 drums could breach due to the earthquake without exceeding the risk comparison guideline.

The leachate collection tank and the retention basin below it are designed to the design base earthquake. Failure of both during an earthquake is very unlikely. The basin is designed to hold the contents of the storage tank and the precipitation from the 25-yr storm.

The leachate liners are tested to ensure compatibility with the environment consisting of both radiological and hazardous components in accordance with the U.S. Environmental Protection Agency 9090 test (Golder 1990). The leachate liners are designed and installed to meet the seismic design basis of 0.12 g.

6.3.2 Environmental Restoration Disposal Facility

The ERDF, located between the 200 West and 200 East Areas, will process large volumes of bulk soil and solid wastes. These waste streams will contain low concentration of contamination.

6.3.2.1 Environmental Restoration Disposal Facility Inventory. The radionuclide inventory of waste proposed for disposal at the ERDF is listed in Table 6-4. The toxicological inventories are given in Tables 6-5 and 6-6. The estimated concentration information listed is taken from the Source Inventory Development Engineering Study for the Environmental Restoration Disposal Facility. This information is developed through sampling and analysis of proposed remediation sites and through review of available process records. For some sites where neither analysis data nor process records are available, the Study assumed similar composition to an analogous characterized site. The concentrations listed as "overall average" are calculated based on the total activity of each contaminant expected to result from all remediation activities and the total mass of excavated soil, rubble, and debris expected to result from all remediation activities. The concentrations listed as "maximum average" are calculated based on the average concentration of each contaminant at the individual remediation site which contained the highest concentration of that contaminant.

6.3.2.2 Hazards Identification for Environmental Restoration Disposal Facility. The operation of ERDF will involve the handling of hazardous materials and radioactive mixed waste using heavy equipment of the type normally associated with construction activities. The operations conducted at the ERDF in support of radioactive mixed waste disposal have the potential to present industrial safety, industrial hygiene, and radiological safety hazards to facility worker receptors. Hazards to the maximum onsite and offsite receptors are expected to be minor.

The hazard identification process is conducted in two parts: identification of energy sources and identification of hazardous material inventory. The results of this process are documented in Tables 3-1 through 3-8 of the Safety Assessment found in WHC (1994). Those potential events that are determined to adequately represent the complete range of credible events are listed as follows:

Normal Operations

- Dust generation from container unloading

Abnormal Operations

- Wind transport of fugitive dust from waste pile prior to stabilization

Accidents

- Dispersal of contamination from breach of a waste bulk soil container.

6.3.2.3 Normal Operation for Environmental Restoration Disposal Facility. Normal operations involve receipt and emplacement of bulk soils and solid wastes in the trench. Unloading of bulk soils into the trench and spreading and compacting of soils within the trench provides a mechanism for generation of fugitive dust and release of contaminants.

6.3.2.3.1 Dust Generation From Container Unloading. As the contents of bulk soil containers are placed in the trench, a plume of fugitive dust is released. A plume originates from points below each of the two trailer tippers where the soil is unloaded down the trench working face onto the existing waste pile. Spreading and compacting of the waste soil will also produce fugitive dust in the immediate area of machine operations. Soil stabilization treatment will be provided at the trailer tippers through use of water spray nozzles and by mobile truck sprayers. Normal operations will be conducted only at windspeeds of below 24 km/h (15 mi/h).

Consequences: A safety assessment (WHC 1994) analyzes the radiological and nonradiological consequences of this scenario. The analysis shows the radiological dose to the maximum onsite and offsite receptors to be $8.24\text{E-}02$ rem EDE and $9.47\text{E-}04$ rem EDE respectively. The radiological consequences of this event are within the risk comparison guidelines found in WHC-CM-4-46, Chapter 7.0, Figure 7-1 given a probability of one. Acute concentrations for all nonradiological constituents are also within the permissible exposure limits. Therefore, the radiological and nonradiological risks are acceptable for normal operations.

6.3.2.4 Abnormal Operation for Environmental Restoration Disposal Facility. The abnormal operation scenario which represents the greatest potential for release of hazardous and radioactive material and exposure to the maximum onsite and offsite receptors is wind dispersion of contaminated bulk soils.

6.3.2.4.1 Wind Storm Dispersion. The scenario in the safety assessment (WHC 1994) postulates a 24 hour period of high winds at the design bases wind speed of 36 m/s (80 mi/h). These winds provide a path for suspension of dust from the upper layer of contaminated soil in the disposal trench. It is assumed that the soil stabilization treatment performed as part of normal operations through the use of water spray nozzles at the trailer tipper locations has been conducted during placement of the waste bulk soil, but that no stabilizing fixant was applied at the end of the last operating shift, and that winds capable of causing soil suspension then occur for a period of 24 hours. During the 24-hour period of high winds, no operations occur in the disposal trench; normal operations will be conducted only at wind speeds of below 6.7 m/s (15 mi/h).

Consequences: A safety assessment (WHC 1994) analyzes the radiological and nonradiological consequences of this scenario. The analysis shows the radiological dose to the maximum onsite and offsite receptors to be $6.40\text{E-}02$ rem EDE and $1.71\text{E-}03$ rem EDE respectively. The radiological consequences of this event are within the risk comparison guidelines

found in WHC-CM-4-46, Chapter 7.0, Figure 7-1 given a probability of one. Acute concentrations for all nonradiological constituents are also within the permissible exposure limits. Therefore, the radiological and nonradiological risks are acceptable for abnormal operations.

6.3.2.5 Accident Analysis for Environmental Restoration Disposal Facility. Accident events involving container breach have the potential to provide a path for dispersion of relatively small amounts of bulk waste soil and fugitive dust. This type of release is actually similar in nature to normal trench disposal operations, although much smaller in magnitude than the fugitive releases resulting from a normal operational shift, as only one container is involved. The release from that one container is, however, larger than any one-container release during normal operations, as the releases during operations are reduced by use of dust-suppressants.

6.3.2.5.1 Container Spill. This acute exposure scenario postulates an incident in which a single container of waste bulk soil is spilled due to an operator error allowing unplanned dumping or a vehicle accident which breaches the container. The contents of a breached container are assumed to be ejected from the container with sufficient force to create an amount of fugitive dust comparable to the amount released in dumping the contents of a container down the trench working face. The plume will originate from the point of the release, which is presumed to occur on or adjacent to a facility road or transfer pad. Spill cleanup is assumed to be effected promptly using front end loaders and vacuum trucks. Some additional fugitive dust will be created in the process of spill cleanup: this release is assumed to be comparable in magnitude to the release resulting from spreading and compaction of one container of bulk waste soil in the disposal trench. Because waste handling will not occur at wind speeds of greater than 6.7 m/s (15 mi/h), the contribution of wind suspension to the release is considered to be negligible.

Consequences: A safety assessment (WHC 1994) analyzes the radiological and nonradiological consequences of this scenario. The analysis shows the radiological dose to the maximum onsite and offsite receptors to be $2.24\text{E-}08$ rem EDE and $4.04\text{E-}10$ rem EDE respectively. The radiological consequences of this event are within the risk comparison guidelines found in WHC-CM-4-46, Chapter 7.0, Figure 7-1 given a probability of one. Acute concentrations for all nonradiological constituents are also within the permissible exposure limits. Therefore, the radiological and nonradiological risks are acceptable for accident conditions.

6.3.3 Submarine Reactor Compartment

This section presents the methodology, assumptions, and results of the systematic evaluation of the hazards associated with the disposal of the Naval submarine reactor compartments located in the 218-E-12B burial ground.

6.3.3.1 Submarine Reactor Compartment Inventory.

Radiological: The defueling of the reactor leaves residual radioactive material in the submarine reactor compartment (SRC). Table 6-7, taken from Navy (1984), provides the distribution of the radioactive materials throughout the SRC. The nominal residual radioactive inventory consists

of 62,000 Ci (2.3×10^{15} Bq) of which 99.9% is irradiated material. The remaining 0.1 percent consists of the contaminated residues and solid materials shown in Table 6-10. Table 6-11 provides detailed isotopic breakdowns of the radioactivity within the SRC. The radionuclide inventory within the SRC compares favorably with the Hanford limitations for MW disposal. Table 6-12 presents a comparison of the radionuclide concentrations within the SRC with the Hanford MW disposal limits given in WHC-EP-0063.

The radioactive material within the SRC generates a thermal output of approximately 800 watts at 6 months following final reactor operation. Most of the heat is generated by ^{60}Co and so the thermal output will decay at a rate approximately the same as the rate of decay of ^{60}Co (the half-life of ^{60}Co is about 5.3 yr). This thermal output is not sufficient to cause any significant thermally-induced effects in terms of radioactive releases.

The SRC unit meets the NRC and the U.S. Department of Transportation criteria for packaging and contains Type B highway route controlled quantities of radioactive material. The radioactive material within the SRC is in nondispersable form bound in the metal matrix. There are no fissile materials within the SRC.

Toxicological: The following hazardous materials are present in the typical SRC: chromium and nickel metal as constituents of structural alloys; cadmium as plating material on certain fasteners; lead as ballast and as radiation shielding installed on bulkheads and components; and asbestos as thermal insulation on piping and components. In addition, each SRC contains approximately 1.4 kg (3 lb) of polychlorinated biphenyls that are found in solid components such as thermal insulation, electrical cable, and rubber items (DOE-RL 1990). Some of these hazardous components are also radioactive. These materials would be hazardous or toxic if they were available in a chemical or physical form that could be ingested or inhaled. The possibility that these materials could return to the environment is minimized by enclosure within the SRC or by incorporation into the structural metal matrix of the SRC as activation products.

A maximum of approximately 870.6 L (230 gal) of liquids may remain in small pockets within the SRC. The SRC is drained and pumped to remove as much liquid as feasible and then absorbent materials (diatomaceous earth) are added. There are no materials that are considered to be ignitable, corrosive, or reactive (with exception of a very small amount of paint).

6.3.3.2 Hazards Identification for Submarine Reactor Compartments. A PHA has been conducted to identify the outstanding events that are likely to dominate the risk associated with the operation. The PHA, Appendix 6A, Table 6A-3, included qualitative estimates of the frequency and consequences of each event based on engineering judgement and using the categories defined in WHC-CM-4-46. Those events found to dominate the risk are selected for further analysis. The overall risk of the SRC disposal activity is then evaluated by comparing the identified event risks with the guidelines given in WHC-CM-4-46. All conceivable accidents, credible or incredible, are within the risk acceptance guidelines.

Hydrogen gas may be generated within the SRC from hydrolysis of the water absorbed in diatomaceous earth materials. This phenomenon has been examined by Henry (1986) who concluded that hydrogen generation will not be a problem because of the large volume of the SRC, the small quantity of water, low radiation levels, and the structural integrity of the SRC. Hydrogen-oxygen gas recombiners are installed within the SRC as an additional safety precaution.

The principal hazards of concern pertaining to the SRC disposal operation are as follows:

- Loss of waste confinement
- Natural forces impact
- Personnel exposure to radioactive or hazardous substances
- Industrial type accidents/injuries.

These topics are evaluated in the PHA for the purpose of determining the risks associated with the operations.

Each event listed in the PHA is given a qualitative estimate of occurrence likelihood (annual frequency) and consequence severity. The qualitative descriptions given are taken from WHC-CM-4-46. These categories are defined in Tables 6-1 and 6-2.

6.3.3.3 Abnormal Operation For Submarine Reactor Compartments. Events which could occur from malfunctions of systems, operating conditions, or operator error are considered in this section. In general, the magnitude of the events discussed in this section would not have a significant effect beyond the exclusion area.

The abnormal events selected from the PHA table in Appendix 6A are surface contamination or high surface dose rates on the SRC and subsidence.

6.3.3.3.1 Receipt of Submarine Reactor Compartments Having High Surface Dose Rates and/or Contamination. This postulated abnormal event involves operator and/or monitoring equipment failures at the Naval facility and at the trench. Refer to Section 6.2.2.2.2 for discussion of this scenario.

6.3.3.3.2 Backfill Subsidence. Refer to Section 6.2.2.2.1 for discussion of this scenario.

6.3.3.4 Accident Analysis For Submarine Reactor Compartments. The credible accident selected for detailed analysis from the PHA table is SRC rupture. Corrosion of the SRC is also discussed.

6.3.3.4.1 Submarine Reactor Compartment Rupture. The postulated accident involving dose release during disposal operations would be one in which both penetration of the containment provided by the reactor compartment hull and bulkheads and the fracture of the primary coolant system outside the isolated reactor vessel. An accident that would cause penetration of the isolated reactor vessel, which contains approximately 99% of the initial radioactivity, is not considered credible because of the strength of the materials which make up the reactor vessel.

An engineering study in the *Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Naval Submarine Reactor Plants*, Vol. 1, (Navy 1984) shows that if the reactor compartment is assumed to fall 30 feet onto an unyielding surface, the maximum dynamic impact force would occur on the aft bulkhead in an end drop orientation. This would do the most damage to the internal components and some of the components might break free of their foundations. These internal components would not break through the pressure hull or the bulkheads due to the bluntness of the components and the strengths of the hull and bulkhead materials. The reactor vessel would not be damaged and would remain in its normal position. As a result, the reactor compartment containment would not be ruptured.

If the reactor compartment is assumed to fall 40 inches onto a 6-inch diameter mild steel bar mounted vertically on an unyielding horizontal surface, the hull would probably be punctured. The bar would not penetrate the reactor vessel but it might puncture the shell of the steam generator and some of the heat-exchanger tubes might be ruptured, depending on the orientation of the drop (Navy 1984).

More than 99.8 % of the radioactive material in the reactor compartment is due to neutron activation of the structural materials within the reactor compartment. This radioactive material cannot become loose and be released from the reactor compartment under accident conditions. Only the surface-deposited activated corrosion products could potentially become available for release (Navy 1984).

The activated corrosion products amount to a total of approximately 62 Ci of radioactive material. This is determined by taking one-tenth percent (Table 6-10) of the total 62,000 Ci from Table 6-11. This represents the corrosion products present as a film on surfaces inside the reactor vessel and piping. The remaining 99.9% consists of activated metal in structural components that would not be released. The corrosion material has been carried by the reactor coolant and adhered to all wetted surfaces inside the reactor vessel, pipe walls, and steam generators. Most of this material is tightly adherent and only a small fraction would be released in a severe shock to the reactor compartment. In developing an estimate of the activity to be released, it has been conservatively assumed that 33% of the deposited activity is loose and would be available for potential release under accident conditions. The amount of loose activity assumed represents an upper limit based on shock tests and the actual amount of loose material present would be expected to be less than 33%.

Because of the complex geometry of the primary coolant system, only a small fraction of the loose material could be released under accident conditions. It is conservatively assumed that a total of 33% of the loose activity would be released to the reactor compartment from the steam generators, reactor vessel, purification system, and main coolant piping.

Only a small fraction of the radioactivity that could enter the reactor compartment could be released to the environment because the release paths would be blocked by closed valves, welded closures, and similar barriers. It is conservatively assumed that approximately 50% of the radioactivity loose in the reactor compartment would be released to the environment.

Source term development: The source term for this postulated event is calculated by multiplying together the quantity of material available for release and a RF for impact-type accidents taken from Appendix 6C. The source term for this postulated event is estimated as follows:

- **Radioactive material at risk** — The following amount of radioactive material at risk is calculated: 62 Ci potentially available for release x 33% available for release from reactor vessel x 33% release to reactor compartment from reactor vessel x 50% release from reactor compartment to the environment. The quantity of material potentially available for release, i.e., 62 Ci, is the quantity of corrosion material that is present in the SRC (0.1% of 62,000 Ci) (see Tables 6-5 and 6-6).

Total material at risk = 3.38 Ci

- **Release fraction** — The kinetic energy derived from the impacted or falling SRC constitutes the driving force for the release. A large fraction of the energy will be dissipated in the rupture of the SRC. The remaining energy will be applied to the contents ejected from the SRC upon rupture. The mechanical release in Appendix 6C applied to this scenario is:

Release fraction = 1.0 E-05

- **Source term** — The source term for this postulated event can be estimated as follows:

3.38 Ci material at risk x 1.0 E-05 RF

Source term = .00003 Ci

The quantities of each radionuclide estimated to be released are calculated using the fractional inventories of each radionuclide. Fractional inventories are calculated by dividing the inventory of each radionuclide in Table 6-11 by the total inventory (i.e., 62,000 Ci). These fractions are then multiplied by 0.00003 Ci to calculate the total quantities of radionuclide released.

Consequences: Using the same methodology applied in Section 6.2.2.3.1, the maximum onsite and offsite receptor dose for a mechanical release is calculated. Table 3 in Appendix 6D, shows the maximum onsite receptor to be 100 m ESE. The maximum offsite receptor is the site boundary located

11.1 km W of the MW landfill. Using Table 4 baseline unit release in Appendix 6D, the dose consequence of a single drum rupture is calculated as follows:

$$\text{maximum onsite dose} = \left(3.44\text{E-}02 \frac{\text{s}}{\text{m}^3} \right) * \left(8.0\text{E+}02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}} \right) * (3.00\text{E-}05 \text{ Ci})$$

$$= 8.26 \text{ E-}04 \text{ rem BS}$$

$$\text{maximum offsite dose} = \left(1.51\text{E-}05 \frac{\text{s}}{\text{m}^3} \right) * \left(8.0\text{E+}02 \frac{\frac{\text{rem}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}} \right) * (3.00\text{E-}05 \text{ Ci})$$

$$= 3.62 \text{ E-}07 \text{ rem BS}$$

Conclusions: The maximum onsite and offsite dose consequences of 8.26 E-04 rem BS and 4.51 E-07 rem BS respectively, falls below the radiological risk comparison guidelines found in WHC-CM-4-46, Chapter 7.0, Figure 7-1, at an annual frequency of 1.00 E+00; therefore, the risk is acceptable.

6.3.3.4.2 Corrosion of Submarine Reactor Compartments. A postulated release of radioactive nuclides from the corrosion of an SRC is analyzed in the following scenario.

Scenario description: Although the number of curies of radioactive nuclides in the SRC is approximately 62,000 Ci at the time of disposal, the actual release into the burial grounds would be small because of the multiple containment of the radioactive material and the short radioactive decay half-lives of the nuclides making up the majority of the material. The thickness and durability of the containment barriers, combined with the fact that the radioactive material is almost entirely an integral part of the metal matrix lead to the conclusion that all but the longest lived radionuclides (principally ⁵⁹Ni with a half-life of 75,000 years) will have decayed to a stable form before any release can occur.

Based on the conservative assumptions that the ground area in the vicinity of the buried SRC would be continuously wet and that sufficient water flow would be available to carry any corrosion products away from the burial site to the ground water or a river. The exterior containment would remain intact for at least 200 years, an estimate based on the minimum bulkhead thickness (one-half inch walls) and an average annual corrosion rate of 0.0025 in. for low alloy steel. Following an eventual penetration of the exterior containment, which would thereafter allow water into the reactor compartment, the reactor vessel would remain intact for an additional period of several thousand years. The

structures within the reactor vessel would then be subject to corrosion release, with ^{59}Ni being the only radioactive nuclide remaining in significant quantity.

The subsequent annual release rate of the ^{59}Ni is estimated to be no greater than 0.057 Ci for each reactor compartment, based on an average annual corrosion rate of 0.0003 in. per exposed surface for corrosion-resistant alloy (both surfaces of components within the reactor vessel are assumed to be exposed). Total ^{59}Ni release to the burial site over time would eventually be about 120 Ci per reactor compartment. This approach is conservative for the estimate of radioactivity release at the Hanford burial site where it is likely that the SRC would remain dry for an indefinitely long period of time because of the low annual precipitation (15.9 cm/yr [6.25 in./yr]) and the fact that the groundwater table is ~45.7 m (~150 ft) below the SRC disposal site. The effects would be further mitigated by the absorptive property of the soil which slows down the migration of the released radioactive material.

Consequences: The release of radioactive nuclides into the burial ground that could eventually occur compares favorably with what is expected using current burial practices. The principal difference with the buried reactor compartments would be the considerable longer-lasting containment relative to most low-level burial packages.

6.4 RISK ASSESSMENT FOR RETRIEVABLE STORAGE OF TRANSURANIC WASTE

TRU waste is waste contaminated with alpha-emitting TRU radionuclides with half-lives greater than 20 years and in concentrations greater than 100 nCi/g of the waste matrix at the time it is declared waste. The TRU radionuclides are radionuclides having an atomic number greater than 92. In addition to TRU radionuclides, radium sources and ^{235}U in concentrations greater than 100 nCi/g of the waste matrix are managed as TRU waste because of hazards similar to TRU waste per the requirements of the DOE Order 5820.2A. Additional treatment of TRU waste (i.e., grouting) cannot be used to reduce the concentration (dilution) of the fissile material in the waste package. The only acceptable method to be used in reducing the concentration of fissile material in a waste package is an approved decontamination process.

Packaged TRU waste with a surface dose rate that does not exceed 200 mrem/h is designated as contact-handled (CH)-TRU. Packaged TRU waste with an external dose rate in excess of 200 mrem/h is designated as remote-handled (RH)-TRU.

The risk assessment for retrievable storage of TRU waste considers:

- CH-TRU drums and boxes, covered and uncovered
- EBR-II, casks covered and uncovered
- Miscellaneous TRU waste packages
- RH-TRU caissons.

6.4.1 Contact-Handled Transuranic Waste Inventory

The SWBG TRU waste inventory for covered and uncovered waste packages is found in the Solid Waste Information Tracking System (SWITS) database. All uncovered TRU is CH-TRU and is summarized in Table 6-13. The uncovered TRU is located in 218-W-04C: Trench 01 Modules 13 and 14, Trench 20 Module 05, Trench 29 Modules 6, 7, and 8. Each module is analyzed to determine the drum with the largest amount of TRU, the bin-weighted average, and the 95% value for that module. The bin-weighted average is calculated by assigning all drums in each range (or bin) the upper weight assigned to that bin. The bin weighted average of all drums are derived by assuming all drums in a particular bin have the upper gram value shown. This results in an average drum weight more conservative than the actual arithmetic average. The 95% value indicates that only 5% of the drums exceed the values shown.

6.4.1.1 Contact-Handled Transuranic Waste Form. Waste form and waste package criteria are considered in the following subsections.

6.4.1.1.1 Waste Form Criteria. CH-TRU waste retrievably stored at the Hanford Site will meet the waste form criteria described in WHC-EP-0063.

6.4.1.1.2 Waste Package Criteria. The waste package includes the waste, internal packaging, waste container, and any disposable overpack. All waste packages accepted at the Hanford Site will meet the criteria listed in WHC-EP-0063 as applicable for waste container, containment, surface dose rate, surface contamination, thermal power, gas generation, interior void space, and nuclear criticality.

6.4.2 Hazards Identification for Contact-Handled Transuranic Waste Drums and Boxes

Hazards associated with CH-TRU waste operation are identified by an OHA process. The outcome of the OHA is reported in the PHA tables found in Appendix 6A, Table 6A-4. Those potential events that are determined to adequately represent the complete range of credible events are listed as follows:

- Abnormal operations for uncovered TRU containers
 - Receipt and handling of TRU container(s) having high surface dose rates
 - Receipt and handling of TRU container(s) having surface contamination

- Abnormal operations for covered TRU containers
 - Backfill subsidence
- Accidents for uncovered TRU containers
 - Mechanical release from impacted container(s)
 - Container(s) fire
- Accidents for covered TRU containers
 - Burial ground collapse
 - Criticality.

6.4.2.1 Abnormal Operations Analysis for Uncovered Contact-Handled Transuranic Containers. Two abnormal events are analyzed in this analysis; receipt of TRU container(s) having high surface dose rates and receipt of TRU container(s) having surface contamination. Either event could potentially increase the radiation exposure to the SWBG operator but would have no affect on the maximum onsite or maximum offsite receptor.

6.4.2.1.1 Receipt of Contact-Handled Transuranic Container(s) Having High Surface Dose Rates and/or Surface Contamination. Refer to Section 6.2.2.2.2 for discussion of this scenario.

6.4.2.2 Abnormal Operations and Accident Analysis for Covered Contact-Handled Transuranic Containers. The abnormal event analyzed for covered TRU containers is backfill subsidence.

6.4.2.2.1 Backfill Subsidence. Refer to Section 6.2.2.2.1 for discussion of this scenario.

6.4.2.2.2 Criticality. The inventory of TRU waste containers placed in the 200 Area burial grounds from 1978 through 1990 is analyzed to assure criticality safety of the fissile material distribution. The results of the analysis are found in WHC-SD-SQA-CSA-20346 (1994), CSER 91-003, Criticality Safety Review for 1978-1990 Burial Grounds Placement. This compliments a review of pre-1978 placements reported in CSAR 90-007.

The Criticality Prevention Specification restricts container burial duration to 90% of the time that the container remains intact (assumed to be 20 years). Most containers may be excused from this time limit because of their low fissile contents. However, for 40 sequences of high fissile-content drums criticality safety cannot be assured if drum deterioration is extensive and for these drums the lifetime limit is applicable. The pilot TRU drum retrieval activity will exhumate a limited number of drums to provide data for drum deterioration and drum lifetime.

6.4.2.3 Accident Analysis For Uncovered CH-TRU Containers. The DOE has restricted the practice of covering retrievably stored TRU in the burial grounds. The Westinghouse Hanford Company (WHC) has restricted the continued storage of retrievable TRU in the burial ground trenches. These restrictions

have left retrievable TRU containers uncovered in Trench 01, 20, and 29 in burial ground 210-W-04C. Activity in the immediate area of the exposed containers is limited to routine surveillance and necessary maintenance.

Potential accidents are analyzed using a fault tree analysis. The preliminary hazards analysis in Appendix 6A, Table 6A-4 identifies plausible accidents expected to result in radiological releases and are incorporated into the fault tree. The fault tree analysis in Appendix 6B shows the minimal accident event sequence (cutsets) that could potentially result in a radiological release from uncovered TRU containers. The fault tree analysis is plotted using CAFTA (WHC 1990a). The accident events shown to be credible are summarized as follows:

- Events in which one or more containers are breached without an ensuing fire or explosion
 - Corrosion
 - Over pressurization
 - An ignited vehicle crash
 - Earthquake
 - High wind projectile
- Events in which the contents of one or more containers burn in an ensuing fire
 - Lightning
 - Ignited vehicle crash
 - Spontaneous combustion
- Events in which one or more drums explode
 - No credible events identified.

The accident scenarios range from accidents with smaller consequences (one or two drums) and higher frequencies, to accidents with larger consequences and lower frequencies. Accidents involving one or two drums include container fork lift impact, corrosion, or natural events such as wind driven missiles. Accidents involving a large number of drums would involve a natural event such as seismic activity that topples the drum stack or a vehicle crashing into the drum stack.

Those potential accidents determined to adequately represent the complete range of credible accidents are examined in greater detail in the following subsections.

6.4.2.3.1 Vehicle Accident Without Ensuing Fire. Among those credible accidents identified in the PHA table and quantified in the fault tree analyses resulting in a mechanical release are container corrosion, container over pressurization, and a vehicle crash.

Corrosion could occur from corrosive chemicals in the container resulting in corrosion from the inside. Corrosion could also occur from drums setting in the open environment and corroding from the outside. Either way the corrosion could compromise the container and expose the contents to the

environment. The amount of material made airborne is expected to be small. Little of the TRU material is expected to be in the form of easily dispersed liquid or powder. The drums are inspected periodically and a corroded drum would be noticed and repackaged before total confinement is lost. The amount of material made airborne is further reduced due to the absence of an energy source other than the wind.

Over pressurization would be detected when the first drums become compromised. Corrective action would limit the number of drums to one or two.

The maximum mechanical release accident would be a vehicle that crashes into the drum stack. The number of drums impacted in the accident would depend on the cross section of the vehicle. A vehicle crash is analyzed in the following subsections.

Scenario description for vehicle crash: It is postulated that a vehicle crashes into the stack of drums during a drum handling activity.

Assumptions: The following assumptions are made:

- The vehicle that crashes into the stack of drums is a forklift.
- The number of drums potentially affected by a truck could be as many as 30 based on the velocity of the truck.
- As shown in Table 6-10, Trench 29, Module 6 contains the largest number of drums with the highest yield of TRU. The TRU inventory in the compromised drums is the actual inventory of all 24 drums in the 95% TRU range bin plus the 6 worst drums in the 90% TRU range bin. This methodology insures that only 5% of the drum population exceed the 30 drums in TRU content. The total TRU inventory from the 30 drums is 4,090 g (65 oz).
- 100% of the breached drum contents are released from the drums.
- The RF is 1.00E-05 (Appendix 6C).
- Credit is not taken for plume meander for either maximum onsite or offsite receptors.

Source term development: The source term is the product of the dispersed inventory and the RF, therefore:

$$\text{source term} = (4,090 \text{ g Pu}) * (1.0 \text{ E-05 RF}) = 4.09 \text{ E-02 g.}$$

Consequences: Using the same methodology applied in Section 6.2.2.3.1, the maximum onsite and offsite receptor dose for a vehicle accident are calculated. Appendix 6D shows the maximum onsite receptor to be located

at PFP, 210 m NE. The maximum offsite receptor is the site boundary located 11.1 km W. The dose consequence of a 30 drum accident without an ensuing fire is calculated as follows:

$$\text{maximum onsite dose} = \left(4.30\text{E-}03 \frac{\text{S}}{\text{m}^3} \right) * \left(2.5\text{E+}04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{S}}{\text{m}^3}} \right) * (4.1\text{E-}02\text{g})$$

$$= 4.41 \text{ rem EDE}$$

$$\text{maximum offsite dose} = \left(1.88\text{E-}05 \frac{\text{S}}{\text{m}^3} \right) * \left(2.5\text{E+}04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{S}}{\text{m}^3}} \right) * (4.1\text{E-}02\text{g})$$

$$= 1.93 \text{ E-}02 \text{ rem EDE}$$

Annual frequency: The frequency of a DOE reportable truck accident occurring on the Hanford Site of a magnitude that could breach drums is calculated to be $8.9\text{E-}07/\text{mile}$ (WHC-SD-TP-RPT-007 Rev. 0, 1993). There are 888 drums in Trench 29. If each drum is removed from the trench with a forklift, the forklift would travel a conservative estimate of 1/4 mile round trip. If all 888 drums are removed from the trench in a given year the annual mileage would be 222 mile/year. The annual frequency is therefore calculated to be $8.9\text{E-}07/\text{mile} \times 222 \text{ miles/yr} = 2.0\text{E-}04/\text{yr}$.

Conclusions: The maximum onsite and offsite dose consequences of 4.41 rem EDE and $1.93 \text{ E-}02 \text{ rem EDE}$ respectively are plotted with the annual frequency of $2.0\text{E-}4/\text{yr}$ on the radiological risk comparison guidelines found in WHC-CM-4-46, Chapter 7.0, Figure 7-1 to determine if the risk is acceptable. As illustrated in Figures 6-1 and 6-2, the risk is acceptable.

6.4.2.3.2 Vehicle Accident With Ensuing Fire. Among those credible accidents identified in the PHA table and quantified in the fault tree analysis resulting in a fire release are: lightning, spontaneous combustion, and an ignited vehicle crash. Lightning and spontaneous combustion would only involve one drum where as a vehicle crash with ensuing fire could potentially involve a multiple number of drums. An ignited vehicle crash is analyzed in the following subsections.

Scenario description: It is postulated that an ignited vehicle crashes into the stack of drums during drum handling activity and ignites the contents of the breached containers.

Assumptions: The assumptions are the same as those listed in Section 6.4.2.3.1 with the following exceptions:

- RF of $5.00\text{E-}04$ (Mishima 1993)

- Only the contents of breached drums will be consumed in the fire. Fires will not propagate among uncompromised drums (this assumption to be validated by an approved FHA).

Source term development: The source term is the product of the dispersed inventory and the RF, therefore:

$$\text{source term} = (4,090 \text{ g Pu}) * (5.00 \text{ E-04 RF}) = 2.05 \text{ g.}$$

Consequences: Using the same methodology applied in Section 6.2.2.3.1, the dose consequences are calculated for a fire release, induced by a vehicle accident, as follows:

$$\begin{aligned} \text{maximum onsite dose} &= \left(2.53\text{E-04} \frac{\text{g}}{\text{m}^3} \right) * \left(2.0\text{E+04} \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{g}}{\text{m}^3}} \right) * (2.05\text{E+00g}) \\ &= 1.04 \text{ E+01 rem EDE} \end{aligned}$$

$$\begin{aligned} \text{maximum offsite dose} &= \left(3.31\text{E-06} \frac{\text{g}}{\text{m}^3} \right) * \left(2.0\text{E+04} \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{g}}{\text{m}^3}} \right) * (2.05\text{E+00g}) \\ &= 1.36 \text{ E-01 rem EDE} \end{aligned}$$

Annual frequency: The frequency of a DOE reportable truck accident resulting from a vehicle fire during operation on the Hanford Site of a magnitude that could breach drums is calculated to be 3.6E-08/mile (WHC-SD-TP-RPT-007 Rev. 0, 1993). There are 888 drums in Trench 29. If each drums is removed from the trench with a forklift, the forklift would travel a conservative estimate of 1/4 mile round trip. If all 888 drums are removed from the trench in a given year the annual mileage would be 222 mile/year. The annual frequency is therefore calculated to be 3.6E-08/mile x 222 miles/yr = 8.0E-06/yr.

Conclusions: The maximum onsite and offsite dose consequences of 1.04 E+01 rem EDE and 1.36 E-01 rem EDE respectively are plotted with the annual frequency of 8.0E-6 on the radiological risk comparison guidelines found in WHC-CM-4-46, Chapter 7.0, Figure 7-1 to determine if the risk is acceptable. As illustrated in Figures 6-1 and 6-2, the risk is acceptable.

At an annual frequency of 8.0 E-06 the onsite risk acceptance curve is not exceeded until the dose consequences exceed 50.9 rem EDE. This equates to 27.75% of the contents of trench 1, 100% of the contents of trench 20, and 86.73% of the contents of trench 29 released in a fire.

Bounding Fire Analysis: Based on the vehicle and the storage array the above analysis examined a fire with 30 drums. However, it is not known how far a worst case fire might propagate once initiated. This propagation is the subject of a Fire Hazards Analysis currently in work. As part of the accident analysis the condition was identified where the consequences of burning the entire inventory in Trench 1 exceeds the risk acceptance criteria for a credible $1.0E-06$ event. Such an event would require 54.5% of the inventory to be involved before exceeding the onsite risk acceptance criteria. With an inventory of 1001 drums and boxes uncovered in the trench this would involve the equivalent of 545 drums, which is more than one of the two modules exposed in the trench. The FHA will more fully examine this and other initiating events.

The following analysis shows the maximum inventory of TRU that can burn in a fire without exceeding the onsite and offsite consequences of 100 rem EDE and 25 rem EDE respectively on the risk acceptance curve in WHC-CM-4-46 given a probability of $1.0E-06$. The maximum inventory derived from the analysis is referred to as the Maximum Inventory Threshold.

Since the maximum offsite receptor X/Q values for trenches 1, 20, and 29 are the same (see Appendix 6D, Attachment 1, Table 3), the maximum inventory threshold values are also the same. The maximum onsite receptor X/Q values for trenches 1, 20, and 29 are not the same and the maximum inventory threshold value for each trench is calculated using the same methodology applied in Section 6.2.2.3.1.

Trench 1 Maximum Inventory Threshold - Onsite

$$\frac{100.0 \text{ rem EDE}}{\left(4.10E-03 \frac{\text{S}}{\text{m}^3}\right) * \left(2.0E+04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{S}}{\text{m}^3}}\right) * (5.0E-04)} = 2,439 \text{ g TRU}$$

Trench 20 Maximum Inventory Threshold - Onsite

$$\frac{100.0 \text{ rem EDE}}{\left(4.37E-04 \frac{\text{S}}{\text{m}^3}\right) * \left(2.0E+04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{S}}{\text{m}^3}}\right) * (5.0E-04)} = 22,883 \text{ g TRU}$$

Trench 29 Maximum Inventory Threshold - Onsite

$$\frac{100.0 \text{ rem EDE}}{\left(2.53E-04 \frac{\text{S}}{\text{m}^3}\right) * \left(2.0E+04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{S}}{\text{m}^3}}\right) * (5.0E-04)} = 39,525 \text{ g TRU}$$

Trenches 1, 20, and 29 Maximum Inventory Threshold - Offsite

$$\frac{25 \text{ rem EDE}}{\left(3.31E-06 \frac{\text{S}}{\text{m}^3}\right) * \left(2.0E+04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{S}}{\text{m}^3}}\right) * (5.0E-04)} = 755,287 \text{ g TRU}$$

Table 6-14 shows the percent TRU inventory that can burn within each trench without exceeding the risk acceptance guidelines mentioned above.

6.4.2.3.3 Drum Explosion. Hydrogen gases are known to be generated in waste containers containing radioactive materials. Vent clips or catalyst packs are used on waste drums to mitigate the hazards of combustible gases. The fault tree in Appendix 6B evaluates the likelihood of a hazardous material release resulting from a drum explosion.

Annual frequency: The cutset report in Appendix 6B shows the basic event requirements for a drum explosion. The frequencies assigned to the basic events are also found in Appendix 6B and generalized in Section 6.2.2.3.3. In addition to Section 6.2.2.3.3, a visual inspection for vent clips/filters of no less than 10% of the uncovered TRU drums was completed at the request of the DOE, Richland Operations Office. One hundred percent of the drums inspected had vent clips. An order of magnitude of assurance is given for this inspection resulting in an annual frequency of 1.00 E-04 for the basic event "Gas is not vented from or recombined in the container."

The annual frequency per drum for this event is calculated using the most likely ignition source (over pressurization) as follows:

$$(1.00E+00) * (1.00E-04) * \left(\frac{4.60E-03}{\text{drum}}\right) * (2.5E-01) = \frac{1.15E-07}{\text{drum}}$$

There are a maximum of 640 TRU drums exposed to direct solar radiation from the sun for all 3 trenches. This number includes top drums and southern exposed drums. Therefore, the annual frequency of this event is calculated as follows:

$$\left(\frac{1.15E-07}{\text{drum}}\right) * (640 \text{ drums}) = 7.36E-05$$

However, the probability of a drum explosion involving any one of the 8 highest loaded TRU drums is incredible:

Therefore, the 9th highest loaded TRU drum with a probability of $\approx 1.0E-06$ is 180.4 g located in trench 29. Since the X/Q value for Trench 1 is 3.4 times

$$(7.36E-05) * \left(\frac{8}{640} \right) = 9.2E-07$$

greater than that of Trench 29, the dose consequences are bounded by the highest credible loaded TRU drum in Trench 1 of 171.8 g.

Source term development: The source term for a single drum explosion is calculated based on the following assumption:

- The TRU inventory of the exploding drum is considered to be the credible drum containing the most TRU. For Trench 1 it is 171.8 g; for Trench 20 it is 172 g; and for Trench 29 it is 180.4 g.
- A respirable RF of 1.5 E-03 for an explosion is estimated as follows:
 - 10% waste volume is directly released from the drum and dispersed (WHC-SD-WM-SAR-058, Section 6.4.3). Of this 10% 1.0 E-03 becomes respirable (Mishima 1993).
 - 100% of material not made airborne burns. Of the 10% released from the drum, 1.0 E-02 becomes respirable (Mishima 1993). Of the 90% remaining in the drum, 5.0 E-04 becomes respirable (Mishima 1993).

Therefore, the source term is calculated as follows:

$$(171.8 \text{ g Pu}) * (1.5 \text{ E-03}) = 2.58 \text{ E-01}$$

Consequences: The dose consequences are calculated using the same methodology applied in Section 6.2.2.3.1. Table 3 in Appendix 6D, shows the maximum onsite receptor to be located 120 m ESE. The maximum offsite receptor is the site boundary located 11.1 km W of the SWBG. Using Table 4 baseline unit release in Appendix 6D, the dose consequence of a single drum explosion with fire is calculated as follows:

$$\text{maximum onsite dose} = \left(1.25E-02 \frac{\text{S}}{\text{m}^3} \right) * \left(2.0E+04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{S}}{\text{m}^3}} \right) * (2.58E-01 \text{ g})$$

$$= 6.45 \text{ E+01 rem EDE}$$

$$\text{maximum onsite dose} = \left(1.86E-05 \frac{\text{S}}{\text{m}^3} \right) * \left(2.0E+04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{S}}{\text{m}^3}} \right) * (2.58E-01 \text{ g})$$

$$= 9.60 \text{ E-02 rem EDE}$$

Conclusions: The maximum onsite and offsite dose consequences of $6.45 \text{ E}+01 \text{ rem EDE}$ and $9.60 \text{ E}-02 \text{ rem EDE}$ respectively are plotted with the annual frequency of $1.0 \text{ E}-06$ on the radiological risk comparison guidelines found in WHC-CM-4-46, Chapter 7.0, Figure 7-1 to determine if the risk is acceptable. As illustrated in Figure 6-1 and 6-2, the risk is acceptable.

6.4.2.3.4 Natural Phenomena Events. Natural phenomena that could result in a failure of TRU containers include earthquake, wind, and flood.

6.4.2.3.4.1 Seismic Activity. The Fault Tree and the cutset report in Appendix 6B, indicate a seismic event resulting in breached drums to be credible (see Appendix 6B "TRU DRUM RUPTURE IN SWBG" fault tree and the cutset report following the fault tree) in the uncovered TRU modules. Therefore, a mechanical release is analyzed in this subsection.

Scenario description. A typical module of drums is stacked 4 drums high, 12 drums wide, and 12 drums deep as illustrated in Figure 6-3. Given the occurrence of a seismic event, as drums fall, they will begin to fill the available space next to the stack, reducing the falling distance of subsequent falling drums as illustrated in Figure 6-4. The kinetic energy derived from the falling drums constitutes the driving force for the release. A large fraction of the energy will be dissipated in the rupture of the drums; the remaining energy will be applied to the contents ejected from the drums upon rupture.

Assumptions. The following assumptions are made:

- Total contents available for release is postulated to be 100% of the contents of the breached drums.
- The amount of TRU in the ruptured drums of each module is taken to be the bin-weighted average of that module. Table 6-11 shows the TRU inventory for each module and identifies the bin-weighted average.
- The release fraction for respirable radionuclides in this scenario is a mechanical release of $1.0 \text{ E}-05$ as discussed in Appendix 6C.
- Drums falling a distance of more than 4 ft to the trench floor or landing on other drums are assumed to rupture and expose their contents.
- Drums from the outer 2 rows of the two sides and front on the levels that exceed 4 ft are breached as illustrated in Figure 6-4.

Source term development: The source term is the product of the dispersible inventory and the RF. The dispersible inventory is the inventory in the breached drums. The inventory for each breached drum is assumed to be the bin weighted average of the trench. The source term for each trench is calculated as follows:

Trench 1 - Drums are stacked 4 drums high, 12 drums wide, and 22 drums deep. One hundred seventy six drums fall and breach from the top

2 levels, outer 2 side rows (22 x 8 = 176), thirty two drums fall and breach from the top 2 levels, outer 2 front rows (8 x 4 = 32) making a total of 208 breached drums. The bin weighted average for trench 1 is 4.4 g TRU. The source term for trench 1 is therefore calculated to be:

$$(208 \text{ drums}) * \left(\frac{4.4 \text{ g TRU}}{\text{drum}} \right) * (1.0E-05 \text{ RF}) = 9.2E-03 \text{ g TRU}$$

Trench 20 - Drums are stacked 2 high; therefore, no drums breach

Trench 29 - Drums are stacked 3 drums high, 12 drums wide, and 25 drums deep. One hundred drums fall and breach from the top level, outer 2 side rows (25 x 4 = 100), sixteen drums fall and breach from the top level, outer 2 front rows (8 x 2 = 16) making a total of 116 breached drums. The bin weighted average for trench 29 is 31 g TRU. The source term for trench 29 is therefore calculated to be:

$$(116 \text{ drums}) * \left(\frac{31 \text{ g TRU}}{\text{drum}} \right) * (1.0E-05 \text{ RF}) = 3.6E-02 \text{ g TRU}$$

Consequences: Using the same methodology applied in Section 6.2.2.3.1, the dose consequences are calculated for a mechanical release, induced by an earthquake, as follows:

Trench 1

$$\begin{aligned} \text{maximum onsite dose} &= \left(2.36E-02 \frac{\text{S}}{\text{m}^3} \right) * \left(2.5E+04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{S}}{\text{m}^3}} \right) * (9.2E-03 \text{ g}) \\ &= 5.43 \text{ rem EDE} \end{aligned}$$

Trench 29

$$\begin{aligned} \text{maximum onsite dose} &= \left(4.30E-03 \frac{\text{S}}{\text{m}^3} \right) * \left(2.5E+04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{S}}{\text{m}^3}} \right) * (3.6E-02 \text{ g}) \\ &= 3.87 \text{ rem EDE} \end{aligned}$$

The dose to the maximum offsite receptor is the sum of the doses from each trench and is calculated as follows:

Trench 1

$$\text{maximum offsite dose} = \left(1.88E-05 \frac{S}{m^3}\right) * \left(2.5E+04 \frac{\frac{\text{rem EDE}}{g}}{\frac{S}{m^3}}\right) * (9.2E-03 g)$$

$$4.32 E-03 \text{ rem EDE}$$

Trench 29

$$\text{maximum offsite dose} = \left(1.88E-05 \frac{S}{m^3}\right) * \left(2.5E+04 \frac{\frac{\text{rem EDE}}{g}}{\frac{S}{m^3}}\right) * (3.6E-02 g)$$

$$= 1.69 E-02 \text{ rem EDE}$$

therefore:

$$4.32E-03 \text{ rem EDE} + 1.69 E-02 \text{ rem EDE} = \underline{2.12E-02 \text{ rem EDE}}$$

Annual frequency: The design basis earthquake (DBE) is taken to have a return period of 1,000 yr, which means the annual frequency of occurrence is 1.0 E-03.

Conclusions: The maximum onsite and offsite dose consequences from Trench 1 of 5.43 rem EDE and 2.12 E-02 rem EDE respectively are plotted with the annual frequency of 1.0 E-03 on the radiological risk comparison guidelines found in WHC-CM-4-46, Chapter 7, Figure 7-1 to determine if the risk is acceptable. As illustrated in Figures 6-1 and 6-2, the risk is within the risk comparison guidelines.

6.4.2.3.4.2 Seismic Activity With Ensuing Fire. A seismic event with ensuing fire is considered to be extremely unlikely if not incredible. The consequences for this event are calculated as follows:

Source term development: The source term is developed the same as shown in Section 6.4.2.3.4.1 with the exception of the RF. Since this event involves a fire an RF of 5.00 E-04 (Mishima 1993) is used.

Trench 1 Source Term

$$(208 \text{ drums}) * \left(\frac{4.4 \text{ g TRU}}{\text{drum}}\right) * (5.0E-04 \text{ RF}) = 4.6E-01 \text{ g TRU}$$

Trench 29 Source Term

$$(116 \text{ drums}) * \left(\frac{31 \text{ g TRU}}{\text{drum}} \right) * (5.0E-04 \text{ RF}) = 1.8E+00 \text{ g TRU}$$

Consequences: Using the same methodology applied in Section 6.2.2.3.1, the dose consequences are calculated for a fire release, induced by an earthquake, as follows:

Trench 1

$$\text{maximum onsite dose} = \left(4.10E-03 \frac{\text{s}}{\text{m}^3} \right) * \left(2.0E+04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{s}}{\text{m}^3}} \right) * (4.6E-01 \text{ g})$$

$$= 37.72 \text{ rem EDE}$$

Trench 29

$$\text{maximum onsite dose} = \left(2.53E-04 \frac{\text{s}}{\text{m}^3} \right) * \left(2.0E+04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{s}}{\text{m}^3}} \right) * (1.8E+00 \text{ g})$$

$$= 9.11 \text{ rem EDE}$$

The dose to the maximum offsite receptor is the sum of the doses from each trench and is calculated as follows:

Trench 1

$$\text{maximum offsite dose} = \left(3.31E-06 \frac{\text{s}}{\text{m}^3} \right) * \left(2.0E+04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{s}}{\text{m}^3}} \right) * (4.6E-01 \text{ g})$$

$$3.05 \text{ E-02 rem EDE}$$

Trench 29

$$\text{maximum offsite dose} = \left(3.31E-06 \frac{\text{s}}{\text{m}^3} \right) * \left(2.0E+04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{s}}{\text{m}^3}} \right) * (1.8E+00 \text{ g})$$

$$= 1.19 \text{ E-01 rem EDE}$$

therefore:

$$3.05 \text{ E-02 rem EDE} + 1.19 \text{ E-01 rem EDE} = \underline{1.50\text{E-01 rem EDE}}$$

Conclusions: The maximum onsite and offsite dose consequences from trench 1 of 37.72 rem EDE and 1.50 E-01 rem EDE respectively are within the risk comparison guidelines given an annual frequency of 2.00 E-05/yr.

6.4.2.3.4.3 High Wind Missile. Refer to Section 6.2.2.3.5.2 for discussion of this scenario.

The consequences are well below those for a seismic event discussed in Section 6.2.2.3.5.1 shown to be acceptable. Therefore, further analysis of impacts from a highwind missile is bounded by a seismic event.

6.4.2.3.4.4 Flood. Refer to Section 6.2.2.3.5.3 for discussion of this scenario.

6.4.2.4 Accident Analysis for Covered Transuranic and Irradiated Fuel Waste Containers.

6.4.2.4.1 Backfill Subsidence. Covered TRU containers are covered by at least 4 ft of overburden. The containers are also restricted to a 10% void space limitation. Refer to Section 6.2.2.2.1 for discussion of this scenario.

The maximum onsite and offsite exposure is bounded by the uncovered accident releases.

6.4.3 Hazards Identification For Uncovered EBR-II Casks

The abnormal events and accidents that are analyzed in this section are identified using a detailed hazard analysis in Appendix 6A, Table 6A-5 and also WHC 1992b. This PHA table leads to the identification of the abnormal operations and accidents that are analyzed in this section.

6.4.3.1 Abnormal Operations for Uncovered Casks. In this section, events that could occur from malfunctions of systems, operating conditions, or operator error are considered. For each potential abnormal occurrence, a description of the event, a means of detection of the event, the consequences of the event, and the corrective actions necessary to return to a normal condition are presented.

The abnormal events selected for analysis in this section include (1) receipt of a contaminated cask and (2) cask upset. These events are selected for analysis in lieu of others designated unlikely because the potential radiological consequences are higher. No Unusual Occurrence Reports or Event Fact Sheets applicable to abnormal operations with EBR-II casks have been generated in the past, other than for improper or inadequate records.

6.4.3.1.1 Cask Having High Surface Dose Rates and/or Surface Contamination. Refer to Section 6.2.2.2.2 for discussion of this scenario.

6.4.3.1.2 Cask Upset. This abnormal occurrence could occur as a result of rough handling, failure of handling equipment, or as a result of ground motion from a seismic event.

6.4.3.2 Accident Analysis For Uncovered Casks. The effects of a severe accident during the unloading of EBR-II casks have been investigated (see WHC 1992b, Attachment, p. 17 of 64). This may include dropping a cask onto the ground or dropping one cask on top of another. In the analysis, the cask is assumed to be dropped onto an unyielding surface. It has been determined that there is no credible accident that will breach the inner containment. Because the inner containment is not breached, there is no release of radionuclides and, therefore, no dose consequences.

A possibility of a loss of shielding resulting from a cask drop leads to the calculation of the dose rates as a function of distance. A dose rate of approximately 300 rem/h at 1 m (3.3 ft) from the cask surface is calculated to result from this accident. The analysis in WHC 1992b, Attachment, p. 22 of 64, shows that the workers should evacuate the trench immediately. Assuming that the workers evacuate the trench within 3 min, the estimated dose to the worker is 4.1 rem.

Criticality is not possible for any number of EBR-II casks stored in the SWBG trench in the required fuel loading and cask configuration required for this activity, refer to WHC 1992b.

6.4.3.2.1 Natural Phenomena Events. Natural phenomena that could result in failure of the EBR-II cask include earthquake, wind, and flood.

6.4.3.2.1.1 Seismic Activity. The DBE could potentially result in mechanical rearrangement of EBR-II casks in a close-packed (spacer rings are ignored), triangular-pitch, hexagonal array. This condition has been analyzed to show that the arrangement is subcritical (see WHC 1992b, Attachment, p. 20 of 64).

6.4.3.2.1.2 Flood. This event is shown to be immune from the probable maximum flood and have an insignificant risk due to local flooding as discussed in Section 6.2.2.3.5.3.

6.4.3.2.1.3 High Wind Missile. The EBR-II cask is cylindrical and the exterior structure is constructed of carbon steel (0.4 in. thick) with 5 in. of lead for shielding. Based on the discussion in Section 6.2.2.3.5.2, this event for the EBR-II casks is incredible.

6.4.4 Analysis for Miscellaneous Transuranic Waste Packages

A list of miscellaneous TRU packages is given in Table 6-2A. Those packages that are uncovered and subject to a conceivable accident are listed in Table 6-15. Inventory, waste form, and location are identified with each waste package in the table. Each waste package is analyzed with regard to its inventory and waste form under abnormal or accident conditions.

6.4.4.1 Abnormal Operations for Miscellaneous Transuranic Waste Packages. The abnormal operations for miscellaneous TRU waste packages are similar to those already discussed in Sections 6.2.2.2 and 6.2.2.3.

6.4.4.2 Accident Analysis for Uncovered Miscellaneous Transuranic Waste Packages. Only packages that are uncovered and capable of being compromised by a credible accident are analyzed in this section. For simplicity, the waste package in Table 6-15 is analyzed under extreme conditions without consideration of scenario sequence development. One hundred percent of all the isotopic contents are released to the atmosphere by a mechanical release, a respirable RF of $1.0 \text{ E-}05$ (see Appendix 6C).

Consequences: The maximum onsite receptor is located 100 m ESE. The maximum offsite receptor, located at the site boundary, is 11.1 km W. Using the same methodology applied in Section 6.2.2.3.1, the dose consequences are calculated for a mechanical release as follows:

$$\begin{aligned} \text{maximum onsite dose} &= \left(5.20\text{E-}03 \frac{\text{S}}{\text{m}^3} \right) * \left(2.5\text{E+}04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{S}}{\text{m}^3}} \right) * (1.26\text{E-}03\text{g}) \\ &= 1.60 \text{ E-}01 \text{ rem EDE} \end{aligned}$$

$$\begin{aligned} \text{maximum offsite dose} &= \left(1.88\text{E-}05 \frac{\text{S}}{\text{m}^3} \right) * \left(2.5\text{E+}04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{S}}{\text{m}^3}} \right) * (1.26\text{E-}03\text{g}) \\ &= 5.92 \text{ E-}04 \text{ rem EDE} \end{aligned}$$

Conclusions: The maximum onsite and offsite dose consequences of $1.6 \text{ E-}01 \text{ rem EDE}$ and $5.9 \text{ E-}04 \text{ rem EDE}$ are within the radiological risk comparison guidelines at an annual frequency of 1.0; therefore, the onsite risk is acceptable.

6.4.5 Analysis for Remote-Handled Transuranic Waste in Caissons

Dry, RH-TRU wastes are stored in reinforced-concrete cylindrical, underground caissons. RH-TRU caissons, located 14 ft below grade, are accessed by a 3-ft-diameter inlet chute and a 1-ft-diameter ventilation shaft. The 3-ft-diameter inlet chute is offset or convoluted to eliminate radiation "shine" from the radioactive contents. At the surface, the 1-ft-diameter ventilation shaft is attached to a high-efficiency particulate air filter and

an electrically driven exhaustor. Since the Alpha 5 caisson has never been used for waste storage and the beta/gamma caissons are considered LLW, they are bounded by the analysis herein.

During charging of the RH-TRU caissons, waste packages are allowed to fall freely through the inlet chute into the caisson where they could become damaged and/or ruptured. Waste packages consisted of 1-gal cans, 2-gal containers, 5-gal containers, and miscellaneous hot cell equipment. These waste packages are no longer transferred to the RH-TRU caissons.

The inventory of radioactive wastes stored in the RH-TRU caissons is found in the SWITS database. The database contains records of the shipments from 300 Area laboratories, where the wastes are generated, to the caissons (WHC 1988). The radioactive inventory is summarized in Table 6-16.

Nonradioactive materials used in the 300 Area hot cells and shipped to the RH-TRU caissons in unknown quantities consist of plastics, metals, rubber goods, metal oxides, acids, organics, miscellaneous chemicals, paper, and cloth (Lott 1985).

6.4.5.1 Accident Analysis for Remote-Handled Transuranic Waste in Caissons. Based on the PHA presented in Appendix 6A, Table 6A-6, the bounding accident selected to document the risk acceptability of the RH-TRU caissons is a large scale fire within a caisson.

6.4.5.1.1 Remote-Handled Transuranic Caisson Fire. Large scale fires in RH-TRU caisson are deemed extremely unlikely, if not incredible, because of limited ignition sources and a restricted oxygen atmosphere within the caissons. Waste packages are no longer transferred to the RH-TRU caissons due to restrictions imposed by the DOE and WHC. Activities around the caissons are currently limited to surveillance and maintenance. This limited activity reduces the hazards associated with the caissons. However, the caissons contain suspect flammable/combustible materials in unknown quantities that could potentially provide fuel for a fire. Without knowing the fire load of materials, calculating the magnitude of a postulated fire and developing a defensible accident sequence analysis becomes arduous. Therefore, a consequence analysis is performed in which the total radiological inventory of each caisson is released by a postulated fire. The following analysis shows the consequences of a bounding release are below the risk acceptance for an extremely unlikely event. This dismisses the need for an accident sequence analysis to identify and quantify a large scale fire scenario.

Source Term Development: From the radiological inventory shown in Table 6-13, a source term for each RH-TRU caisson is calculated. There are two source terms associated with each caisson: one for the MFP and one for the plutonium. The source term for MFP and plutonium is obtained by multiplying the inventory at risk by the RF (8.00 E-05 [Mishima 1993]). The source term for the plutonium is calculated by multiplying the grams of plutonium by the RF. The source terms for each caisson are shown below. Note that only plutonium and MFP are assumed to contribute to the dose consequences. The other radiological constituents have negligible dose consequences (natural uranium, depleted uranium, enriched uranium, ^{233}U , ^{232}Th , and the additional ^{60}Co in Caisson 4) or have decayed away (^{210}Po). This results in an inventory at risk of: 35,016 Ci MFP and

1,377 g Pu in Caisson 1, 19,854 Ci MFP and 1,160 g Pu in Caisson 2, 20,476 Ci MFP and 1,197 g Pu in Caisson 3, and 18,485 Ci MFP and 2,472 g Pu in Caisson 4.

RH-TRU Caisson 1

$$\begin{aligned}\text{MFP Source Term} &= (35,016 \text{ Ci}) * (8.00\text{E-}05 \text{ RF}) \\ &= 2.80\text{E+}00 \text{ Ci}\end{aligned}$$

$$\begin{aligned}\text{Pu Source Term} &= (1,377 \text{ g}) * (8.00\text{E-}05 \text{ RF}) \\ &= 1.10\text{E-}01 \text{ g}\end{aligned}$$

RH-TRU Caisson 2

$$\begin{aligned}\text{MFP Source Term} &= (19,854 \text{ Ci}) * (8.00\text{E-}05 \text{ RF}) \\ &= 1.59\text{E+}00 \text{ Ci}\end{aligned}$$

$$\begin{aligned}\text{Pu Source Term} &= (1,160 \text{ g}) * (8.00\text{E-}05 \text{ RF}) \\ &= 9.28\text{E-}02 \text{ g}\end{aligned}$$

RH-TRU Caisson 3

$$\begin{aligned}\text{MFP Source Term} &= (20,476 \text{ Ci}) * (8.00\text{E-}05 \text{ RF}) \\ &= 1.64\text{E+}00 \text{ Ci}\end{aligned}$$

$$\begin{aligned}\text{Pu Source Term} &= (1,197 \text{ g}) * (8.00\text{E-}05 \text{ RF}) \\ &= 9.58\text{E-}02 \text{ g}\end{aligned}$$

RH-TRU Caisson 4

$$\begin{aligned}\text{MFP Source Term} &= (18,485 \text{ Ci}) * (8.00\text{E-}05 \text{ RF}) \\ &= 1.48\text{E+}00 \text{ Ci}\end{aligned}$$

$$\begin{aligned}\text{Pu Source Term} &= (2,472 \text{ g}) * (8.00\text{E-}05 \text{ RF}) \\ &= 1.98\text{E-}01 \text{ g}\end{aligned}$$

Consequences: The dose consequences for each caisson is the sum of the MFP dose and the plutonium dose. Using the same methodology applied in Section 6.2.2.3.1, the plutonium dose for a fire release are calculated. The MFP dose is calculated using the Table 4 baseline unit release in Appendix 6D. The MFP is assumed to be 50-50 mixture of ⁹⁰Sr and ¹³⁷Cs. Dose consequences for each caisson are calculated in the following equations.

RH TRU Caisson 1 Maximum Onsite Receptor Dose Calculation
(Receptor Located at 234-5Z, 300 m ESE)

$$\text{Pu dose} = \left(4.91\text{E-}03 \frac{\text{S}}{\text{m}^3} \right) * \left(2.0\text{E+}04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{S}}{\text{m}^3}} \right) * (1.10\text{E-}01\text{g})$$

$$= 1.08 \text{ E+}01 \text{ rem EDE}$$

$$\text{Sr90 dose} = \left(4.91\text{E-}03 \frac{\text{S}}{\text{m}^3} \right) * \left(7.0\text{E+}01 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{S}}{\text{m}^3}} \right) * (1.40\text{E+}00 \text{ Ci})$$

$$= 4.81 \text{ E-}01 \text{ rem EDE}$$

$$\text{Cs137 dose} = \left(4.91\text{E-}03 \frac{\text{S}}{\text{m}^3} \right) * \left(1.0\text{E+}01 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{S}}{\text{m}^3}} \right) * (1.40\text{E+}00 \text{ Ci})$$

$$= 6.87 \text{ E-}02 \text{ rem EDE}$$

therefore:

Maximum onsite dose = 11.35 rem EDE

RH TRU Caisson 1 Maximum Offsite Receptor Dose Calculation
(Receptor Located at Site Boundary, 11.1 km W)

$$\text{Pu dose} = \left(1.88\text{E-}05 \frac{\text{S}}{\text{m}^3}\right) * \left(2.0\text{E+}04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{S}}{\text{m}^3}}\right) * (1.10\text{E-}01\text{g})$$

$$= 4.14 \text{ E-}02 \text{ rem EDE}$$

$$\text{Sr90 dose} = \left(1.88\text{E-}05 \frac{\text{S}}{\text{m}^3}\right) * \left(7.0\text{E+}01 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{S}}{\text{m}^3}}\right) * (1.40\text{E+}00 \text{ Ci})$$

$$= 1.84 \text{ E-}03 \text{ rem EDE}$$

$$\text{Cs137 dose} = \left(1.88\text{E-}05 \frac{\text{S}}{\text{m}^3}\right) * \left(1.0\text{E+}01 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{S}}{\text{m}^3}}\right) * (1.40\text{E+}00 \text{ Ci})$$

$$= 2.63 \text{ E-}04 \text{ rem EDE}$$

therefore:

Maximum offsite dose = 4.35E-02 rem EDE

RH TRU Caisson 2 Maximum Onsite Receptor Dose Calculation
(Receptor Located at 234-5Z, 260 m ESE)

$$\text{Pu dose} = \left(6.26\text{E-}03 \frac{\text{S}}{\text{m}^3} \right) * \left(2.0\text{E+}04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{S}}{\text{m}^3}} \right) * (9.28\text{E-}02\text{g})$$

$$= 1.16 \text{ E+}01 \text{ rem EDE}$$

$$\text{Sr90 dose} = \left(6.26\text{E-}03 \frac{\text{S}}{\text{m}^3} \right) * \left(7.0\text{E+}01 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{S}}{\text{m}^3}} \right) * (7.95\text{E-}01 \text{ Ci})$$

$$= 3.48 \text{ E-}01 \text{ rem EDE}$$

$$\text{Cs137 dose} = \left(6.26\text{E-}03 \frac{\text{S}}{\text{m}^3} \right) * \left(1.0\text{E+}01 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{S}}{\text{m}^3}} \right) * (7.95\text{E-}01 \text{ Ci})$$

$$= 4.98 \text{ E-}02 \text{ rem EDE}$$

therefore:

Maximum onsite dose = 1.20E+01 rem EDE

RH TRU Caisson 2 Maximum Offsite Receptor Dose Calculation
(Receptor Located at Site Boundary, 11.1 km)

$$\text{Pu dose} = \left(1.88\text{E-}05 \frac{\text{S}}{\text{m}^3}\right) * \left(2.0\text{E+}04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{S}}{\text{m}^3}}\right) * (9.28\text{E-}02\text{g})$$

$$= 3.49 \text{ E-}02 \text{ rem EDE}$$

$$\text{Sr90 dose} = \left(1.88\text{E-}05 \frac{\text{S}}{\text{m}^3}\right) * \left(7.0\text{E+}01 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{S}}{\text{m}^3}}\right) * (7.95\text{E-}01 \text{ Ci})$$

$$= 1.05 \text{ E-}03 \text{ rem EDE}$$

$$\text{Cs137 dose} = \left(1.88\text{E-}05 \frac{\text{S}}{\text{m}^3}\right) * \left(1.0\text{E+}01 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{S}}{\text{m}^3}}\right) * (7.95\text{E-}01 \text{ Ci})$$

$$= 1.49 \text{ E-}04 \text{ rem EDE}$$

therefore:

Maximum offsite dose = 4.35E-02 rem EDE

RH TRU Caisson 3 Maximum Onsite Receptor Dose Calculation
(Receptor Located at 234-5Z, 200 m ESE)

$$\text{Pu dose} = \left(9.78\text{E-}03 \frac{\text{s}}{\text{m}^3}\right) * \left(2.0\text{E+}04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{s}}{\text{m}^3}}\right) * (9.58\text{E-}02\text{g})$$

$$= 1.87 \text{ E+}01 \text{ rem EDE}$$

$$\text{Sr90 dose} = \left(9.78\text{E-}03 \frac{\text{s}}{\text{m}^3}\right) * \left(7.0\text{E+}01 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (8.20\text{E-}01 \text{ Ci})$$

$$= 5.61 \text{ E-}01 \text{ rem EDE}$$

$$\text{Cs137 dose} = \left(9.78\text{E-}03 \frac{\text{s}}{\text{m}^3}\right) * \left(1.0\text{E+}01 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}}\right) * (8.20\text{E-}01 \text{ Ci})$$

$$= 8.02 \text{ E-}02 \text{ rem EDE}$$

therefore:

Maximum onsite dose = 1.93E+01 rem EDE

RH TRU Caisson 3 Maximum Offsite Receptor Dose Calculation
(Receptor Located at Site Boundary, 11.1 km W)

$$\text{Pu dose} = \left(1.88\text{E-}05 \frac{\text{S}}{\text{m}^3}\right) * \left(2.0\text{E+}04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{S}}{\text{m}^3}}\right) * (9.58\text{E-}02\text{g})$$

$$= 3.60 \text{ E-}02 \text{ rem EDE}$$

$$\text{Sr90 dose} = \left(1.88\text{E-}05 \frac{\text{S}}{\text{m}^3}\right) * \left(7.0\text{E+}01 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{S}}{\text{m}^3}}\right) * (8.20\text{E-}01 \text{ Ci})$$

$$= 1.08 \text{ E-}03 \text{ rem EDE}$$

$$\text{Cs137 dose} = \left(1.88\text{E-}05 \frac{\text{S}}{\text{m}^3}\right) * \left(1.0\text{E+}01 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{S}}{\text{m}^3}}\right) * (8.20\text{E-}01 \text{ Ci})$$

$$= 1.54 \text{ E-}04 \text{ rem EDE}$$

therefore:

Maximum offsite dose = 3.72E-02 rem EDE

**RH TRU Caisson 4 Maximum Onsite Receptor Dose Calculation
(Receptor Located at 234-5Z, 270 m ESE)**

$$\text{Pu dose} = \left(5.87\text{E-}03 \frac{\text{s}}{\text{m}^3} \right) * \left(2.0\text{E+}04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{s}}{\text{m}^3}} \right) * (1.98\text{E-}01\text{g})$$

$$= 2.32 \text{ E+}01 \text{ rem EDE}$$

$$\text{Sr90 dose} = \left(5.87\text{E-}03 \frac{\text{s}}{\text{m}^3} \right) * \left(7.0\text{E+}01 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}} \right) * (7.40\text{E-}01 \text{ Ci})$$

$$= 3.04 \text{ E-}01 \text{ rem EDE}$$

$$\text{Cs137 dose} = \left(5.87\text{E-}03 \frac{\text{s}}{\text{m}^3} \right) * \left(1.0\text{E+}01 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{s}}{\text{m}^3}} \right) * (7.40\text{E-}01 \text{ Ci})$$

$$= 4.34 \text{ E-}02 \text{ rem EDE}$$

therefore:

Maximum onsite dose = 2.35E+01 rem EDE

RH TRU Caisson 4 Maximum Offsite Receptor Dose Calculation
(Receptor Located at Site Boundary, 11.1 km W)

$$\text{Pu dose} = \left(1.88\text{E-}05 \frac{\text{g}}{\text{m}^3}\right) * \left(2.0\text{E+}04 \frac{\frac{\text{rem EDE}}{\text{g}}}{\frac{\text{g}}{\text{m}^3}}\right) * (1.98\text{E-}01\text{g})$$

$$= 7.44 \text{ E-}02 \text{ rem EDE}$$

$$\text{Sr90 dose} = \left(1.88\text{E-}05 \frac{\text{g}}{\text{m}^3}\right) * \left(7.0\text{E+}01 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{g}}{\text{m}^3}}\right) * (7.40\text{E-}01 \text{ Ci})$$

$$= 9.74 \text{ E-}04 \text{ rem EDE}$$

$$\text{Cs137 dose} = \left(1.88\text{E-}05 \frac{\text{g}}{\text{m}^3}\right) * \left(1.0\text{E+}01 \frac{\frac{\text{rem EDE}}{\text{Ci}}}{\frac{\text{g}}{\text{m}^3}}\right) * (7.40\text{E-}01 \text{ Ci})$$

$$= 1.39 \text{ E-}04 \text{ rem EDE}$$

therefore:

$$\text{Maximum offsite dose} = 7.55\text{E-}02 \text{ rem EDE}$$

Conclusions: Of the four RH-TRU caissons analyzed, Caisson 4 proved to have the worst potential consequences resulting from a potential accidental fire involving its inventory (maximum onsite receptor, 23.5 rem EDE; maximum offsite receptor, 7.55 E-02 rem EDE). Because this event borders on credible and incredible as discussed in the first paragraph of this section, an annual frequency of 1.0E-06 is assumed.

The maximum onsite and offsite dose consequences of 23.5 rem EDE and 7.55E-02 rem EDE respectively are plotted with the annual frequency of 1.0E-06 on the risk comparison guidelines found in WHC-CM-4-46, Chapter 7.0, Figure 7-1 to determine if the risk is acceptable. As illustrated in Figures 6-1 and 6-2 the risk is acceptable.

At an annual frequency of 1.0 E-03 the offsite risk acceptance curve is not exceeded until the dose consequences exceed 1.33 rem EDE. Table 6-17 shows that TRU contributes to 2.18 E-02 rem EDE. This allows for 1.308 rem EDE from LLW/LLMW. This equates to the contents of 318,564 drums mechanically released due to an earthquake.

6.5 COMBINED OFFSITE CONSEQUENCES RESULTING FROM SEISMIC ACTIVITY

An analysis is performed to determine the combined dose consequences to the maximum offsite receptor as a result of a seismic activity in the SWBG. The dose consequences from the contributing waste packages are illustrated in Table 6-17.

At an annual frequency of 1.0 E-03 the offsite risk acceptance curve is not exceeded until the dose consequences exceed 1.33 rem EDE . Table 6-17 shows that TRU contributes to $2.18 \text{ E-02 rem EDE}$. This allows for 1.308 rem EDE from LLW/LLMW. This equates to the contents of 318,564 drums mechanically released due to an earthquake.

6.6 HAZARD CATEGORIZATION

The Hazard Classification determines the appropriate review and authorization level of the safety analysis and provides a basis for applying a graded approach to the level of the analysis and documentation. It is accomplished, for this document, by performing a hazard categorization as defined in DOE-STD-1027-92 (DOE 1992).

Facilities are defined as Hazard Category 1, 2, or 3 depending on the quantities of radioactive material in the facility. Attachment 1 of DOE (1992) gives the threshold quantities (Table A-1), as well as the appropriate ground rules for evaluating the facility.

Hazard Category 1 is assigned to facilities with hazards analysis showing the potential for significant offsite consequences. This would include Category A reactors and facilities designated by Program Secretarial Officer (PSO). Hazard Category 2 is assigned to facilities with hazard analysis showing the potential for significant onsite consequences. This would include facilities with the potential for nuclear criticality events or with sufficient quantities of hazardous material and energy, which would require onsite emergency planning activities. Hazard Category 3 is assigned to facilities with hazards analysis showing the potential for significant but localized consequences. This would exclude those facilities which cannot have a significant radiological impact outside the facility.

In facility categorization, flexibility is allowed in the definition of facility segments. The standard (DOE 1992), permits the concept of facility segmentation provided the hazardous material in one segment can not interact with hazardous materials in other segments. In the SWBG, the facility is segmented by burial trenches. Each trench is separated by a barrier of earth preventing interaction with hazardous materials in other trenches. Individual TRU trenches are considered as well as LLW and LLMW trenches.

6.6.1 Low-Level Waste and Low-Level Mixed Waste Hazard Categorization Analysis

It is not feasible to generate an expected radionuclide inventory that will be received in the LLW and LLMW trenches. Therefore, for worst-case conditions, it is assumed that all containers contain the radiological inventory discussed in Section 6.2.1.1.

Assumptions used to reduce the inventory at risk and the use of a smaller RF for a seismic event are supported in Section 6.2.2.3.5.1 and summarized as follows:

- Credit is taken for the 55-gal steel drums
- Only drums falling a distance of more than 4 ft to the trench floor or landing on other drums are assumed to rupture and expose their contents
- A fire or explosion was determined to be incredible; therefore, a RF of $1.0 \text{ E-}06$ for mechanical release is used
- Strontium-90 is limited to $1.5 \text{ E}+04 \text{ Ci/m}^3$ (WHC-EP-0063-4).

The Category 2 threshold value of 22,000 Ci for ^{90}Sr is increased by a factor of 1,000 as shown in the following equation.

$$\left(\frac{1.0\text{E-}06}{1.0\text{E-}03} \right) = 0.001 \text{ (reciprocal} = 1000)$$

Over 7,051 drums could rupture before the adjusted Category 2 threshold value of 22,000,000 Ci ^{90}Sr is exceeded for either LLW or LLMW.

Drums from the top two levels of the outer rows of drums are breached for a 4 high stack as illustrated in Figure 6-4. This corresponds to 22% or 32,050 drums. Therefore 6,666 m^3 of LL uncovered waste can be stacked before exceeding Hazard Category 3.

The maximum allowable number of vulnerable drums involved in an earthquake for the LLMW is limited to 34,482 drums as shown in Section 6.3.1.5.5. Therefore, the LLMW must be limited to 7,051 vulnerable drums to remain Hazard Category 3. LLMW is limited to 6,666 m^3 of uncovered, stacked waste.

6.6.2 Transuranic Hazard Categorization Analysis

Existing SWBG records do not indicate an isotopic breakdown of the TRU elements for all waste; therefore, the isotopic distribution for nominal 12% ^{240}Pu after 20 years as shown in Table 1 of Appendix 6D is used based on process knowledge and SWBG records. Most of the SWBG records that do state an isotopic breakdown show predominately less than 12% ^{240}Pu content. Table 6-18 shows the isotopic distribution with the inventory of each isotope. The isotopic inventory is calculated by multiplying the total inventory of

28,222.5 g from module 6, 7, and 8 in trench 29 by the weight fraction of the isotope. The ratio of inventory to threshold is calculated by dividing the inventory for each isotope by the Category 2 threshold value of the isotope. The sum of the ratios is 84.08 which corresponds to an initial Hazard Category 2. Since Trench 29 is bounding, Trenches 1 and 20 are not analyzed.

The threshold values provided in Table A-1 of the standard and shown in Table 6-18 are based on a conservative RF of $1.0 \text{ E-}03$. However, the standard states that if credible RFs can be shown to be significantly different than $1.0 \text{ E-}03$ based on physical and chemical form and available dispersive energy sources, the threshold inventory values for Category 2 in Table A-1 can be divided by the ratio of the maximum potential RF to $1.0 \text{ E-}03$. The assumptions used to reduce the inventory at risk are supported in the hazards analysis.

Vehicle Accident With Ensuing Fire

Assumptions used to reduce the inventory at risk and the use of a smaller RF for a vehicle accident with ensuing fire are supported in Section 6.4.2.3.2 and summarized as follows:

- Credit is taken for the 55-gal steel drums.
- Only the contents of the 30 drums impacted by vehicle, burn in the postulated fire. The inventory of drums is assumed to be the actual inventory of the 30 most heavily loaded plutonium drums up to the 95th percentile drum as explained in Section 6.4.2.3.1. The sum of the contents of these drums is 4,090 g Pu. These drums represent 14.5% of the total inventory of 28,222.5 g.
- An RF of $5.0 \text{ E-}04$ is used.

The threshold values are increased by a factor of 13.25 as shown in the following equation.

$$\left(\frac{5.0\text{E-}04}{1.0\text{E-}03} \right) * 14.5\% = 0.0725 \text{ (reciprocal} = 13.79)$$

This corresponds to a reduction in the Sum of Ratios by a factor of 0.0725. Therefore the sum of ratios equals 6.10 which corresponds to Hazard Category 2.

Seismic Event

Assumptions used to reduce the inventory at risk and the use of a smaller RF for a seismic event are supported in Section 6.4.2.3.4.1 and summarized as follows:

- Credit is taken for the 55-gal steel drums.
- Only drums falling a distance of more than 4 ft to the trench floor or landing on other drums are assumed to rupture and expose their contents (approximately 22% of the total number of drums in the trench).

- A fire or explosion was determined to be incredible; therefore, a RF of $1.0 \text{ E-}05$ for mechanical release is used.

The threshold values are increased by a factor of 454.5 as shown in the following equation.

$$\left(\frac{1.0\text{E-}05}{1.0\text{E-}03} \right) * 22\% = 0.0022 \text{ (reciprocal} = 454.5)$$

This corresponds to a reduction in the Sum of Ratios by a factor of .0022; therefore the sum of ratios = 0.18 which corresponds to Hazard Category 3

RH-TRU Caissons

The inventory of the RH-TRU Caissons are given in Table 6-16. Since RH-TRU Caisson 4 is bounding, Caissons 1, 2, and 3 are not analyzed. The same methodology used to calculate the isotopic inventory in section 6.6.1 is applied here. The isotopic inventory with Category 2 threshold values are shown in Table 6-19 with the calculated ratio of inventory to threshold values. The sum of the ratios is 97.65 which corresponds to an initial Hazard Category 2.

The Category 2 threshold values can be increased by a factor of 12.5 in the following equation by applying the smaller RF of $8.00 \text{ E-}05$ used in the analysis in Section 6.4.5.1.1.

$$\left(\frac{8.0\text{E-}05}{1.0\text{E-}03} \right) = 0.08 \text{ (reciprocal} = 12.5)$$

This corresponds to a reduction in the Sum of Ratios by a factor of 0.08. Therefore the sum of ratios = 7.81 which corresponds to Hazard Category 2.

6.6.3 Conclusions

The SWBG is declared Hazard Category 2 based on the postulated vehicle accident with ensuing fire in TRU inventory located in Trench 29 and a postulated fire in RH-TRU Caisson 4.

6.7 CHAPTER CRITERIA

A summary description of the information in the chapter is provided with acceptance criteria derived from appropriate guidance documents.

6.7.1 Summary Description

This chapter identifies and evaluates hazards, analyzes postulated accident scenarios, and determines risk acceptability. Both the frequency of events and the consequences are considered in the determination of risk.

6.7.2 Acceptance Criteria

The acceptance criteria for this chapter are based on the following:

1. DOE Order 5480.11, *Radiation Protection for Occupational Workers*, July 1989.
2. DOE Order 6430.1A, *General Design Criteria*, April 1989.

Specific acceptance criteria are as follows:

1. The safety analysis should identify all credible accident scenarios and the location within the facility where they occur.
2. The description of each accident scenario should:
 - Provide the sequence of events leading to the initiation of the accident
 - Estimate the probability of occurrence
 - Estimate the concentration of radioactive material released as a result of each postulated accident
 - Provide conditions of meteorology, topography, and of other circumstances considered in the accident analyses
 - Analyze the radiological and toxicological effects
 - Assess the consequences to persons and property onsite and offsite
 - Identify the mathematical or physical models employed in the analysis and the assumptions that were used
 - Identify the uncertainties of input parameters involved in the accident analysis.
3. The safety analysis should identify the physical and administrative controls that are in place to mitigate the risks associated with the identified accidents to below acceptable levels.

6.8 REFERENCES

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Figure 6-1. Onsite Radiological Risk Comparison Guidelines.

S9406046.1
SWBG8/94

Figure 6-2. Offsite Radiological Risk Comparison Guidelines.

S9406046.2
SWBG8/94

Figure 6-3. Drum Stack Configuration Before Seismic Event.

S9311013.1
SWEG6/94

Figure 6-4. Drum Stack Configuration After Seismic Event.

Table 6-1. Radiological Risk Comparison Guidelines.

Frequency category	Category description	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	An abnormal event that is expected to occur once or more during the lifetime of the facility (e.g., small radioactive materials spills, small fires).	$1 - 10^{-2}$	0.01 - 0.5	0.03 - 1.5	0.1 - 5
Unlikely	Individually, the condition is not expected to occur during plant lifetime, but collectively, events in this category may occur several times.	$10^{-2} - 10^{-4}$	0.5 - 4	1.5 - 12	5 - 40
Extremely unlikely	Extremely low-probability conditions that are not expected during the plant lifetime but that present extreme or limiting cases of faults identified as possible. This category includes design basis accidents.	$10^{-4} - 10^{-6}$	4 - 25	12 - 75	40 - 250
Incredible	Accidents for which no credible scenario can be identified.	$<10^{-6}$	--	--	--
Onsite guidelines					
Anticipated	An abnormal event that is expected to occur once or more during the lifetime of the facility (e.g., small radioactive materials spills, small fires).	$0.1 - 10^{-2}$	1 - 5	3 - 15	10 - 50
Unlikely	Individually, the condition is not expected to occur during plant lifetime, but collectively, events in this category may occur several times.	$10^{-2} - 10^{-4}$	5 - 25	15 - 75	50 - 250
Extremely unlikely	Extremely low-probability conditions that are not expected during the plant lifetime but that present extreme or limiting cases of faults identified as possible. This category includes design basis accidents.	$10^{-4} - 10^{-6}$	25 - 100	75 - 300	250 - 1000
Incredible	Accidents for which no credible scenario can be identified.	$<10^{-6}$	--	--	--

Table 6-2. Qualitative Accident Severity Levels.

Severity categories	Consequences to the public, workers, or environment
Category I	May cause deaths 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 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.

Table 6-3. Radionuclide Concentration Limits.

Isotope	Whole body inhalation baseline unit release dose (rem EDE/Ci) (s/m)	Maximum organ inhalation baseline unit release dose (rem/Ci) (s/m)	Category 1 Ci concentration limits Ci/m	Category 1 dose concentration limits rem/g s/m	Category 3 Ci concentration limits Ci/m	Category 3 dose concentration limits rem/g s/m
^3H	3.0 E-02	3.8 E-02	8.3 E+01	2.5 E+00	--	--
^{14}C	6.8 E-01	8.7 E-01	4.0 E-02	2.7 E-02	9.1 E+00	6.2 E+00
^{40}K	4.0 E+00	5.7 E+00	1.7 E-03	6.8 E-03	3.4 E-01	1.4 E+00
^{60}Co	6.6 E+01	4.3 E+02	7.7 E+01	5.1 E+03	--	--
^{59}Ni	4.2 E-01	4.8 E-01	4.0 E+00	1.7 E+00	8.3 E+02	3.5 E+02
^{63}Ni	1.0 E+00	1.2 E+00	4.8 E+00	4.8 E+00	1.7 E+04	1.7 E+04
^{79}Se	3.1 E+00	1.2 E+01	3.8 E+01	1.2 E+02	8.3 E+01	2.6 E+02
^{90}Sr	7.0 E+01	8.0 E+02 (BS)	4.3 E-03	3.4 E+00	1.5 E+04	1.2 E+07
^{93}Mo	9.4 E+00	7.7 E+01	3.0 E-01	2.8 E+00	7.1 E+01	6.7 E-02
^{94}Nb	1.3 E+02	9.1 E+02	2.6 E-4	3.4 E-02	5.6 E-02	7.3 E+00
^{99}Tc	3.0 E+00	2.1 E+01	5.6 E-03	1.7 E-02	1.2 E+00	3.6 E+00
^{129}I	5.0 E+01	1.7 E+03 (Thyroid)	2.9 E-03	4.9 E+00	5.9 E-01	1.0 E+03
^{137}Cs	1.0 E+01	1.1 E+01	6.3 E-03	6.3 E-02	1.3 E+04	1.3 E+05
^{151}Sm	9.9 E+00	1.7 E+02 (BS)	3.8 E+01	6.5 E+03	5.8 E+04	9.9 E+06
^{152}Eu	6.9 E+01	4.2 E+02	8.3 E-01	5.7 E+01	--	--
^{210}Pb	4.6 E+03	6.6 E+04 (BS)	1.0 E-02	6.6 E+02	1.5 E+02	9.9 E+06
^{232}Th	5.5 E+05	1.4 E+07 (BS)	1.2 E-04	1.7 E+03	2.2 E-02	3.1 E+05
^{235}U	4.1 E+04	3.4 E+05	3.2 E-03	1.3 E+02	5.9 E-01	2.4 E+04
^{238}U	3.9 E+04	3.2 E+05	6.3 E-03	2.5 E+03	1.4 E+00	5.5 E-04
^{239}Pu	1.4 E+05	2.6 E+06 (BS)	3.6 E-03	9.4 E+03	7.7 E-01	2.0 E+06
^{241}Am	1.5 E+05	2.7 E+06 (BS)	2.6 E-03	7.0 E+03	1.1 E+00	3.0 E+06
^{237}Np	2.1 E+05	4.7 E+06 (BS)	1.9 E-04	8.9 E+02	4.0 E-02	1.9 E+05

* Indicates that the limiting organ dose is more than 10 times the effective dose equivalent so the curie release limit is based on the organ dose criterion.

BS = bone surface.

EDE = effective dose equivalent.

Table 6-4. Radionuclide Inventory for Bulk Waste.

Isotope	Maximum Average Soil Concentration (pCi/kg)	Overall Average Soil Concentration (pCi/kg)	Waste Acceptance Criteria (Ci/g)	Consequence Values (Ci/g)
¹⁴ C	199000	13440	7.00E-12	7.00E-12
²² Na	5400	60	<MDA	0.00E+00
⁴⁰ K	16000	7210	2.30E-07	2.30E-07
⁵⁸ Co	3500	10	2.30E-07	2.30E-07
⁶⁰ Co	157500	10960	2.00E-06	2.00E-06
⁹⁰ Sr	267000	15810	3.00E-07	3.00E-07
⁹⁹ Tc	500	61	8.60E-12	8.60E-12
¹³⁷ Cs	448800	3230	1.00E-05	1.00E-05
¹⁵² Eu	925300	74300	3.50E-08	3.50E-08
¹⁵⁴ Eu	207500	15180	5.50E-07	5.50E-07
¹⁵⁵ Eu	18000	1090	<MDA	0.00E+00
²²⁶ Ra	9400	450	2.40E-08	2.40E-08
²²⁸ Th	1100	480	<MDA	0.00E+00
²³² Th	1740	390	8.00E-11	8.00E-11
²³³ U	359900	22930	<MDA	0.00E+00
²³⁵ U	5000	950	<MDA	0.00E+00
²³⁸ U/ ²³⁴ U	451200	20700	2.50E-13	2.50E-13
²³⁸ Pu	2900	150	5.00E-10	5.00E-10
²³⁹ Pu/ ²⁴⁰ Pu	62200	3290	3.00E-10	3.00E-10
²⁴¹ Am	15600	850	3.00E-10	3.00E-10

Note: Where the WAC states <MDA, a zero value was substituted.

Table 6-5. Organic Inventory for Bulk Waste. (2 sheets)

Chemical	Maximum Average Soil Conc. ($\mu\text{g}/\text{kg}$)	Overall Average Soil Conc. ($\mu\text{g}/\text{kg}$)	Waste Acceptance Criteria ($\mu\text{g}/\text{kg}$)	Consequence Calculation Values ($\mu\text{g}/\text{kg}$)
Acetone	2800	2.25	28000	28000
Benzene	190	0.01	0	0
2-Butanone	5	0.07	33000	33000
Carbondisulfide	36	0.02	TBD	0
1,2-Dichloroethane (Ethylene) dichloride)	0	0	10000	10000
4-Methyl-2-Pentanone	5	0.05	278000	278000
Methylene Chloride	18	0.6	20800	20800
Tetrachloroethene	29	0.91	112800	112800
Toluene	30	2.90	185600	185600
Trichloroethene	36	1.23	57800	57800
Vinyl Chloride	120	1.01	30800	30800
Acenaphthene	81	0.15	2805000	2805000
Aroclor-1248	159	23.7	1000	1000
Aroclor-1254	678	91.7	1000	1000
Aroclor-1260	600	0.54	1000	1000
Anthracene	6300	2.24	14000000	14000000
Benzo(a)anthracene	900	3	unlimited	900
Benzo(a)pyrene (Coal tar pitch)	470	1.74	TBD	0
Benzo(b)fluoranthene	1200	3.85	unlimited	1200
Benzo(ghi)perylene	230	1.26	500000000	500000000
Benzo(k)fluoranthene	190	3.61	850000000	850000000
Benzoic Acid	850	1.8	unlimited	850
Bis (2-ethylhexyl) phthalate	16780	618	15000000	15000000
Butylbenzylphthalate	1300	233	206000	206000
Carbazole	170	0.12	500	500
Carbon Tetrachloride	3	0.05	0	0
4-Chloro-3-Methylphenol	170	0.11	TBD	0
2-Chlorophenol	170	0.11	601000	601000
Chloroform	1	0.02	700	700
4-Chloroaniline	3150	69.60	unlimited	3150
Chrysene	460	3.38	380000	380000
Di-n-octyl-phthalate	170	0.09	unlimited	170
Di-n-butyl-phthalate	1472	257	TBD	0
Dibenzofuran	60	0	TBD	0

Table 6-5. Organic Inventory for Bulk Waste. (2 sheets)

Chemical	Maximum Average Soil Conc. (µg/kg)	Overall Average Soil Conc. (µg/kg)	Waste Acceptance Criteria (µg/kg)	Consequence Calculation Values (µg/kg)
1,3 Dichlorobenzene	170	0.10	400	400
1,4 Dichlorobenzene	170	0.11	101400	101400
Diethyl phthalate	170	0.66	325000	325000
Ethylbenzene	330	0.013	70000	70000
Fluoranthene	1450	5.12	16500000	16500000
Fluorene	1700	0.83	1251000	1251000
Indeno(1,2,3-cd)pyrene	240	1.20	20000000	20000000
2-Hexanone	0	0.0002	TBD	0
2-Methylnaphthalene	13000	0.49	unlimited	13000
4-Methylphenol	500	11.10	unlimited	500
Naphthalene	4100	0.16	1400000	1400000
2-Nitrophenol	170	4.08	unlimited	170
N-Nitrosodiphenylamine	37	0.68	unlimited	37
Pentachlorophenol	850	11.20	unlimited	850
Phenanthrene	2500	0.81	24000000	24000000
Phenol	170	5.93	71600	71600
1,1,1-Trichloroethane	0	0.00002	unlimited	0
Pyrene	1350	12.10	12000000	12000000
Xylenes	1300	0.05	unlimited	1300
2,4-D	0	0	unlimited	0
4,4'-DDD	6	0.002	20500000	20500000
4,4'-DDE	41	0.90	12500000	12500000
Aldrin	4	0.002	unlimited	4
Beta-BHC-Lindane	4	0.002	1500000	1500000
Dieldrin	8	0.004	0.5	0.5
Endrin	8	0.005	unlimited	8
gamma-Chlordane	9	0.0003	0	0
Heptachlor	4	0.003	unlimited	4
Methoxychlor	none listed	none listed	10000	10000
Dibenzo(a,h)anthracene	none listed	none listed	TBD	0
1,1,2,2-Tetrachloroethane	none listed	none listed	unlimited	0

TBD entries indicate that no value was provided for this constituent.

Table 6-6. Inorganic Inventory for Bulk Waste.

Chemical	Maximum Average Soil Concentration (mg/kg)	Overall Average Soil Concentration (mg/kg)	Waste Acceptance Criteria (mg/kg)	Consequence Calculation Values (mg/kg)
Aluminum	20470.5	3708	unlimited	20470.5
Antimony	18.6	0.272	0.6	0.6
Arsenic	11.8	3.155	0.005	0.005
Barium	3095	92.22	unlimited	3095
Beryllium	0.900	0.052	0.4	0.4
Cadmium	25.5	0.329	0.5	0.5
Chromium	1765	37.7	10	10
Cobalt	12.2	5.074	41	41
Copper	2853.7	521.3	100	100
Iron	98316.7	7692	unlimited	98316.7
Lead	250	50	unlimited	250
Magnesium	3630	905	unlimited	3630
Manganese	462	219	5	5
Mercury	35.55	1.2	0.2	0.2
Nickel	83.1	21.6	10	10
Potassium	2965	112	unlimited	2965
Selenium	3.9	0.281	1	1
Silver	169.2	6.39	10	10
Sodium	274	19	unlimited	274
Thallium	4.5	0.001	0.078	0.078
Vanadium	119	17.9	7.8	7.8
Zinc	5120	89.5	500	500

Table 6-7. Miscellaneous Low-Level Waste Packages. (2 sheets)

Waste package	Inventory	Waste form	Release fraction	Maximum onsite release (rem) EDE	Maximum offsite release (rem) EDE
Canoga Park glove boxes uncovered 218-W-4C, Trench 14	Waste Category 1 0.11 g Pu	28 boxes containing stainless steel glove boxes and exhaust tunnel sections; ports and windows covered with plywood; double plastic wrapped; ~97% steel, 1% wood, 2% plastic	5.0 E-04 ^a	5.72 E-03	3.64 E-06
V EPCO steam generator uncovered 218-E-4C, Trench 14	Waste Category 1 60 Ci ⁶⁰ Co	Self contained cask; 10% stainless steel, 90% steel	1.0 E-05 ^b	1.36 E-03	7.44 E-07
K-3 filters in concrete liners - grouted 218- E-010, Trench 09	800 Ci ¹³⁷ Cs and ⁹⁰ Sr	2 boxes; 5% combustible, 95% combustible	1.25 E-05 ^c	3.64 E-03	2.32 E-06
Shippingport reactor vessel uncovered 218-W-4C, Trench 14	16,467 Ci ⁶⁰ Co, ⁵⁵ Fe, ⁵⁹ Ni, ⁶³ Ni	1 cask; 49% heavy metal, 50% concrete, and 1% lead	1.0 E-05 ^b	3.74 E-01	2.04 E-04
Pm glove box hoods in steel boxes uncovered 218-W-4C, Trench 14	Primary isotope 15,000 Ci ¹⁴⁷ Pm as of 9-81	2 boxes; 90% metal, 5% plastic, and 5% glass	5.0 E-04 ^a	5.07 E-01	3.23 E-04
KAPL casks uncovered 218-E-4C, Trench 14	Primary isotope 28 Ci ⁶⁰ Co	7 casks; 80% concrete, 3% metal, and 12% resin	1.0 E-05 ^b	6.36 E-04	3.47 E-07
100N storage tank - uncovered 218-W-4C, Trench 14	0.1 Ci covered with asbestos insulation	1 tank; 98% metal and 2% cloth	1.0 E-05 ^b	2.75 E-05 BS ^d	1.50 E-08 BS ^d
REDOX tanks One tank is uncovered 218-W-4C, Trench 14	9.0 Ci thorium (19,051 g)	4 tanks; 90% metal, 8% silicon, and 2% absorbent	1.0 E-05 ^b	4.33 E+01 BS ^d	2.37 E-02 BS ^d
FFTF casks uncovered 218-W-4C, Trench 14	Primary isotope 58,095 Ci ⁶⁰ Co	3 casks; 95% concrete and 5% metal	1.0 E-05 ^b	1.32 E-01	7.21 E-04
Alaska casks uncovered 218-W-4C, Trench 14	24 Ci ⁶⁰ Co (1988)	2 casks; 100% metal	1.0 E-05 ^b	5.45 E-04	2.98 E-07
Classified waste naval pumps uncovered 218-W-4C, Trench NC	Primary isotopes 15 Ci ⁶⁰ Co and ⁵⁵ Fe	37 containers; 39% metal, 5% nonmetal, 2% lastic, 5% bsorbent, and 49% yrofoam	5.0 E-04 ^a	2.57 E-03	1.64 E-06
Classified waste core baskets uncovered 218-E-3A E, Trench 08	138,000 total Ci primary isotopes ⁶⁰ Co, ⁶³ Ni, and ⁵⁵ Fe	2 containers; 96% metal and 4% absorbent	1.0 E-05 ^b	3.13 E+00	1.71 E-03

Table 6-7. Miscellaneous Low-Level Waste Packages. (2 sheets)

Waste package	Inventory	Waste form	Release fraction	Maximum onsite release (rem) EDE	Maximum offsite release (rem) EDE
Classified waste naval closure heads uncovered 218-E-3A E, Trench 08	4 Ci ⁵⁵ Fe	2 containers; 100% metal	1.0 E-05 ^b	1.24 E-06	6.77 E-10
Category 3 waste uncovered 218-W-4C Trench 24	3.6695 g Pu 0.02289 g ²³⁸ Pu	447 55-gal drums; 50% combustible, 50% noncombustible	5.0 E-04 ^a	1.92 E-01	1.22 E-04
Boxes uncovered 218-W-5, Trench 27	0.646 Ci ¹³⁷ Cs, ⁹⁰ Co, and ⁹⁰ Sr	151 boxes; 50% combustible, 50% noncombustible	5.0 E-04 ^a	1.34 E-03 BS ^d	8.55 E-07 BS ^d
Drums uncovered 218-W-5, Trench 22	41.0285 Ci ¹³⁷ Cs and ⁹⁰ Sr	446 55-gal drums; 50% combustible, 50% noncombustible	5.0 E-04 ^a	8.53 E-02 BS ^d	5.43 E-05 BS ^d
Low-level equipment uncovered 218-W-03A, Trench 49	0.096 Ci Dep U (30 g)	9 items; 50% combustible, 50% noncombustible	5.0 E-04 ^a	9.73 E-03	6.20 E-06
Ion Exchange Modules 218-W-4C Trench 24	1,480.4 curies primarily ¹³⁷ Cs and ⁹⁰ Sr	11 modules; Ion Exchange Resins =10% Concrete =50% Metal =40%	6.1 E-04	2.30 E+00	2.5 E-03

^aFire release fraction.

^bWaste Category 1 mechanical release fraction.

^cWaste Category 3 fire release fraction.

^dIndicates that the limiting organ dose is more than 10 times the EDE so the Ci release limit is based on the organ dose criterion.

BS = bone surface.

Table 6-8. Isotopic Inventory in Leachate Collection Tank.

Isotope	Curies in 37.85 m ³ tank
⁶⁰ Co	2.1 E-04
⁹⁰ Sr	2.3 E-05
¹²⁹ I	1.6 E-03
¹³⁷ Cs	2.3 E-06
²³⁹ Pu	6.5 E-06
²⁴¹ Am	5.7 E-05

Table 6-9. Droplet Releases - 50 Micrometer.

Hole size (cm)	Total flow (cc/s)	Release fraction	Spray release (cc/s)
2.00 E-04	3.12 E+00	1.00 E+00	3.12 E+00
6.00 E-04	9.35 E+00	1.00 E+00	9.35 E+00
2.00 E-03	3.12 E+01	1.00 E+00	3.12 E+01
6.00 E-03	9.35 E+01	6.00 E-01	5.61 E+01
2.00 E-02	3.12 E+02	6.58 E-02	2.05 E+01
6.00 E-02	9.35 E+02	6.32 E-03	5.91 E+00

Table 6-10. Distribution of Radioactive Material Six Months
After Last Reactor Operations. (Navy 1984)

Description	Total radionuclides (%)
Structural components (corrosion resistant alloys) inside the reactor vessel	97.8
Crud — corrosion products from reactor operation. Present as a film on surfaces inside reactor vessel and piping of the plant	0.1
Reactor pressure vessel wall	1.8
Structural components outside the reactor vessel and inside the reactor compartment	0.3
Compartment bulkheads and hull	0.00006

Table 6-11. Radioactivity by Individual Radionuclide Present in Typical Reactor Compartment Six Months After Final Reactor Shutdown and 100 Years Later (Navy 1984). (2 sheets)

Radioactivity level	^{60}Co	^{63}Ni	^{55}Fe	^{58}Co	^{51}Cr	^{54}Mn	^{59}Ni	^{59}Fe
Half-life (yr)	5.27	100	2.69	0.19	0.076	0.85	75,000	0.12
Radiation emitted	Gamma and beta	Beta ⁻ only	X-rays	X-rays, beta ⁺ and gamma	X-rays, beta ⁻ and gamma	X-rays and gamma	X-rays	Gamma and beta
Maximum energy per disintegration (MeV)	2.82	0.067	0.232	2.31	0.75	1.38	1.07	1.57
Prominent gamma energies (MeV)	1.17 1.33	None	Continuous 1.8. ^a to 0.22	0.58 0.81	0.32	0.84	Continuous 1.8. ^a to 1.06	1.10 1.29
Resulting stable nuclide	^{60}Ni	^{63}Cu	^{55}Mn	^{58}Fe	^{51}V	^{54}Cr	^{59}Co	^{59}Co
External exposure hazard/Ci, relative to ^{60}Co	1.00	0	<0.01	0.39	0.02	0.33	<0.01	0.48
Internal exposure hazard/Ci, relative to ^{60}Co	1.00	0.92	0.09	0.35	<0.01	0.18	0.35	0.83
Initial radioactivity (Ci) after 6 mo	2.2×10^4	1.8×10^4	1.7×10^4	3.2×10^3	1.0×10^3	6.5×10^2	1.2×10^2	5.1×10^1
Radioactivity after (Ci) 100 yr	4.0×10^{-2}	9.0×10^3	--	--	--	--	1.2×10^2	--

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Table 6-11. Radioactivity by Individual Radionuclide Present in Typical Reactor Compartment
Six Months After Final Reactor Shutdown and 100 Years Later (Navy 1984). (2 sheets)

Radioactivity level	$^{95}\text{Zr}/^{95}\text{Nb}$	^{14}C	^{35}S	^{46}Sc	^{181}Hf	^{94}Nb	^{93}Mo	^{99}Tc
Half-life (yr)	0.18	5,730	0.24	0.23	0.12	20,300	3,500	214,000
Radiation emitted	Gamma and beta	Beta ⁻ only	Beta ⁻ only	Beta ⁻ and gamma	Beta ⁻ and gamma	Beta ⁻ and gamma	X-rays	Beta ⁻ only
Maximum energy per disintegration (MeV)	2.04	0.156	0.167	2.37	1.023	2.06	0.42	0.29
Prominent gamma energies (MeV)	0.72 0.76 0.77	None	None	0.89 1.12	0.13 0.35 0.48	0.70 0.87	Continuous I.B. ^a to 0.37	None
Resulting stable nuclide	^{95}Mo	^{14}N	^{35}Cl	^{46}Ti	^{181}Ta	^{94}Mo	^{93}Nb	^{99}Ru
External exposure hazard/Ci, relative to $^{60}\text{Co}^b$	0.30	0	0	0.76	<0.01	0.67	0.03	^{60}Co
Internal exposure hazard/Ci, relative to $^{60}\text{Co}^b$	<0.01	0.12	0.55	<0.01	<0.01	0.03	0.04	0.01
Initial radioactivity (Ci) after 6 mo ^b	1.04	1.0	4.5×10^{-1}	3.9×10^{-1}	1.2×10^{-1}	8.2×10^{-2}	1.3×10^{-2}	3.6×10^{-3}
Radioactivity after (Ci) 100 yr	--	1.0	--	--	--	8.2×10^{-2}	1.3×10^{-2}	3.6×10^{-3}

NOTE: Total initial Ci: 6.2×10^4 (2.3×10^{15} Bq) all nuclides.
^aI.B. - Inner Bremsstrahlung.
^bCi = 3.7×10^{10} Bq.

Table 6-12. Concentration Limits for Burial of Certain Low-Level Nuclides.

Nuclide (or isotope)	Concentration in reactor compartment (Ci/m ³ of waste matrix) ^a (Navy 1984)	Concentration limits (Ci/m ³ of waste matrix) ^a (Rockwell 1985)
⁶⁰ Co	55	None ^b
⁶³ Ni in activated metal	45	None ^b
¹⁴ C in activated metal	2.5×10^{-3}	80 Ci of waste matrix ^a
⁵⁹ Ni in activated metal	0.3	None ^b
⁹⁴ Nb in activated metal	2.1×10^{-4}	None ^b
⁹⁹ Tc	9.0×10^{-6}	3 Ci of waste matrix ^a
Any with half-life <5 yr	<55	None ^b

^a1 Ci = 3.7×10^{10} Bq.^bNo limit provided in RHO-MA-222.

Table 6-13. 218-W-04C Inventory: Trench 01, Module 13. (6 sheets)

Transuranic range (g)	Number of containers	Containers (%)	Containers (cumulative %)
$\leq .0001$	0	0	0
$>.0001$ to $\leq .001$	0	0	0
$>.001$ to $\leq .01$	0	0	0
$>.01$ to $\leq .1$	0	0	0
$>.1$ to ≤ 1.0	455	94.99	94.99
>1.0 to ≤ 10.0	3	0.63	95.62
>10.0 to ≤ 25	3	0.63	96.25
>25 to ≤ 50	7	1.46	97.71
>50 to ≤ 75	2	0.42	98.13
>75 to ≤ 100	4	0.84	98.97
>100 to ≤ 125	1	0.21	99.18
>125 to ≤ 150	3	0.63	99.81
>150 to ≤ 175	0	0	99.81
>175 to ≤ 200	1	0.21	100.00
>200 to ≤ 225	0	0	--
Totals	479		100.00

NOTES:

472 drums and 7 boxes.

Maximum container = 190 g.

Bin-weighted average = 4.7 g.

95% (i.e., only 5% of containers exceed this value) = 10.0 g.

Table 6-13. 218-W-04C Inventory: Trench 01, Module 14. (6 sheets)

Transuranic range (g)	Number of containers	Containers (%)	Containers (cumulative %)
$\leq .0001$	0	0	0
$>.0001$ to $\leq .001$	0	0	0
$>.001$ to $\leq .01$	0	0	0
$>.01$ to $\leq .1$	1	0.19	0.19
$>.1$ to ≤ 1.0	501	95.98	96.17
>1.0 to ≤ 10.0	2	0.38	96.55
>10.0 to ≤ 25	1	0.19	96.74
>25 to ≤ 50	6	1.15	97.89
>50 to ≤ 75	7	1.34	99.23
>75 to ≤ 100	1	0.19	99.42
>100 to ≤ 125	0	0	99.42
>125 to ≤ 150	2	0.38	99.80
>150 to ≤ 175	1	0.19	100.00
>175 to ≤ 200	0	0	--
>200 to ≤ 225	0	0	--
Totals	522		100.00

NOTES:

522 Drums.

Maximum container = 171.8 g.

Bin-weighted average = 3.7 g.

95% (i.e., only 5% of containers exceed this value) = 1.0 g.

Table 6-13. 218-W-04C Inventory: Trench 20, Module 5. (6 sheets)

Transuranic range (g)	Number of containers	Containers (%)	Containers (cumulative %)
$\leq .0001$	4	4.88	4.88
$> .0001$ to $\leq .001$	39	47.56	52.44
$> .001$ to $\leq .01$	0	0	52.44
$> .01$ to $\leq .1$	0	0	52.44
$> .1$ to ≤ 1.0	14	17.07	69.51
> 1.0 to ≤ 10.0	8	9.76	79.27
> 10.0 to ≤ 25	7	8.54	87.81
> 25 to ≤ 50	6	7.32	95.13
> 50 to ≤ 75	1	1.23	96.36
> 75 to ≤ 100	0	0	96.36
> 100 to ≤ 125	1	1.23	97.59
> 125 to ≤ 150	1	1.23	98.82
> 150 to ≤ 175	1	1.23	100.00
> 175 to ≤ 200	0	0	--
> 200 to ≤ 225	0	0	--
Totals	82		100.00

NOTES:

79 drums, 3 boxes.

Maximum container = 172.0 g.

Bin-weighted average = 13.3 g.

95% (i.e., only 5% of containers exceed this value) = 50.0 g.

Table 6-13. 218-W-04C Inventory: Trench-29, Module 6. (6 sheets)

Transuranic range (g)	Number of containers	Containers (%)	Containers (cumulative %)
$\leq .0001$	0	0	0
$>.0001$ to $\leq .001$	0	0	0
$>.001$ to $\leq .01$	0	0	0
$>.01$ to $\leq .1$	1	0.23	0.23
$>.1$ to ≤ 1.0	16	3.72	3.95
>1.0 to ≤ 10.0	246	57.21	61.16
>10.0 to ≤ 25	59	13.72	74.88
>25 to ≤ 50	25	5.81	80.69
>50 to ≤ 75	12	2.79	83.48
>75 to ≤ 100	16	3.72	87.20
>100 to ≤ 125	13	3.02	90.22
>125 to ≤ 150	24	5.58	95.80
>150 to ≤ 175	12	2.79	98.59
>175 to ≤ 200	6	1.40	100.00
>200 to ≤ 225	0	0	--
Totals	430		100.00

NOTES:

430 drums.

Maximum container = 200.0 g.

Bin-weighted average = 37.7 g.

95% (i.e., only 5% of containers exceed this value) = 146.0 g.

Table 6-13. 218-W-04C Inventory: Trench 29, Module 7. (6 sheets)

Transuranic range (g)	Number of containers	Containers (%)	Containers (cumulative %)
$\leq .0001$	0	0	--
$>.0001$ to $\leq .001$	0	0	--
$>.001$ to $\leq .01$	0	0	--
$>.01$ to $\leq .1$	12	2.73	2.73
$>.1$ to ≤ 1.0	88	20.00	22.73
>1.0 to ≤ 10.0	166	37.73	60.46
>10.0 to ≤ 25	94	21.36	81.82
>25 to ≤ 50	33	7.50	89.32
>50 to ≤ 75	16	3.64	92.96
>75 to ≤ 100	9	2.04	95.00
>100 to ≤ 125	12	2.73	97.73
>125 to ≤ 150	3	0.68	98.41
>150 to ≤ 175	6	1.36	99.77
>175 to ≤ 200	1	0.23	100.00
>200 to ≤ 225	0	0	--
Totals	440		100.00

NOTES:

440 drums.

Maximum container = 197.3 g.

Bin-weighted average = 25.1 g.

95% (i.e., only 5% of containers exceed this value) = 100.0 g.

Table 6-13. 218-W-04C Inventory: Trench 29, Module 8. (6 sheets)

Transuranic range (g)	Number of containers	Containers (%)	Containers (cumulative %)
$\leq .0001$	0	0	0
$>.0001$ to $\leq .001$	0	0	0
$>.001$ to $\leq .01$	0	0	0
$>.01$ to $\leq .1$	4	22.22	22.22
$>.1$ to ≤ 1.0	5	27.78	50.00
>1.0 to ≤ 10.0	4	22.22	72.22
>10.0 to ≤ 25	4	22.22	94.44
>25 to ≤ 50	0	0	--
>50 to ≤ 75	0	0	--
>75 to ≤ 100	0	0	--
>100 to ≤ 125	0	0	--
>125 to ≤ 150	0	0	--
>150 to ≤ 175	0	0	--
>175 to ≤ 200	1	5.56	100.00
>200 to ≤ 225	0	0	--
Totals	18		100.00

NOTES:

18 drums.

Maximum container = 178.3 g.

Bin-weighted average = 19.2 g.

95% (i.e., only 5% of containers exceed this value) = 25.0 g.

Table 6-14. Percent of TRU in Trenches That Can Burn Without Exceeding Limits.

Effective Dose Equivalent	Trench 1 Inventory 4,474g TRU	Trench 20 Inventory 552g TRU	Trench 29 Inventory 23,196.5g TRU
100 rem Onsite	54.5% (2,439g TRU)	100% (22,883g TRU)	100% (39,525g TRU)
25 rem Offsite	100% (755,287g TRU)	100% (755,287g TRU)	100% (755,287g TRU)

Table 6-15. Miscellaneous Transuranic Waste Packages.

Waste package	Inventory	Waste form	Release fraction
EBR II casks of irradiated fuel waste from INEL, FFTF, and GETR, retrievable uncovered, 218-W-4C, Trench 01	32,641 g Pu 154,278 g U	34 containers containing 100% metal including lead	N/A
105N Casks, retrievable uncovered, 218-W-4C, Trench 01	126 g Pu	1 cask containing 100% noncombustibles	1.0 E-05*

*Mechanical release fraction.

GETR =

INEL = Idaho National Engineering Laboratory

FFTF = Fast Flux Test Facility.

Table 6-16. Remote-Handled Transuranic Caisson Radiological Inventory.

Caisson	Waste type and quantity								
	Pu (g)	MFPs (Ci)	U-E ^a (g)	U-N ^b (g)	U-D ^c (g)	²³² Th (g)	²³³ U (g)	²¹⁰ Po (g)	⁶⁰ Co (Ci)
1	1,377	35,016	41,848	1	10,529	8,862	0	0	0
2	1,160	19,854	3,106	160	687	0	0	0	0
3	1,197	20,476	2,501	337	544	3	4	0	0
4	2,472	18,485	12,668	1,973	11,306	8,897	39	7	1,635

^aEnriched Uranium.

^bNatural Uranium.

^cDepleted Uranium.

Table 6-17. Combined Dose Consequences To Maximum Offsite Receptor.

Waste packages	Maximum offsite receptor (rem) EDE
Dose consequences of unmitigated seismic event from Section 6.4.2.3.4.1	2.12 E-02
Miscellaneous TRU waste packages from Section 6.4.4.2.	5.92 E-04
1,164 drums (242 m ³) LLW discussed in Section 6.2.2.2.5.1	5.46 E-03
Miscellaneous LLW packages from Table 6-4	7.97 E-3
34,482 drums (7,172 m ³) LLMW discussed in Section 6.3.2.2.5.	1.62 E-01
Total contribution	1.97 E-01

EDE = effective dose equivalent.

LLMW = low-level mixed waste.

LLW = low-level waste.

TRU = transuranic.

Table 6-18. Comparison of Total Trench 29, Modules 6, 7, and 8 Inventory With Category 2 Threshold Values.

Isotope	Weight fraction	Total inventory (g)	Threshold values for Category 2 (g)	Ratio of inventory to threshold
²³⁸ Pu	0.0008	22.58	36	6.27 E-01
²³⁹ Pu	0.8395	23,692.78	900	2.63 E+01
²⁴⁰ Pu	0.1297	3,660.46	242	1.51 E+01
²⁴¹ Pu	0.011	310.45	28	1.11 E+01
²⁴² Pu	0.0003	8.47	13995	6.05 E-04
²⁴¹ Am	0.0175	493.89	16	3.09 E+01
Sum of ratios:				84.08

*DOE 1992.

Table 6-19. Comparison of Total Remote-Handled Transuranic Caisson 4 Inventory With Category 2 Threshold Values.

Isotope	Inventory (Ci)	Threshold values for Category 2 (Ci)	Ratio of inventory to threshold
^{238}Pu	33.86	62	0.55
^{239}Pu	128.66	56	2.30
^{240}Pu	72.78	55	1.32
^{241}Pu	2,800.57	2900	0.97
^{242}Pu	0.0029	55	0.0001
^{241}Am	147.95	55	2.69
MFP	18,485	2,500,000	0.0074
^{232}Th	0.001	18	0.0001
^{233}U	0.38	220	0.0017
^{235}U	0.027	240	0.0001
^{238}U	0.0045	240	0.00002
^{60}Co	1,638.5	190,000	0.0086
^{210}Po	31,430	350	89.8
Sum of ratio:			97.65

*DOE 1992.

APPENDIX 6A
PRELIMINARY HAZARDS ANALYSIS TABLES

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Table 6A-1. PHA Table for Low-Level Waste Drum and Box Disposal. (6 sheets)

Hazard or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features		Annual frequency	Severity
			Engineered	Administrative		
			METAL DRUMS AND BOXES, WOOD BOXES			
I. CHEMICAL A. Fire	1. Fuel spill ignites combustible waste in metal drums and/or boxes.	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker	a. steel constructed drums/boxes b. equipment fuel tank	a. porosity of soil b. fire extinguisher	Extremely unlikely	Category II
	2. Fuel spill ignites combustible waste in wood boxes.	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker	b. equipment fuel tank	a. porosity of soil b. fire extinguisher	Unlikely	Category II
	3. Range or brush fire ignites combustible waste in metal drums and/or boxes	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker	a. steel constructed drums/boxes	a. plant growth control b. housekeeping c. fire extinguisher	Incredible	Category II
	4. Range or brush fire ignites combustible waste in wood boxes.	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker		a. plant growth control b. housekeeping c. fire extinguisher	Extremely unlikely	Category II
B. Gas explosion	1. H ₂ , Methane, CO buildup in drum. Drum ruptures due to pressure or disposal activity and ignites gas. Combustibles in drum are consumed by fire.	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker. Possible injury or fatality to occupational worker.	a. vent clips to vent internal gas pressure. b. catalyst pack recombines H ₂ to H ₂ O	a. containers are covered with overburden at end of each day to reduce solar radiation. b. fire extinguisher	Incredible	Category II
C. Corrosion fails drum	1. Corrosion from internal chemical activity or external sources weaken integrity of container allowing low-level waste spill when moved	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker		a. visual inspection b. restriction on container weight c. new containers	Unlikely	Category III
	2. Corrosion from internal chemical activity or external sources breach container. Contamination seeps into soil.	Contamination to environment. Potential unacceptable dose to ground water	a. porosity of soil b. sloped asphalt pad	a. tarp cover over drums	Unlikely	Category III

Table 6A-1. PHA Table for Low-Level Waste Drum and Box Disposal. (6 sheets)

Hazard or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features		Annual frequency	Severity
			Engineered	Administrative		
D. Pressure	1. Solar radiation expands potential gases in drum causing drum to swell and rupture before stack is covered with earth	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker	a. vent clips or vent caps	a. containers are covered with overburden at end of each day	Unlikely	Category III
	2. Solar radiation expands potential gases in drum causing drum to swell, rupture, and ignite before stack is covered with earth	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker	a. fire extinguisher	a. containers are covered with overburden at end of each day	Extremely unlikely	Category II
II. POTENTIAL/KINETIC ENERGY A. Heavy equipment impacts container(s)	1. Truck backs into trench, tips over and ruptures containers on truck	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker. Potential injury or fatality to occupational worker.		a. PM program b. restricted access to work area c. qualified operators d. chock tires	Unlikely	Category III
	2. Truck backs into trench, tips over, ruptures and ignites containers on truck	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker. Potential injury or fatality to occupational worker.	a. fire extinguisher	a. PM program b. restricted access to work area c. qualified operators d. chock tires	Extremely unlikely	Category II
	3. Truck backs into stack of containers breaching containers in stack and truck	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker. Potential injury or fatality to occupational worker.		a. PM program b. restricted access to work area c. qualified operators d. chock tires	Unlikely	Category III
	4. Truck backs into stack of containers breaching and igniting containers in stack and truck	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker. Potential injury or fatality to occupational worker.	a. fire extinguisher	a. PM program b. restricted access to work area c. qualified operators d. chock tires	Extremely unlikely	Category II

Table 6A-1. PHA Table for Low-Level Waste Drum and Box Disposal. (6 sheets)

Hazard or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features		Annual frequency	Severity
			Engineered	Administrative		
	5. Crane backs into stack of containers breaching containers in stack	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker. Potential injury or fatality to occupational worker.		a. PM program b. restricted access to work area c. qualified operators	Unlikely	Category III
	6. Crane backs into stack of containers breaching and igniting containers in stack	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker. Potential injury or fatality to occupational worker.	a. fire extinguisher	a. PM program b. restricted access to work area c. qualified operators	Extremely unlikely	Category II
	7. Forklift crashes into stack of containers rupturing containers	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker. Potential injury or fatality to occupational worker.		a. PM program b. restricted access to work area c. qualified operators	Unlikely	Category III
	8. Forklift crashes into stack of containers rupturing and igniting containers	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker. Potential injury or fatality to occupational worker.	a. fire extinguisher	a. PM program b. restricted access to work area c. qualified operators	Extremely unlikely	Category II
	9. Forklift pierces containers on truck rupturing containers.	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker		a. PM program b. restricted access to work area c. qualified operators	Unlikely	Category III
	10. Crane pierces containers on truck rupturing containers	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker		a. PM program b. restricted access to work area c. qualified operators	Unlikely	Category III
	11. Forklift drops container, rupturing container	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker.	a. rigging and handling fixture design	a. PM program b. qualified operators	Anticipated	Category III

Table 6A-1. PHA Table for Low-Level Waste Drum and Box Disposal. (6 sheets)

Hazard or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features		Annual frequency	Severity
			Engineered	Administrative		
	12. Crane drops container rupturing container	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker.	a. rigging and handling fixture design	a. PM program b. qualified operators	Anticipated	Category III
	13. Crane drops lid from cask onto drums in cask rupturing drums	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker	a. rigging and handling fixture design	a. PM program b. qualified operators	Unlikely	Category III
	14. Crane swings into stack crushing and toppling containers. Toppled containers rupture	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker		a. PM program b. qualified operators	Unlikely	Category III
	15. Crane drops container on stack rupturing containers	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker	a. rigging and handling fixture design	a. PM program b. qualified operators	Unlikely	Category III
	16. Bulldozer crashes into trench rupturing containers in stack	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker. Potential injury or fatality to occupational worker.		a. PM program b. qualified operators c. restricted access to work area	Unlikely	Category III
	17. Bulldozer crashes into trench rupturing containers in stack with ensuing fire	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker. Potential injury or fatality to occupational worker.	a. fire extinguisher	a. PM program b. qualified operators c. restricted access to work area	Extremely unlikely	Category II
	18. Weight of bulldozer on overburden crushes containers	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker.		a. appropriate amount of overburden over trench b. 10% void space requirement c. weekly inspection for subsidence	Unlikely	Category III

Table 6A-1. PHA Table for Low-Level Waste Drum and Box Disposal. (6 sheets)

Hazard or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features		Annual frequency	Severity
			Engineered	Administrative		
B. Missile	1. Wind driven missile rupture containers in stack before stack is covered with overburden	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker.		a. containers are subterranean b. maintain housekeeping to prevent loose debris from becoming missile c. secure equipment d. stack covered with overburden at end of day	Unlikely	Category III
C. Cave-in	1. Side of trench collapses rupturing containers in stack	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker. Potential injury or fatality to occupational worker.		a. trench sides maintain a 1.5:1 slope	Unlikely	Category III
D. Seismic	1. Earthquake causes containers in stack to topple, rupturing containers	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker. Potential injury or fatality to occupational worker.	a. stack is stabilized	a. stack covered with overburden at end of day	Unlikely	Category III
E. Overburden	1. Weight of overburden crushes containers	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker.		a. 10% void space requirement b. 8 ft of overburden c. weekly inspection for subsidence	Unlikely	Category III
F. Drag-off	1. Container ruptures during drag-off activity	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker	a. engineered drag-off containers		Unlikely	Category III
G. Backfill Subsidence	1. Pathway for potential release to environment	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker. Personal injury to occupational worker.		a. weekly inspection for subsidence	Anticipated	Category III
III. RADIATION A. Exposure	1. Container received is > 200 mrem/h and/or container received is > 5 mrem/h at 100 yards	Exposure to occupational worker		a. containers are surveyed before they are received b. containers are surveyed before they are moved	Anticipated	Category III

Table 6A-1. PHA Table for Low-Level Waste Drum and Box Disposal.. (6 sheets)

Hazard or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features		Annual frequency	Severity
			Engineered	Administrative		
B. Release	2. Shielding inside container shifts during movement exposing operator to > 200 mrem/h	Exposure to occupational worker		a. containers are surveyed before they are received b. containers are surveyed before they are moved	Anticipated	Category III
	3. Localized flooding due to run off leaches activity to soil	Potential contamination to ground water		a. distance to ground water	Unlikely	Category III
	1. Loose container lid	Exposure to occupational worker		a. visual verification that container lid is secure	Anticipated	Category III
	2. As containers are moved and handled, surface contamination is released and becomes airborne	Exposure and contamination to occupational worker		a. container to be smeared and surveyed before moving	Anticipated	Category III
C. Criticality	1. Change in geometrical array of the fissile materials within the waste occurs due to corrosion. In addition there is an intrusion of moderating materials such as water	Potential exposure to maximum onsite receptor and exposure to occupational worker		a. low-level waste b. SD-SQA-CSA-20346	Incredible	Category III
CORE BASKET THERMAL SHIELDS						
I. POTENTIAL/ KINETIC ENERGY A. Heavy Equipment Accident	1. When transporter with cask and crane move to burial trench, transportation accident impacts cask exposing CBTS	Potential unacceptable exposure to occupational worker due to high radiation field.	a. engineered shipping cask	a. PM program b. qualified operators	Extremely unlikely	Category III
	2. When 160 ton crane removes cask with CBTS from transporter to bottom of trench, crane drops cask. Impact to cask breaches cask exposing CBTS	Potential unacceptable exposure to occupational worker due to high radiation field.	a. engineered shipping cask b. engineered rigging and handling fixtures	a. PM program b. qualified operators	Extremely unlikely	Category III
	3. When trench is covered with overburden, cask is impacted during the burial activity exposing CBTS	Potential unacceptable exposure to occupational worker due to high radiation field.	a. engineered shipping cask	a. qualified operators b. PM program	Extremely unlikely	Category III

Table 6A-2. PHA For Mixed Waste. (4 sheets)

Hazards or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features		Annual frequency	Severity
			Engineered	Administrative		
CONTAINER FAILURES						
I. CHEMICAL A. Fire B. Gas explosion C. Toxic gas exposure D. Corrosion fails container	1. Dry weather results in a range fire which throws sparks into area. Previously spilled waste or contents of breached drums ignite, causing nearby drums to rupture or vent.	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker	a. Site cleared of vegetation. b. Drums/containers are steel construction.	a. Maintain good housekeeping practices. b. Fire department can control fires.	Unlikely	Category II
	1. Gas formed in drum or container explodes.	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker	a. Drum has vent clip to vent internal gas pressure and catalyst pack to recombine H ₂ to H ₂ O	a. Verify container vents are open, and SDAR shows drums contain catalytic pack per WHC-EP-0063.	Extremely unlikely	Category II
	1. Exposure to heat, blocked vent, and/or missing catalytic pack cause toxic gas release.	Radiological/toxicological releases onsite/offsite could occur. Workers in trench could be exposed.	a. Drums and containers are vented.	a. Verify container vents are open, and SDAR shows drums contain catalytic pack per WHC-EP-0063.	Extremely unlikely	Category III
	1. Liquids in container cause corrosion.	Contaminated leachate could reach leachate liner and tank. Workers in trench could be exposed.	a. Leachate collection system prevents leachate from reaching groundwater.	a. All liquids will be absorbed, solidified, or otherwise bound in the waste material. b. Verify SDAR shows compliance with WHC-EP-0063.	Unlikely	Category III
	2. Leachate seeping into or collecting around damaged containers cause corrosion.	Contaminated leachate could reach leachate liner and tank. Workers in trench could be exposed.	a. Leachate collection system prevents leachate from reaching groundwater.	a. Waste packages provide at least two containment barriers or per SDAR. b. Exterior surfaces painted or galvanized per HS-V-P-0010 (WHC 1988).	Unlikely	Category III

Table 6A-2. PHA For Mixed Waste. (4 sheets)

Hazards or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features		Annual frequency	Severity
			Engineered	Administrative		
II. POTENTIAL/ KINETIC ENERGY A. Heavy equipment impacts containers	1. Vehicle rolls off ramp, crushing and rupturing containers.	If spillage not cleaned up and ruptured drums repacked, radiological/toxicological releases onsite/offsite could occur.	a. Drums/containers meet drop test and penetration test requirements in 48 CFR 173 Subpart I. b. One to 2 feet of topsoil is placed over each layer before the next layer is started.	a. Use trained operators who have experience in backing down ramps.	Unlikely	Category III
	2. Forklift rams container with tine causing rupture.	Radiological/toxicological releases onsite/offsite could occur.	a. Drums/containers meet drop test and penetration test requirements in 48 CFR 173 Subpart I.	a. Use trained drivers and guides to direct placement of drums. b. Verify compliance with WHC-EP-0063.	Unlikely	Category III
	3. Operator drops container while unloading.	Radiological/toxicological releases onsite/offsite could occur.	a. Access ramp to bottom of trench is an 8% grade.	a. Use trained driver.	Likely	Category III
	4. Vehicle impacts containers with ensuing fire	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker. Potential injury or fatality to occupational worker		a. Use trained operators b. restrict access to work area.	Extremely unlikely	Category II
	B. Flood					
	2. Trench is flooded	Radiological/toxicological releases onsite/offsite could occur.			Incredible	Category III
	C. Seismic event					
	1. Earthquake could tumble drums in the trench, damage leachate liner and tank supports. Drums could fall off transport vehicles.	Radiological/toxicological releases to groundwater, onsite/offsite could occur.	a. Texture of operational layer soil will retard rolling of drums. b. Leachate liner is designed to Safety Class 2.	a. Each layer of drums is covered with 1 to 2 feet of top soil before next layer is started, to protect liner.	Extremely unlikely	Category III
	D. Wind					
	1. Windblown missiles could impact drums/container, spilling waste. Wind carries some waste out of trench.	Radiological/toxicological releases to groundwater, onsite/offsite could occur.		a. Keep area free of missiles. b. Shutdown operations in wind storms.	Unlikely	Category III

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Table 6A-2. PHA For Mixed Waste. (4 sheets)

Hazards or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features		Annual frequency	Severity
			Engineered	Administrative		
III. RADIATION A. Exposure	1. Container received is > 200 mrem/hr at external surface and/or > 5 mrem/h at 100 yds	Exposure to occupational worker		a. Containers are surveyed before receipt.	Anticipated	Category III
	2. Exposure to RH-Waste	Exposure to occupational worker	a. Remote handled waste will be placed behind concrete block walls and immediately covered with about 1 to 5 feet of topsoil as required to keep exposure to a minimum. b. Each layer of drums will be covered with 1 to 2 feet of topsoil.	a. WHC-EP-0063 dose limits are: contact-handled (CH)- 100 mrem/h, packages larger than 55 gallon drums may have in addition a marked point with surface radioactivity up to 1000 mrem/h on the bottom and one side, with permission of responsible engineering organization. Remote handled (RH)- 3,000 mrem at 1 m from the side of the truck.	Unlikely	Category III
LEACHATE COLLECTION SYSTEM FAILURES						
A. Pump Failure	1. Pump failure during heavy rains.	Failure of pumps could cause large accumulation of leachate in primary liner, leachate could reach secondary liner.	a. Instrumentation would signal pump failure. b. The three pumps (2 primary and 1 secondary) are a standard design. Piping system is designed for easy pump replacement.	a. Maintain good preventive maintenance.	Unlikely	Category III
B. Piping Failure	1. Pipe leaks while pumping.	Some local spray release could occur.	a. Pipe is high density polyethylene (HDPE). The pumps are 5 gpm and 150 gpm. Leaks below ground would drain back to the leachate sump. Leaks in exposed piping would drain to the tank sump. Spray would be minimized by the pump pressure and the operating time of the pumps.	a. Maintain good preventive maintenance.	Unlikely	Category III
C. Temporary storage tank failure	1. Contents of tank leak into sump around the temporary storage tank.	Some air borne release could occur if wind is high.	a. The sump around the temporary storage tank is designed to hold the contents of the tank plus the expected volume of water from the 25 year storm.	a. Maintain good preventive maintenance.	Unlikely	Category III

Table 6A-2. PHA For Mixed Waste. (4 sheets)

Hazards or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features		Annual frequency	Severity
			Engineered	Administrative		
D. Loss of liner integrity	<p>1. Loss of primary liner integrity could result in leachate leaking to secondary liner. Loss of integrity of both liners could result in leachate reaching unsaturated zone, possibly ground water. Ground water under liner can increase migration rate of contamination. Potential causes are:</p> <p>a. Fault in liner. b. Damage while installing liner. c. Bonding of liner sections poorly done. d. Damage while spreading topsoil over liner, from blades, sharp rough stones, or gravel. e. Separation of liner from slope, liner sliding down slope. f. Heat damage. g. Dehydration cracking of admix layer causing separation or splitting of liner.</p>	Radiological/toxicological releases to groundwater onsite/offsite could occur.	a. Liner designed to meet shear and friction requirements, and installed in graded sandy soil.	<p>a. 9090 test of liner. Daily tests of liner sections being installed. b. Daily testing and training of installers. c. Use trained operators. d. QA soil analysis. e. 1 to 3 slope used in trench to prevent cave-ins. f. Anchor trench at top of slope and soil friction calculated to keep liner in place. g. Two feet of top soil protects from heat damage. h. Moisture content of admix layer beneath liners calculated to prevent dehydration cracking.</p>	Extremely unlikely	Category III
E. Corrosion fails leachate tank or piping	<p>1. Liquids in leachate tank cause corrosion and leaks in tank or piping. Contents of tank run into tank sump. Piping leaks run into tank or leachate sump depending on the location of the leak.</p>	Radiological/ toxicological releases could occur onsite/offsite.	<p>a. Leachate tank is coated with epoxy which is not reactive with the expected contents of tank. b. The tank leak containment concrete sump will hold the tank volume plus the depth of average annual rainfall. c. It is also coated with epoxy, with waterstops in all construction joints, Golder 1990.</p>	<p>a. Monitor tank contents for radioactive and toxicity levels. b. Monitor tank level. c. Inspect tank and piping for signs of corrosion or leaks.</p>	Unlikely	Category III

Table 6A-3. PHA Table For Submarine Reactor Compartment Burial. (3 sheets)

Hazard or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features			Severity
			Administrative	Engineered	Annual frequency	
I. CHEMICAL A. Fire	1. Fuel spill ignites combustible waste in SRC	Release of hazardous material to environment	a) steel construction of SRC b) fuel tank	a) limited fuel in tank b) porosity of soil	Extremely unlikely	Category II
	2. Range/brush fire ignites combustibles in SRC	Same as above	a) steel construction of SRC	a) plant growth control b) house keeping	Incredible	Category II
	3. Spontaneous combustion in SRC	Same as above	a) steel construction of SRC	a) original packaging criteria	Extremely unlikely	Category III
	4. Fire spreads to adjacent SRC's	Same as above	a) steel construction of SRC	a) all H2O removed or absorbed before SRC is shipped to burial ground	Extremely unlikely	Category II
B. Gas explosion	1. H2, Methane, CO build up in SRC and ignites. SRC is ruptured	Release of hazardous material to environment	a) steel construction of SRC b) catalyst pack recombines H2 to H2O		Extremely unlikely	Category II
	1. Internal chemical activity or external sources breach SRC resulting in mixed waste release	Release of mixed waste to environment and exposure/contamination to occupational worker if uncovered. Release of mixed waste to ground water if covered.	a) steel construction of SRC		Extremely unlikely	Category III
C. Corrosion fails SRC						
	1. Transporter trailer drops SRC while unloading. SRC fails to ground rupturing upon impact	Possible injury or fatality to operator. Mixed waste release to environment. Exposure to occupational worker.	a. Steel construction of SRC welded to column before transporter and then SRC is cut from transporter	a. Operator training b. Equipment inspection	Extremely unlikely	Category II
	2. Transporter trailer crashes into and ruptures SRC	Same as above	Same as above	Same as above	Extremely unlikely	Category II
	3. Transporter trailer crashes into SRC knocking SRC off foundation column. SRC falls to ground rupturing upon impact	Same as above	Same as above	Same as above	Extremely unlikely	Category II
II. POTENTIAL/KINETIC ENERGY A. Heavy equipment impacts SRC						
	4. Transporter tractor crashes into and ruptures SRC	Same as above	Same as above	Same as above	Extremely unlikely	Category II
	3. Transporter trailer crashes into SRC knocking SRC off foundation column. SRC falls to ground rupturing upon impact	Same as above	Same as above	Same as above	Extremely unlikely	Category II
	4. Transporter tractor crashes into and ruptures SRC	Same as above	Same as above	Same as above	Extremely unlikely	Category II

Table 6A-3. PHA Table For Submarine Reactor Compartment Burial. (3 sheets)

Hazards or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features		Annual frequency	Severity
			Engineered	Administrative		
	5. Transporter tractor crashes into SRC knocking SRC off foundation column. SRC falls to ground rupturing upon impact	Same as above	Same as above	Same as above	Extremely unlikely	Category II
	6. Heavy equipment crashes into and ruptures SRC during back fill operation	Same as above	Same as above	Same as above	Extremely unlikely	Category II
B. Column collapses	1. Foundation column collapses under the load of the SRC. SRC subsequently crashes to the ground and ruptures	Same as above	Steel construction of SRC. Engineered foundation design	Construction QA program	Incredible	Category III
C. Land slide	1. Sides of the burial trench caves in toppling over the SRC from off column causing SRC to rupture	Same as above	Steel construction of SRC	Distance SRC's are placed from walls of trench	Incredible	Category III
D. Vehicle crash	1. Vehicle crashes into pit from above rupturing SRC	Same as above	Steel construction of SRC	Vehicles to remain on designated roads	Incredible	Category III
E. High wind missile	1. High wind missile pierces SRC and causes SRC to rupture	Release of mixed waste to environment. Exposure or contamination to occupational worker	Would have to penetrate two steel barriers (1/2 in minimum each) and the reactor vessel wall consisting of lead and steel	Maintain house keeping to prevent loose debris from becoming a missile	Incredible	Category III
F. Aircraft crash	1. Aircraft crashes into exposed SRC. SRC is ruptured	Same as above	Same as above		Incredible	Category III
G. Earthquake	1. Earthquake causes SRC support columns to collapse. SRC falls to the ground striking unyielding steel structural component in the column and ruptures	Same as above	Same as above		Extremely unlikely	Category III
H. Subsidence	1. Backfill subsidence	Potential injury to occupational worker	Same as above		Extremely unlikely	Category III

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Table 6A-3. PHA Table For Submarine Reactor Compartment Burial. (3 sheets)

Hazards or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features		Annual frequency	Severity
			Engineered	Administrative		
III. RADIATION A. Exposure	1. Receipt of an SRC that exceeds allowable dose rate due to radioactivity within the vessel	Exposure to occupational worker		SRC's are surveyed before leaving the Naval base and again when they arrive at the LLBG	Extremely unlikely	Category III
	2. Receipt of an SRC that exceeds allowable dose rate due to radioactivity within the vessel	Same as above		Same as above	Extremely unlikely	Category III
B. Criticality	1. Change in geometrical array of activated metals. In addition there is an intrusion of moderating materials such as water	Onsite dose	Steel construction of SRC and their physical separation on columns.	Distance SRCs are placed from each other and fissile material is restricted from being buried in the SRC's	Incredible	Category III

Table 6A-4. PHA Table For Buried And Uncovered TRU Containers. (3 sheets)

Hazard or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features		Annual frequency	Severity
			Engineered	Administrative		
Uncovered TRU Containers						
I. Chemical A. Corrosion B. Pressure C. Explosion D. Fire	1. Corrosion from internal chemical activity or external sources breach container. Contamination seeps into soil.	Contamination to environment. Potential unacceptable dose to ground water	a. porosity of soil b. sloped asphalt pad	a. tarp cover over drums b. to be retrieved within life time of drum	Unlikely	Category III
	1. Solar radiation expands potential gases in drum causing drum to swell and rupture.	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker	a. vent clips or vent caps	a. containers are covered with plywood. b. packaging criteria	Unlikely	Category III
	2. Solar radiation expands potential gases in drum causing drum to swell, rupture, and ignite.	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker	a. vent clips or vent caps	a. Same as above	Extremely unlikely	Category II
	1. H ₂ , Methane, CO buildup in drum. Drum explodes due to pressure from solar radiation	Same as above	Same as above	Same as above	Extremely unlikely	Category II
	1. Range fire ignites combustible waste in containers in trench	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker	a. steel constructed containers	a. plant growth control b. housekeeping c. fire extinguishers	Incredible	Category II
	2. Fuel spill ignites combustible waste in containers in trench	Same as above	a. steel constructed containers b. equipment fuel tank c. trench slopes away from drums	a. fire extinguishers	Incredible	Category II
	II. POTENTIAL/KINETIC ENERGY A. Heavy equipment impacts container(s)	1. Heavy equipment or a vehicle crashes into containers in trench	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker. Potential injury or fatality to occupational worker.	a. steel construction of drums	a. No activity in trench. Washington State Dept. of Ecology restricts burial of TRU containers. WHC restricts storage of TRU containers in trench. b. restricted access to burial ground.	Extremely unlikely

Table 6A-4. PHA Table For Buried And Uncovered TRU Containers. (3 sheets)

Hazard or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features		Annual frequency	Severity
			Engineered	Administrative		
B. Missile	2. Heavy equipment or a vehicle crashes into containers in trench with ensuing fire.	Same as above	Same as above	Same as above	Incredible	Category II
	1. Wind driven missile rupture containers in stack.	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker.		a. containers are subterranean b. maintain housekeeping to prevent loose debris from becoming missile	Unlikely	Category III
C. Cave-in	1. Side of trench collapses rupturing containers in stack	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker. Potential injury or fatality to occupational worker.		a. trench sides maintain a 1.5:1 slope	Unlikely	Category III
D. Seismic	1. Earthquake causes containers in stack to topple, rupturing containers	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker. Potential injury or fatality to occupational worker.	a. stack is stabilized with plywood between each tier of drums		Unlikely	Category III
III. RADIATION A. Exposure	1. Container received is > 200 mrem/ and/or Container received is > 5 mrem/h at 100 yds	Exposure to occupational worker		a. containers are surveyed before they are received	Anticipated	Category III
	2. Shielding inside container shifts during movement exposing operator to > 200 mrem/h	Exposure to occupational worker		a. containers are surveyed before they are received	Anticipated	Category III
	B. Release 1. Loose container lid	Exposure to occupational worker		a. visual verification that container lid is secure	Anticipated	Category III
	C. Criticality 1. Change in geometrical array of the fissile materials within the waste occurs due to corrosion. In addition there is an intrusion of moderating materials such as water	Potential exposure to maximum onsite receptor and exposure to occupational worker	a. steel construction of drums	a. WHC-SD-SQA-CSA-20346 b. containers to be retrieved before integrity loss/severe corrosion per referenced document (see #a above)	Incredible	Category III

Table 6A-4. PHA Table For Buried And Uncovered TRU Containers. (3 sheets)

Hazard or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features		Annual frequency	Severity
			Engineered	Administrative		
Buried TRU Containers						
I. CHEMICAL A. Corrosion	1. Internal chemical activity or external sources create hole(s) in container resulting in release of contamination to the environment.	Impact to soil column and possible ground water	a. Drums have 20 yr life expectancy. Buried drum integrity to be re-evaluated after being buried 18 yr.	a. packaging criteria WHC-EP-0063	Anticipated after 20 years	Category III
II. POTENTIAL/KINETIC ENERGY A. Heavy equipment	1. Weight of heavy equipment on overburden crushes containers	a. Impact to soil column and possible ground water b. Potential exposure to maximum onsite receptor and occupational worker c. potential injury to occupational worker		a. Access is limited to authorized equipment	Unlikely	Category III
B. Overburden	1. Weight of overburden crushes containers	Same as above		a. 10% void space requirement b. weekly inspection for subsidence	Unlikely	Category III
C. Subsidence	1. Pathway for potential release to environment	Same as above		Same as above	Unlikely	Category III
III. RADIATION A. Criticality	1. Change in geometrical array of the fissile materials within the waste occurs due to corrosion. In addition there is an intrusion of moderating materials such as water.	Same as above	a. 20 yr life expectancy for drums	a. packaging requirements WHC-EP-0063 b. WHC-SD-SQA-CSA-20346 c. containers to be retrieved before integrity loss/severe corrosion per referenced document (see #b above)		

Table 6A-5. PHA Table For Irradiated Fuels Stored In SWBG. (2 sheets)

Hazard or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features		Annual frequency	Severity
			Engineered	Administrative		
POST-EMPLACEMENT						
I. CHEMICAL A. Fire B. Corrosion C. Pressure	1. SWBG involved in range fire breaching EBR-II cask and releasing radionuclides to environment	Potential unacceptable dose to maximum onsite receptor and impact to environment	a. casks not flammable b. irradiated fuel not flammable	a. vegetation control b. housekeeping c. 200 area fire department	Incredible	Category II
	1. Long-term cask degradation breaches cask releasing radionuclides to environment	Same as above	a. multiple containers b. downward migration impeded by pad	a. casks to be retrieved before severe degradation should occur	Extremely unlikely	Category II
	2. External corrosion breaches cask releasing radionuclides to environment	Same as above	a. multiple containers b. 25-yr design life		Extremely unlikely	Category II
	3. Internal corrosion breaches cask releasing radionuclides to environment	Same as above	a. multiple containers b. corrosion-resistant container materials	a. absence of free liquids	Extremely unlikely	Category II
	1. Liquids or gas-producing materials create sufficient pressure to breach cask. Radionuclides are released to environment	Same as above	a. container/seal integrity	a. packaging procedures and criteria prevent liquids and gas producing materials	Extremely unlikely	Category II
II. POTENTIAL/KINETIC ENERGY A. High wind missile B. Flooding	1. EBR-II cask breached by high wind missile releasing radionuclides to environment	Same as above	a. cask integrity b. multiple containers	a. housekeeping b. casks are subterranean	Incredible	Category II
	1. EBR-II cask submersed under water releasing radionuclides to environment due to damaged seals, accelerated corrosion, or increased reactivity when water comes in contact with fissile materials.	Same as above	a. container/seal integrity b. trench design	a. burial ground elevation b. container spacing prevents criticality	Extremely unlikely	Category II

Table 6A-5. PHA Table For Irradiated Fuels Stored In SWBG. (2 sheets)

Hazard or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features		Annual frequency	Severity
			Engineered	Administrative		
C. Seismic	1. EBR-II cask breached by falling object or tips over striking unyielding surface. Radionuclides are released to environment	Same as above	a. cask integrity b. multiple containers	a. lack of extremely hard surfaces	Incredible	Category II
D. Mechanical	1. Installation of defective seal or improper installation of seal results in release of radionuclides to environment	Same as above		a. QA/QC procedures b. operating procedures c. leak test	Unlikely	Category II
III. CRITICALITY	1. Criticality results from clustering of containers that have been internally flooded	Same as above	a. container design and sealing measures	a. criticality prevention specifications b. no credible event could cluster enough containers	Incredible	Category II
WASTE EMPLACEMENT OPERATIONS						
I. POTENTIAL/KINETIC ENERGY	1. EBR-II cask dropped during handling. Breached cask releases radionuclides to environment or reduction of shielding	Same as above	a. cask integrity b. multiple containers	a. lack of extremely hard surfaces	Extremely unlikely	Category II
	2. EBR-II cask strikes hard object (e.g., forklift) during handling or tips over striking unyielding surface. Breached cask releases radionuclides to environment or reduction of shielding	Same as above	a. cask integrity b. multiple containers	a. lack of extremely hard surfaces b. operator training	Extremely unlikely	Category II
II. RADIATION A. Exposure	1. Receipt of contaminated cask	Potential unacceptable radiation exposures to occupational worker		a. decontamination procedures b. radiation monitoring checks	Extremely unlikely	Category II

Table 6A-6. PHA Table for RH-TRU Caissons.

Hazard or energy source	Potential accident and/or sequence	Target and/or potential consequences	Mitigating features		Annual frequency	Severity
			Engineered	Administrative		
I. CHEMICAL						
A. Corrosion	1. Corrosion from internal chemical activity or external sources breach container. Contamination seeps into soil.	Contamination to environment. Potential unacceptable dose to ground water	a. minimum of 4 inches reinforced-concrete walls		Extremely unlikely	Category III
B. Fire	1. Flammable/combustible material stored in caisson is ignited by electrical short or during maintenance resulting in radiological release to the atmosphere	Potential unacceptable dose to maximum onsite receptor and exposure to occupational worker	a. block vent pipe when performing maintenance	a. air sample potential gases before work b. work plan	Extremely unlikely	Category II
C. Explosion	1. Buildup of explosive vapor in caisson. Ignited by electrical short or during maintenance resulting in radiological release to the atmosphere	Same as above	a. caissons are vented b. minimum of 4 inches reinforced-concrete walls c. 14 ft of earth over caisson		Extremely unlikely	Category II
II. POTENTIAL/KINETIC ENERGY						
A. Impact to ventilation shaft or inlet chute	1. Heavy equipment or vehicle impacts ventilation shaft or inlet chute resulting in radiological release to the atmosphere	Same as above	a. fencing b. colored markings or paint	a. restricted access to burial ground	Extremely unlikely	Category III
B. Seismic	1. Earthquake causes caisson to breach, releasing content to the soil	Contamination to environment. Potential unacceptable dose to ground water	a. construction of caissons b. caissons are located 14 ft underground		Incredible	Category III
III. RADIATION						
A. Criticality	1. Change in geometrical array of the fissile materials within the waste occurs due to breached containers. In addition there is an intrusion of moderating materials such as water	Potential exposure to maximum onsite receptor and exposure to occupational worker		a. SD-SQA-CSA-20124 b. Total fissile material in caisson (2,511 g worst case in caisson 4) is well below CPS limit of 5,000 g	Incredible	Category III

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APPENDIX 6B
FAULT TREE ANALYSES

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FAULT TREE ANALYSIS

Fault tree analysis is a deductive failure approach that focuses on one particular undesired event and provides a method for determining causes of this event. The undesired event constitutes the top event in the fault tree. The preliminary hazards analysis (PHA) identified significant plausible abnormal operations and accidents which could be expected to result in radiological or toxicological releases and were incorporated into the fault tree. The fault tree was then plotted on CAFTA (WHC 1990) and cut sets were generated by the program. The minimal cut sets are the smallest combination of failures which, if they all occur, will cause the top event to occur. Fault trees provide a convenient means for mathematically combining the probabilities of contributing events in order to systematically quantify the probability for the overall accident scenario.

The following section provides a brief description of the basic events in the fault tree with estimated probabilities. When documentation exists for the probability of an event, it is used and referenced. However, when such documentation is not available, basic events are qualitatively categorized as "anticipated," "unlikely," or "extremely unlikely," as defined in WHC-CM-4-46 and the more conservative end of the range is assigned as the annual probability for the event.

FAILURE RATE AND ANNUAL PROBABILITY ESTIMATES

1. Uncovered Container Not Buried Within 20 Years of Trench Emplacement. 55-gal LLW drums have been given a life expectancy of 20 yr unless additional studies show the life of the drum can be extended. The drums will be buried well within the life of the drum. An annual probability of $1.00E-02$ is assigned to this basic event.
2. Container Exposed to Corrosive Environment. The uncovered TRU and LLW Containers are exposed to the sun, rain, and other natural elements. This basic event is assigned an annual probability of $1.00E+00$.
3. Container Corrodes. Exposed to the right conditions it is assumed that any container will corrode. This has an assigned annual probability of $1.00E+00$.
4. Uncovered Container Not Retrieved Within 20 Years of Trench Emplacement. TRU drums have been given a life expectancy of 20 yr unless additional studies show the life of the drum can be extended. The exposed drums are to be retrieved within 90% of their life expectancy. Failure to do so would be a Human error with an associated annual probability of $1.00E-02$.
5. Container Is Exposed To Solar Radiation. Uncovered TRU and LLW containers are exposed to solar radiation from the sun. This basic event is assigned an annual probability of $1.00E+00$.
6. Sufficient Solar Energy To Expand Gas Generated In Container. At the Hanford reservation June, July, and August tend to be the warmest months

of the year with monthly averages exceeding 69, 76, and 74 °F respectively. The highest monthly averages are 75.5, 82, and 81.5 °F respectively. The probability of this event is based on 3 months out of the year or an annual probability of $2.50\text{E-}01$.

7. Gas is Generated in Container. Gases other than hydrogen are generated in the burial drums such as CO_2 , CO, nitrous oxides, O_2 or methane. This event is anticipated ($1.00\text{E+}00$ to $1.00\text{E-}02$) and has an assigned probability of $1.00\text{E+}00$.
8. Operator Fails To Install Vent Clip. Based on standard human reliability (Swain & Guttman), this basic event is assigned an annual probability of $1.00\text{E-}03$.
9. Vent Clip Is Plugged Or Damaged. Because gases readily diffuse and the limited ways in which the simple design of the vent clip could fail, it is unlikely or an annual probability of $1.00\text{E-}03$ the vent clip will fail to vent gases.
10. Earthquake Topples Container From Stack. The DBE for a moderate hazard facility has a return period of $1.00\text{E+}03$ yr (UCRL 15910), which is usually taken to mean the annual probability of occurrence is $1.00\text{E-}03$.
11. Unauthorized Vehicle In Trench. DOE-RL has restricted the continued covering of retrievable TRU in the burial grounds. WHC has restricted the continued storage of retrievable TRU in the burial ground trenches. Activity in the immediate area of the exposed containers is limited to maintenance and drum handling activities. The annual probability of an unauthorized vehicle in the trench is $1.00\text{E-}02$.
12. Vehicle Crashes Into Containers. The frequency of a DOE reportable truck accident occurring on the Hanford Site of a magnitude that could breach drums is calculated to be $8.9\text{E-}07$ per mile (WHC-SD-TP-RPT-007 Rev. 0, 1993). Annual mileage for drum handling equipment at the low level burial ground is conservatively assumed to be 15,000 miles; therefore, the annual frequency of such an accident in the LLW or LLMW trenches is calculated to be $1.3\text{E-}02$. Traffic at the TRU trenches with exposed TRU drums is restricted. There are 888 drums in Trench 29. If each drum is removed from the trench with a forklift, the forklift would travel a conservation estimate of 1/4 mile round trip/drum. If all 888 drums are removed from the trench in a given year the annual mileage would be 222 miles/yr. The annual frequency is therefore calculated to be $8.9\text{E-}07/\text{mile} \times 222 \text{ miles/yr} = 2.0\text{E-}4/\text{yr}$.
13. High Wind Sufficient to Launch a Projectile. Using 35 yr of wind data, 100-yr return period peak gust of 138 km/h (86 mi/h) has been calculated at the 15-m (50-ft) elevation (Stone et al. 1983); therefore, this basic event is assigned an annual probability of $1.00\text{E-}02$.
14. Projectile Capable of Being Launched by High Wind. Containers are below grade and weekly inspections include removal of any potential missiles. However, the operator could fail to remove potential missiles or a missile could be generated from side paneling or roofing from near by

facilities. This basic event has an assigned annual probability of $1.00\text{E}-02$.

15. Corrosive Chemicals are Discarded in Container. Waste with corrosive capabilities must be stabilized in an approved manner (DOE Order 5820.2a Chapter III section 3.i.[5][d], DOE 1988) before discarding. Failure to do so would require operator error. Based on standard human reliability, the probability of $1.00\text{E}-02$ is used in the analysis.
16. Liner is Defective. A defective liner is assigned an annual probability of $1.00\text{E}-02$.
17. Operator Fails to Place Liner In Container. By procedure operators are to place a polyethylene liner within the drum to serve as one of two containment barriers. Failure to perform this operation has an annual probability of $1.00\text{E}-03$ (Swain & Guttman).
18. Hydrogen is Generated in Container. In closed systems containing organic or wet radioactive materials, the buildup of flammable mixtures of hydrogen-oxygen can be expected and has been observed (Hydrogen Control in the Handling, Shipping, and Storage of Westinghouse Hanford Radioactive Waste) (Henrie 1986). The most important source of hydrogen-oxygen generation is radiolysis. This is an anticipated event ($1.00\text{E}+00$ to $1.00\text{E}-02$) with an assigned annual probability of $1.00\text{E}+00$.
19. Hydrogen Reaches Explosive Concentration with Oxygen. Hydrogen is flammable in concentrations of 4.1 to 74.2 vol% in air. It requires an oxidizing agent (usually oxygen, minimum 5.0%) to be flammable. Detonations can occur at higher concentrations (18.3 to 59 vol% hydrogen in air) (EG&G 1987). An INEL study (EG&G 1985) shows that out of 184 Rocky Flats drums and 33 Los Alamos drums, only 1 drum (an 8-mo-old drum) had an explosive mixture. This data gives this event a frequency of $4.60\text{E}-03/\text{drum}$. Hydrogen generation rate slows down in older drums and the gas diffuses out of the drum, giving rise to lower concentrations of hydrogen in older drums. Since the drums being retrieved are older drums, this is a conservative number.
20. Catalyst Pack Fails To Recombine Hydrogen To Water Due To Chemical Composition. Catalytic recombiners remove hydrogen-oxygen gases in the stoichiometric 2:1 ratio. Where nonstoichiometric net-gas generation occurs, such as in cases where the oxygen is scavenged by waste components, the hydrogen can build up in excess. If oxygen is sufficiently limited, flammability presents little hazard; however, excess hydrogen can over pressurize the container. This provides a potential for ignition-upon-venting. This event is considered to be unlikely $1.00\text{E}-04$.
21. Fuel Spill. A fuel tank would have to rupture and go unnoticed for this event to occur. With scheduled maintenance and inspections this event would be unlikely ($1.00\text{E}-02$ to $1.00\text{E}-04$). This event has an assigned annual probability of $1.00\text{E}-02$.
22. Spontaneous Combustion. Spontaneous combustion in the solid waste burial ground has been given an annual probability of $3.3\text{E}-02$ (RDA 1975).

However, Hanford site solid waste acceptance criteria (WHC-EP-0063) restricts the disposal of reactive chemicals. Failure to observe the waste acceptance criteria has an annual probability of $1.00\text{E-}02$ making the combined annual probability of these two basic events $3.3\text{E-}04$.

23. Carelessly Thrown Cigarette. Smoking in a radiation zone is prohibited. Failure to observe this rule is assigned an annual probability of $1.00\text{E-}02$ (Swain and Guttman). The cigarette would also have to be carelessly thrown into ignitable material in the vicinity of the containers, an annual probability of $3.3\text{E-}02$ (ERDA 1975). The combined annual probability of these two basic events is $3.3\text{E-}04$.
24. Ignited by Spark. A fire in the solid waste burial ground generated by a spark from a vehicle is given an annual probability of $3.3\text{E-}02$ (ERDA 1975). This probability is based on the disposal of solid waste in cardboard boxes and not steel drums. Before a spark from a vehicle could ignite the contents of a drum, the drum would have to be compromised and the contents exposed. During weekly surveillance the compromised drum would be detected and corrective measures taken allowing for only a small window of time in which a spark from a vehicle could ignite the exposed contents. Based on a one weak window of time this basic event has an annual probability of $6.3\text{E-}04$.
25. Ignited by Open Flame. The Work Authorization/Job Control System (WA/JCS) controls activities involving open flames (welding, cutting torches, etc.) in the low level burial ground. The WA/JCS includes safety preplanning to insure the safety of the activity. Failure to go through WA/JCS would be a human error. Based on standard human reliability, the annual probability of $1.00\text{E-}02$ is assigned to this event. Also, before an open flame could ignite the contents of a drum, the drum would have to be compromised and the contents exposed. During weekly surveillance the compromised drum would be detected and corrective measures taken allowing for only a small window of time in which an open flame could ignite the exposed contents. Based on a one weak window of time, this basic event has an annual probability of $1.9\text{E-}04$.
26. Material in Container Capable Of Generating Static Electricity. This basic event is assigned an annual probability of $5.00\text{E-}01$.
27. Container Is Jarred. Containers are jarred by being dropped, a vehicle bumping into it, or the crane swinging it into a solid object such as another drum. Any one of these initiators result from human error and has an annual probability of $1.00\text{E-}02$.
28. Container Is Dropped By Crane. Because the crane has scheduled maintenance and inspection, this is considered to be an unlikely event ($1.00\text{E-}02$ to $1.00\text{E-}04$); therefore, an annual probability of $1.00\text{E-}02$ is assigned to this event.
29. Container Is Dropped By Forklift. Because the forklift has scheduled maintenance and inspection, this is considered to be an unlikely event with an annual probability of $1.00\text{E-}02$.

30. Energy From Impact Ignites Hydrogen/Oxygen Mixture. The minimum ignition energy for hydrogen in air is only 0.02 mJ, therefore, the annual probability of this basic event is 1.00E+00
31. Container Contains Sufficient Organic For Fire. The exact content of each container is not known; therefore it is assumed the containers contain sufficient organic to sustain a fire. This event has an assigned annual probability of 1.00E+00.
32. Lightning. A fire in the solid waste burial ground resulting from lightning is given an annual probability of 3.3E-02 (ERDA 1975). This probability is based on the disposal of solid waste in cardboard boxes and not steel drums. Before lightning could ignite the contents of a drum, the drum would have to be compromised and the contents exposed. During weekly surveillance the compromised drum would be detected and corrective measures taken allowing for only a small window of time in which lightning could ignite the exposed contents. Based on a one week window of time this basic event has an annual probability of 6.3E-04.
33. Range Fire. This basic event is assigned an annual probability of 2.00E-03 (ERDA 1975). Before a range fire could ignite the contents of a drum, the drum would have to be compromised and the contents exposed. During weekly surveillance the compromised drum would be detected and corrective measures taken allowing for only a small window of time in which a range fire could ignite the exposed contents. Based on a one week window of time this basic event has an annual probability of 3.8E-05.
34. Range Fire Spreads Into Trench Igniting Contents Of Breached Containers. Although plant growth is controlled in the Solid Waste Burial Ground, winds carry tumble weeds into the area where they collect in the trenches. Wood containers and plywood sheeting are also found in the trenches. Weekly inspections include housekeeping at which time weeds are removed. Failure to maintain good housekeeping would be an operator error. Based on standard human reliability, this basic event is assigned an annual probability of 1.00E-02.
35. Vehicle On Fire Crashes Into Containers Igniting Contents Of Breached Container. The frequency of a DOE reportable truck accident resulting from a vehicle fire during operation on the Hanford Site of a magnitude that could breach drums is calculated to be 3.6E-08 per mile (WHC-SD-TP-RPT-007 Rev. 0 1993). Annual mileage for drum handling equipment at the low level burial ground is conservatively assumed to be 15,000 miles; therefore, the annual frequency of such an accident in the LLW or LLMW trenches is calculated to be 5.4E-04. Traffic at the TRU trenches with exposed TRU drums is restricted. There are 888 drums in Trench 29. If each drum is removed from the trench with a forklift, the forklift would travel a conservation estimate of 1/4 mile round trip/drum. If all 888 drums are removed from the trench in a given year the annual mileage would be 222 miles/yr. The annual frequency is therefore calculated to be 3.6E-08/mile x 222 miles/yr = 8.0E-06/yr.

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MODULE/EVENT NAME	DESCRIPTION	RATE	EXPOSURE	B.E. PROB.	MOD./CS. PROB.
1) TOP					*2.66E-06
1) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	1.15E-06
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.6E-03	4.60E-03	
204	OPERATOR FAILED TO INSTALL VENT CLIP		1.0E-03	1.00E-03	
207	CONTAINER IS EXPOSED TO SOLAR RADIATION		1.0E+00	1.00E+00	
209	SUFFICIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER		2.50E-01	2.50E-01	
210	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
225	GAS IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	
2) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	1.15E-06
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.6E-03	4.60E-03	
203	VENT CLIP IS DAMMAGED		1.0E-03	1.00E-03	
207	CONTAINER IS EXPOSED TO SOLAR RADIATION		1.0E+00	1.00E+00	
209	SUFFICIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER		2.50E-01	2.50E-01	
210	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
225	GAS IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	
3) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	5.98E-08
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.6E-03	4.60E-03	
204	OPERATOR FAILED TO INSTALL VENT CLIP		1.0E-03	1.00E-03	
210	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
215	EQUIPMENT CRASHES INTO CONTAINERS		1.3E-02	1.30E-02	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
4) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	5.98E-08
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.6E-03	4.60E-03	
203	VENT CLIP IS DAMMAGED		1.0E-03	1.00E-03	
210	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
215	EQUIPMENT CRASHES INTO CONTAINERS		1.3E-02	1.30E-02	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
5) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	4.60E-08
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.6E-03	4.60E-03	
203	VENT CLIP IS DAMMAGED		1.0E-03	1.00E-03	
210	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
217	CONTAINER IS DROPPED BY CRANE		1.0E-02	1.00E-02	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
6) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	4.60E-08
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.6E-03	4.60E-03	
204	OPERATOR FAILED TO INSTALL VENT CLIP		1.0E-03	1.00E-03	
210	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
218	CONTAINER IS DROPPED BY FORKLIFT		1.0E-02	1.00E-02	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
7) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	4.60E-08
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.6E-03	4.60E-03	
203	VENT CLIP IS DAMMAGED		1.0E-03	1.00E-03	
210	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
218	CONTAINER IS DROPPED BY FORKLIFT		1.0E-02	1.00E-02	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
8) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	4.60E-08
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.6E-03	4.60E-03	
204	OPERATOR FAILED TO INSTALL VENT CLIP		1.0E-03	1.00E-03	
210	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
217	CONTAINER IS DROPPED BY CRANE		1.0E-02	1.00E-02	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
9) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	2.30E-08
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.6E-03	4.60E-03	
204	OPERATOR FAILED TO INSTALL VENT CLIP		1.0E-03	1.00E-03	
210	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
222	CONTAINER IS JARRED		1.00E-02	1.00E-02	
223	MATERIAL IN CONTAINER CAPABLE OF GENERATING STATIC ELECTRICITY		5.00E-01	5.00E-01	
10) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	2.30E-08
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.6E-03	4.60E-03	
203	VENT CLIP IS DAMMAGED		1.0E-03	1.00E-03	
210	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
222	CONTAINER IS JARRED		1.00E-02	1.00E-02	
223	MATERIAL IN CONTAINER CAPABLE OF GENERATING STATIC ELECTRICITY		5.00E-01	5.00E-01	
11) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	4.60E-09
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.6E-03	4.60E-03	
204	OPERATOR FAILED TO INSTALL VENT CLIP		1.0E-03	1.00E-03	

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MODULE/EVENT NAME	DESCRIPTION	RATE	EXPOSURE	B.E. PROB.	MOD./CS. PROB.
Z10	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
Z16	EARTHQUAKE		1.0E-03	1.00E-03	
Z21	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
12) Z01	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	4.60E-09
Z02	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.6E-03	4.60E-03	
Z03	VENT CLIP IS DAMMAGED		1.00E-03	1.00E-03	
Z10	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
Z16	EARTHQUAKE		1.0E-03	1.00E-03	
Z21	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
13) Z01	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	4.60E-10
Z02	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.6E-03	4.60E-03	
Z04	OPERATOR FAILED TO INSTALL VENT CLIP		1.0E-03	1.00E-03	
Z10	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
Z19	HIGH WINDS		1.0E-02	1.00E-02	
Z20	AVAILABLE PROJECTILE		1.0E-02	1.00E-02	
Z21	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
14) Z01	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	4.60E-10
Z02	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.6E-03	4.60E-03	
Z03	VENT CLIP IS DAMMAGED		1.00E-03	1.00E-03	
Z10	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
Z19	HIGH WINDS		1.0E-02	1.00E-02	
Z20	AVAILABLE PROJECTILE		1.0E-02	1.00E-02	
Z21	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	

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B01	1	3						
C01	1	2						
C02	1	4						
D01	1	1						
D01	2	4						
D02	1	2						
D02	3	3						
D03	1	3						
D03	4	2						
D04	1	3						
D04	5	3						
E01	2	1						
E02	2	5						
E03	3	3						
E04	4	1						
E05	4	3						
F01	2	3						
TOP	1	3						
Z01	1	4						
Z02	2	1						
Z03	2	2						
Z04	3	1						
Z05	3	2						
Z06	3	3						
Z07	3	4						
Z08	4	1						
Z09	4	2						
Z10	5	1						
Z11	5	2						
Z12	1	4						
Z13	1	4						
Z14	2	5						
Z15	2	5						
Z16	3	4						
Z17	4	3						
Z18	4	4						
Z19	2	3						
Z20	2	4						
Z21	2	6						
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MODULE/EVENT NAME	DESCRIPTION	RATE	EXPOSURE	B.E. PROB.	MOD./CS. PROB.
1) TOP					*6.30E-02
1) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	1.30E-02
Z12	EQUIPMENT CRASHES INTO CONTAINERS		1.3E-02	1.30E-02	
2) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	1.00E-02
Z18	OPERATOR ERROR		1.00E-02	1.00E-02	
3) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	1.00E-02
Z08	CRANE FAILURE		1.0E-02	1.00E-02	
4) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	1.00E-02
Z09	OPERATOR ERROR		1.0E-02	1.00E-02	
5) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	1.00E-02
Z17	FORKLIFT FAILURE		1.00E-02	1.00E-02	
6) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	1.00E-02
Z14	CONTAINER EXPOSED TO CORROSIVE ENVIRONMENT		1.00E+00	1.00E+00	
Z15	CONTAINER CORRODES		1.00E+00	1.00E+00	
Z21	CONTAINER NOT BURIED WITHIN 20 YR OF TRENCH IMPLACEMENT		1.0E-02	1.00E-02	
7) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	1.00E-03
Z13	EARTHQUAKE TOPPLES CONTAINER FROM STACK		1.0E-03	1.00E-03	
8) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	2.50E-04
Z04	CONTAINER IS EXPOSED TO SOLAR RADIATION		1.0E+00	1.00E+00	
Z05	GAS IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	
Z06	VENT CLIP IS PLUGGED OR DAMMAGED		1.0E-03	1.00E-03	
Z07	SUFFICIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER		2.50E-01	2.50E-01	
9) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	2.50E-04
Z04	CONTAINER IS EXPOSED TO SOLAR RADIATION		1.0E+00	1.00E+00	
Z05	GAS IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	
Z07	SUFFICIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER		2.50E-01	2.50E-01	
Z16	OPERATOR FAILS TO INSTALL VENT CLIP		1.00E-03	1.00E-03	
10) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	1.00E-04
Z02	CORROSIVE CHEMICALS ARE DISCARDED IN CONTAINER		1.00E-02	1.00E-02	
Z03	CORROSIVE CHEMICALS CORRODE CONTAINER		1.00E+00	1.00E+00	
Z20	LINER IS DEFECTIVE		1.00E-02	1.00E-02	
11) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	1.00E-04
Z10	HIGH WIND		1.0E-02	1.00E-02	
Z11	AVAILABLE PROJECTILE		1.0E-02	1.00E-02	
12) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	1.00E-05
Z02	CORROSIVE CHEMICALS ARE DISCARDED IN CONTAINER		1.00E-02	1.00E-02	
Z03	CORROSIVE CHEMICALS CORRODE CONTAINER		1.00E+00	1.00E+00	
Z19	OPERATOR FAILS TO PLACE LINER IN CONTAINER		1.00E-03	1.00E-03	

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B02	1	4	Z25	3	3						
C01	1	3	Z26	3	4						
C02	1	4	Z27	5	1						
C02	6	4	Z28	5	2						
D01	1	3	Z29	5	3						
D01	2	3	Z30	5	4						
D02	1	4	Z31	5	5						
D02	3	3	Z32	4	1						
D03	6	2	Z33	4	2						
D04	6	4	Z34	3	4						
E01	2	2									
E02	2	4									
E03	6	3									
E04	3	3									
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E05	5	2									
F01	2	3									
F02	2	5									
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F04	3	4									
F05	5	4									
G01	3	2									
G01	4	1									
TOP	1	3									
Z01	1	1									
Z02	6	4									
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Z04	6	3									
Z05	6	4									
Z07	1	2									
Z08	1	5									
Z09	2	5									
Z10	2	1									
Z11	2	2									
Z12	2	3									
Z13	2	4									
Z14	2	5									
Z15	2	6									
Z17	6	5									
Z18	6	6									
Z19	6	6									
Z20	6	8									
Z21	6	1									
Z22	6	2									
Z23	3	1									
LOW LEVEL WASTE FIRE IN SWBG			.\TREES\LLW-FIRE.CAF			6-16-94			Page 7		

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MODULE/EVENT NAME	DESCRIPTION	RATE	EXPOSURE	B.E. PROB.	MOD./CS. PROB.
1) TOP					*6.09E-04
1) Z01	CONTAINER FAILURE RESULTING FROM IMPACT	1.0E+00	1.00E+00	5.40E-04	
Z07	IGNITED VEHICLE CRASHES INTO CONTAINERS IGNITING BREACHED CONTAINER CONT	5.4E-04	5.40E-04		
2) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	6.30E-06	
Z20	LIGHTNING	6.3E-04	6.30E-04		
Z25	CONTAINER EXPOSED TO CORROSIVE ENVIRONMENT	1.00E+00	1.00E+00		
Z26	CONTAINER CORRODES	1.00E+00	1.00E+00		
Z34	CONTAINER NOT BURIED WITHIN 20 YR OF TRENCH IMPLACEMENT	1.00E-02	1.00E-02		
3) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	6.30E-06	
Z12	CRANE FAILURE	1.0E-02	1.00E-02		
Z20	LIGHTNING	6.3E-04	6.30E-04		
4) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	6.30E-06	
Z15	OPERATOR ERROR	1.0E-02	1.00E-02		
Z20	LIGHTNING	6.3E-04	6.30E-04		
5) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	6.30E-06	
Z14	FORK LIFT FAILURE	1.0E-02	1.00E-02		
Z20	LIGHTNING	6.3E-04	6.30E-04		
6) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	6.30E-06	
Z13	OPERATOR ERROR	1.0E-02	1.00E-02		
Z20	LIGHTNING	6.3E-04	6.30E-04		
7) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	3.30E-06	
Z15	OPERATOR ERROR	1.0E-02	1.00E-02		
Z19	CARELESSLY THROWN CIGARETTE	3.3E-04	3.30E-04		
8) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	3.30E-06	
Z12	CRANE FAILURE	1.0E-02	1.00E-02		
Z19	CARELESSLY THROWN CIGARETTE	3.3E-04	3.30E-04		
9) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	3.30E-06	
Z13	OPERATOR ERROR	1.0E-02	1.00E-02		
Z17	SPONTANEOUS COMBUSTION	3.3E-04	3.30E-04		
10) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	3.30E-06	
Z12	CRANE FAILURE	1.0E-02	1.00E-02		
Z17	SPONTANEOUS COMBUSTION	3.3E-04	3.30E-04		
11) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	3.30E-06	
Z13	OPERATOR ERROR	1.0E-02	1.00E-02		
Z19	CARELESSLY THROWN CIGARETTE	3.3E-04	3.30E-04		
12) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	3.30E-06	
Z14	FORK LIFT FAILURE	1.0E-02	1.00E-02		
Z19	CARELESSLY THROWN CIGARETTE	3.3E-04	3.30E-04		
13) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	3.30E-06	
Z19	CARELESSLY THROWN CIGARETTE	3.3E-04	3.30E-04		
Z25	CONTAINER EXPOSED TO CORROSIVE ENVIRONMENT	1.00E+00	1.00E+00		
Z26	CONTAINER CORRODES	1.00E+00	1.00E+00		
Z34	CONTAINER NOT BURIED WITHIN 20 YR OF TRENCH IMPLACEMENT	1.00E-02	1.00E-02		
14) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	3.30E-06	
Z15	OPERATOR ERROR	1.0E-02	1.00E-02		
Z17	SPONTANEOUS COMBUSTION	3.3E-04	3.30E-04		
15) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	3.30E-06	
Z14	FORK LIFT FAILURE	1.0E-02	1.00E-02		
Z17	SPONTANEOUS COMBUSTION	3.3E-04	3.30E-04		
16) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	3.30E-06	
Z17	SPONTANEOUS COMBUSTION	3.3E-04	3.30E-04		
Z25	CONTAINER EXPOSED TO CORROSIVE ENVIRONMENT	1.00E+00	1.00E+00		
Z26	CONTAINER CORRODES	1.00E+00	1.00E+00		
Z34	CONTAINER NOT BURIED WITHIN 20 YR OF TRENCH IMPLACEMENT	1.00E-02	1.00E-02		
17) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	6.30E-07	
Z09	EARTHQUAKE TOPPLES CONTAINER FROM STACK	1.0E-03	1.00E-03		
Z20	LIGHTNING	6.3E-04	6.30E-04		
18) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	3.90E-07	
Z18	FUEL DRIVEN EQUIPMENT BURSTS INTO FLAME	3.9E-05	3.90E-05		
Z25	CONTAINER EXPOSED TO CORROSIVE ENVIRONMENT	1.00E+00	1.00E+00		
Z26	CONTAINER CORRODES	1.00E+00	1.00E+00		
Z34	CONTAINER NOT BURIED WITHIN 20 YR OF TRENCH IMPLACEMENT	1.00E-02	1.00E-02		
19) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	3.90E-07	
Z13	OPERATOR ERROR	1.0E-02	1.00E-02		
Z18	FUEL DRIVEN EQUIPMENT BURSTS INTO FLAME	3.9E-05	3.90E-05		
20) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	3.90E-07	
Z15	OPERATOR ERROR	1.0E-02	1.00E-02		
Z18	FUEL DRIVEN EQUIPMENT BURSTS INTO FLAME	3.9E-05	3.90E-05		
21) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.0E+00	1.00E+00	3.90E-07	
Z12	CRANE FAILURE	1.0E-02	1.00E-02		

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Truncation Limit: 1.00E-08

MODULE/EVENT NAME	DESCRIPTION	RATE	EXPOSURE	B.E. PROB.	MOD./CS. PROB.
218	FUEL DRIVEN EQUIPMENT BURSTS INTO FLAME		3.9E-05	3.90E-05	
22) 208	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.0E+00	1.00E+00	3.90E-07
214	FORK LIFT FAILURE		1.0E-02	1.00E-02	
218	FUEL DRIVEN EQUIPMENT BURSTS INTO FLAME		3.9E-05	3.90E-05	
23) 208	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.0E+00	1.00E+00	3.30E-07
209	EARTHQUAKE TOPPLES CONTAINER FROM STACK		1.0E-03	1.00E-03	
217	SPONTANEOUS COMBUSTION		3.3E-04	3.30E-04	
24) 208	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.0E+00	1.00E+00	3.30E-07
209	EARTHQUAKE TOPPLES CONTAINER FROM STACK		1.0E-03	1.00E-03	
219	CARELESSLY THROWN CIGARETTE		3.3E-04	3.30E-04	
25) 208	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.0E+00	1.00E+00	1.58E-07
220	LIGHTNING		6.3E-04	6.30E-04	
227	CONTAINER IS EXPOSED TO SOLAR RADIATION		1.00E+00	1.00E+00	
228	GAS IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	
229	SUFFICIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER		2.5E-01	2.50E-01	
230	VENT CLIP IS PLUGGED OR DAMAGED		1.00E-03	1.00E-03	
26) 208	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.0E+00	1.00E+00	1.58E-07
220	LIGHTNING		6.3E-04	6.30E-04	
227	CONTAINER IS EXPOSED TO SOLAR RADIATION		1.00E+00	1.00E+00	
228	GAS IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	
229	SUFFICIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER		2.5E-01	2.50E-01	
231	OPERATOR FAILS TO INSTALL VENT CLIP		1.00E-03	1.00E-03	
27) 208	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.0E+00	1.00E+00	8.25E-08
217	SPONTANEOUS COMBUSTION		3.3E-04	3.30E-04	
227	CONTAINER IS EXPOSED TO SOLAR RADIATION		1.00E+00	1.00E+00	
228	GAS IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	
229	SUFFICIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER		2.5E-01	2.50E-01	
231	OPERATOR FAILS TO INSTALL VENT CLIP		1.00E-03	1.00E-03	
28) 208	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.0E+00	1.00E+00	8.25E-08
217	SPONTANEOUS COMBUSTION		3.3E-04	3.30E-04	
227	CONTAINER IS EXPOSED TO SOLAR RADIATION		1.00E+00	1.00E+00	
228	GAS IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	
229	SUFFICIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER		2.5E-01	2.50E-01	
230	VENT CLIP IS PLUGGED OR DAMAGED		1.00E-03	1.00E-03	
29) 208	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.0E+00	1.00E+00	8.25E-08
219	CARELESSLY THROWN CIGARETTE		3.3E-04	3.30E-04	
227	CONTAINER IS EXPOSED TO SOLAR RADIATION		1.00E+00	1.00E+00	
228	GAS IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	
229	SUFFICIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER		2.5E-01	2.50E-01	
231	OPERATOR FAILS TO INSTALL VENT CLIP		1.00E-03	1.00E-03	
30) 208	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.0E+00	1.00E+00	8.25E-08
219	CARELESSLY THROWN CIGARETTE		3.3E-04	3.30E-04	
227	CONTAINER IS EXPOSED TO SOLAR RADIATION		1.00E+00	1.00E+00	
228	GAS IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	
229	SUFFICIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER		2.5E-01	2.50E-01	
230	VENT CLIP IS PLUGGED OR DAMAGED		1.00E-03	1.00E-03	
31) 208	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.0E+00	1.00E+00	6.30E-08
210	HIGH WIND		1.0E-02	1.00E-02	
211	AVAILABLE PROJECTILE		1.0E-02	1.00E-02	
220	LIGHTNING		6.3E-04	6.30E-04	
32) 208	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.0E+00	1.00E+00	6.30E-08
220	LIGHTNING		6.3E-04	6.30E-04	
223	CORROSIVE CHEMICALS ARE DISCARDED IN CONTAINER		1.00E-02	1.00E-02	
224	CORROSIVE CHEMICALS CORRODE CONTAINER		1.00E+00	1.00E+00	
233	LINER IS DEFFECTIVE		1.00E-02	1.00E-02	
33) 208	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.0E+00	1.00E+00	3.90E-08
209	EARTHQUAKE TOPPLES CONTAINER FROM STACK		1.0E-03	1.00E-03	
218	FUEL DRIVEN EQUIPMENT BURSTS INTO FLAME		3.9E-05	3.90E-05	
34) 208	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.0E+00	1.00E+00	3.30E-08
217	SPONTANEOUS COMBUSTION		3.3E-04	3.30E-04	
223	CORROSIVE CHEMICALS ARE DISCARDED IN CONTAINER		1.00E-02	1.00E-02	
224	CORROSIVE CHEMICALS CORRODE CONTAINER		1.00E+00	1.00E+00	
233	LINER IS DEFFECTIVE		1.00E-02	1.00E-02	
35) 208	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.0E+00	1.00E+00	3.30E-08
210	HIGH WIND		1.0E-02	1.00E-02	
211	AVAILABLE PROJECTILE		1.0E-02	1.00E-02	
217	SPONTANEOUS COMBUSTION		3.3E-04	3.30E-04	
36) 208	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.0E+00	1.00E+00	3.30E-08
219	CARELESSLY THROWN CIGARETTE		3.3E-04	3.30E-04	
223	CORROSIVE CHEMICALS ARE DISCARDED IN CONTAINER		1.00E-02	1.00E-02	

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MODULE/EVENT NAME	DESCRIPTION	RATE	EXPOSURE	B.E. PROB.	MOD./CS. PROB.
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Z24	CORROSIVE CHEMICALS CORRODE CONTAINER		1.00E+00	1.00E+00	
Z33	LINER IS DEFFECTIVE		1.00E-02	1.00E-02	
37) Z08	BREACHED CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.0E+00	1.00E+00	3.30E-08
Z10	HIGH WIND		1.0E-02	1.00E-02	
Z11	AVAILABLE PROJECTILE		1.0E-02	1.00E-02	
Z19	CARELESSLY THROWN CIGARETTE		3.3E-04	3.30E-04	

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B01	1	2									
B02	1	5									
C02	1	5									
C03	1	6									
C03	5	2									
D01	1	3									
D03	1	5									
D03	2	4									
D04	1	6									
D04	4	1									
D05	5	2									
E01	2	3									
E02	2	5									
F01	2	6									
F01	3	1									
F02	2	2									
TOP	1	5									
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Z02	1	2									
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Z17	5	1									
Z18	5	2									
Z20	5	3									
Z21	1	7									
Z24	2	5									
Z25	2	4									

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MODULE/EVENT NAME	DESCRIPTION	RATE	EXPOSURE	B.E. PROB.	MOD./CS. PROB.
1) TOP					*2.36E-06
1) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	1.15E-06
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.60E-03	4.60E-03	
204	OPERATOR FAILED TO INSTALL VENT CLIP		1.00E-03	1.00E-03	
207	CONTAINER IS EXPOSED TO SOLAR RADIATION		1.00E+00	1.00E+00	
209	SUFFICIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER		2.50E-01	2.50E-01	
215	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
225	GAS IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	
2) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	1.15E-06
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.60E-03	4.60E-03	
203	VENT CLIP IS DAMAGED		1.00E-03	1.00E-03	
207	CONTAINER IS EXPOSED TO SOLAR RADIATION		1.00E+00	1.00E+00	
209	SUFFICIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER		2.50E-01	2.50E-01	
215	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
225	GAS IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	
3) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	2.30E-08
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.60E-03	4.60E-03	
204	OPERATOR FAILED TO INSTALL VENT CLIP		1.00E-03	1.00E-03	
210	MATERIAL IN CONTAINER CAPABLE OF GENERATING STATIC ELECTRICITY		5.00E-01	5.00E-01	
211	CONTAINER IS JARRED		1.00E-02	1.00E-02	
215	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
4) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	2.30E-08
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.60E-03	4.60E-03	
203	VENT CLIP IS DAMAGED		1.00E-03	1.00E-03	
210	MATERIAL IN CONTAINER CAPABLE OF GENERATING STATIC ELECTRICITY		5.00E-01	5.00E-01	
211	CONTAINER IS JARRED		1.00E-02	1.00E-02	
215	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
5) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	4.60E-09
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.60E-03	4.60E-03	
203	VENT CLIP IS DAMAGED		1.00E-03	1.00E-03	
215	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
216	SEISMIC ACTIVITY TOPPLES CONTAINER FROM STACK		1.00E-03	1.00E-03	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
6) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	4.60E-09
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.60E-03	4.60E-03	
204	OPERATOR FAILED TO INSTALL VENT CLIP		1.00E-03	1.00E-03	
215	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
216	SEISMIC ACTIVITY TOPPLES CONTAINER FROM STACK		1.00E-03	1.00E-03	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
7) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	4.60E-10
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.60E-03	4.60E-03	
203	VENT CLIP IS DAMAGED		1.00E-03	1.00E-03	
215	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
217	HIGH WIND		1.00E-02	1.00E-02	
218	PROJECTILE		1.00E-02	1.00E-02	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
8) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	4.60E-10
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.60E-03	4.60E-03	
204	OPERATOR FAILED TO INSTALL VENT CLIP		1.00E-03	1.00E-03	
215	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
217	HIGH WIND		1.00E-02	1.00E-02	
218	PROJECTILE		1.00E-02	1.00E-02	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
9) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	2.12E-10
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.60E-03	4.60E-03	
203	VENT CLIP IS DAMAGED		1.00E-03	1.00E-03	
215	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
220	OPERATOR CRASHES EQUIPMENT INTO CONTAINERS		4.6E-05	4.60E-05	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00	
10) 201	HYDROGEN IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	2.12E-10
202	HYDROGEN REACHES EXPLOSIVE CONCENTRATION WITH OXYGEN		4.60E-03	4.60E-03	
204	OPERATOR FAILED TO INSTALL VENT CLIP		1.00E-03	1.00E-03	
215	CONTAINER FAILS AS A RESULT OF IMPACT		1.00E+00	1.00E+00	
220	OPERATOR CRASHES EQUIPMENT INTO CONTAINERS		4.6E-05	4.60E-05	
221	ENERGY FROM IMPACT IGNITES HYDROGEN/OXYGEN MIXTURE		1.00E+00	1.00E+00

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B01	1	3									
C01	1	2									
C02	1	4									
D02	1	1									
D02	2	1									
D03	1	3									
D03	3	4									
D04	1	4									
D04	4	2									
E01	3	2									
E02	3	5									
E03	4	3									
F01	3	3									
TOP	1	3									
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Z12	4	2									
Z13	4	3									
Z14	4	4									
Z15	4	4									
Z17	3	3									
Z18	3	4									
Z19	3	6									

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MODULE/EVENT NAME	DESCRIPTION	RATE	EXPOSURE	B.E. PROB.	MOD./CS. PROB.
1) TOP					*1.17E-02
1) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	1.00E-02
Z09	CONTAINER EXPOSED TO CORROSIVE ENVIRONMENT		1.00E+00	1.00E+00	
Z10	CONTAINER CORRODES		1.00E+00	1.00E+00	
Z19	CONTAINER NOT RETRIEVED WITHIN 20 YR OF TRENCH IMPLACEMENT		1.00E-02	1.00E-02	
2) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	1.00E-03
Z02	EARTHQUAKE TOPPLES CONTAINER FROM STACK		1.0E-03	1.00E-03	
3) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	2.50E-04
Z11	CONTAINER IS EXPOSED TO SOLAR RADIATION		1.00E+00	1.00E+00	
Z12	GAS IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	
Z13	VENT CLIP IS PLUGGED OR DAMMAGED		1.00E-03	1.00E-03	
Z14	SUFFECIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER		2.5E-01	2.50E-01	
4) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	2.50E-04
Z11	CONTAINER IS EXPOSED TO SOLAR RADIATION		1.00E+00	1.00E+00	
Z12	GAS IS GENERATED IN CONTAINER		1.00E+00	1.00E+00	
Z14	SUFFECIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER		2.5E-01	2.50E-01	
Z15	OPERATOR FAILS TO INSTALL VENT CLIP		1.00E-03	1.00E-03	
5) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	1.00E-04
Z07	CORROSIVE CHEMICALS ARE DISCARDED IN CONTAINER		1.0E-02	1.00E-02	
Z08	CORROSIVE CHEMICAL CORRODES CONTAINER		1.00E+00	1.00E+00	
Z18	LINER IS DEFFECTIVE		1.00E-02	1.00E-02	
6) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	1.00E-04
Z05	HIGH WIND		1.00E-02	1.00E-02	
Z06	AVAILABLE PROJECTILE		1.00E-02	1.00E-02	
7) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	4.60E-05
Z04	VEHICLE CRASHES INTO CONTAINERS		4.6E-05	4.60E-05	
8) Z01	CONTAINER FAILURE		1.00E+00	1.00E+00	1.00E-05
Z07	CORROSIVE CHEMICALS ARE DISCARDED IN CONTAINER		1.0E-02	1.00E-02	
Z08	CORROSIVE CHEMICAL CORRODES CONTAINER		1.00E+00	1.00E+00	
Z17	OPERATOR FAILS TO PLACE LINER IN CONTAINER		1.00E-03	1.00E-03

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A01	1	3									
B01	1	2									
B02	1	4									
C01	1	1									
C01	2	2									
C02	1	2									
C02	3	3									
C04	1	4									
C04	6	1									
D02	2	2									
D03	3	3									
D04	3	4									
D04	5	2									
E01	3	2									
E02	3	4									
E03	5	4									
F01	3	2									
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TOP	1	4									
Z01	1	5									
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Z23	5	4									
Z24	5	5									
Z25	4	1									
Z26	4	2									
Z27	3	4									
TRU DRUM FIRE IN SWBG			.\TREES\TRU-FIRE.CAF			6-16-94			Page 7		

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MODULE/EVENT NAME	DESCRIPTION	RATE	EXPOSURE	B.E. PROB.	MOD./CS. PROB.
1) TOP					*1.71E-05
1) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.00E+00	1.00E+00		6.30E-06
Z09	CONTAINER IS EXPOSED TO CORROSIVE ENVIRONMENT	1.00E+00	1.00E+00		
Z10	CONTAINER CORRODES	1.00E+00	1.00E+00		
Z12	LIGHTNING	6.30E-04	6.30E-04		
Z27	CONTAINER NOT RETRIEVED WITHIN 20 YR OF TRENCH IMPLACEMENT	1.0E-02	1.00E-02		
2) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.00E+00	1.00E+00		3.30E-06
Z09	CONTAINER IS EXPOSED TO CORROSIVE ENVIRONMENT	1.00E+00	1.00E+00		
Z10	CONTAINER CORRODES	1.00E+00	1.00E+00		
Z13	SPONTANIOUS COMBUSTION RESULTING FROM REACTIVE CHEMICALS	3.30E-04	3.30E-04		
Z27	CONTAINER NOT RETRIEVED WITHIN 20 YR OF TRENCH IMPLACEMENT	1.0E-02	1.00E-02		
3) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.00E+00	1.00E+00		3.30E-06
Z09	CONTAINER IS EXPOSED TO CORROSIVE ENVIRONMENT	1.00E+00	1.00E+00		
Z10	CONTAINER CORRODES	1.00E+00	1.00E+00		
Z11	CARELESSLY THROWN CIGARETTE	3.30E-04	3.30E-04		
Z27	CONTAINER NOT RETRIEVED WITHIN 20 YR OF TRENCH IMPLACEMENT	1.0E-02	1.00E-02		
4) Z03	IGNITED VEHICLE CRASHES INTO CONTAINERS IGNITING BREACHED CONTAINER CONT	1.90E-06	1.90E-06		1.90E-06
5) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.00E+00	1.00E+00		6.30E-07
Z02	EARTHQUAKE TOPPLES CONTAINER FROM STACK	1.00E-03	1.00E-03		
Z12	LIGHTNING	6.30E-04	6.30E-04		
6) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.00E+00	1.00E+00		3.30E-07
Z02	EARTHQUAKE TOPPLES CONTAINER FROM STACK	1.00E-03	1.00E-03		
Z11	CARELESSLY THROWN CIGARETTE	3.30E-04	3.30E-04		
7) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.00E+00	1.00E+00		3.30E-07
Z02	EARTHQUAKE TOPPLES CONTAINER FROM STACK	1.00E-03	1.00E-03		
Z13	SPONTANIOUS COMBUSTION RESULTING FROM REACTIVE CHEMICALS	3.30E-04	3.30E-04		
8) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.00E+00	1.00E+00		1.58E-07
Z12	LIGHTNING	6.30E-04	6.30E-04		
Z20	CONTAINER IS EXPOSED TO SOLAR RADIATION	1.00E+00	1.00E+00		
Z21	GAS IS GENERATED IN CONTAINER	1.00E+00	1.00E+00		
Z22	SUFFICIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER	2.50E-01	2.50E-01		
Z23	VENT CLIP IS PLUGGED OR DAMMAGED	1.00E-03	1.00E-03		
9) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.00E+00	1.00E+00		1.58E-07
Z12	LIGHTNING	6.30E-04	6.30E-04		
Z20	CONTAINER IS EXPOSED TO SOLAR RADIATION	1.00E+00	1.00E+00		
Z21	GAS IS GENERATED IN CONTAINER	1.00E+00	1.00E+00		
Z22	SUFFICIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER	2.50E-01	2.50E-01		
Z24	OPERATOR FAILS TO INSTALL VENT CLIP	1.00E-03	1.00E-03		
10) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.00E+00	1.00E+00		8.25E-08
Z11	CARELESSLY THROWN CIGARETTE	3.30E-04	3.30E-04		
Z20	CONTAINER IS EXPOSED TO SOLAR RADIATION	1.00E+00	1.00E+00		
Z21	GAS IS GENERATED IN CONTAINER	1.00E+00	1.00E+00		
Z22	SUFFICIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER	2.50E-01	2.50E-01		
Z23	VENT CLIP IS PLUGGED OR DAMMAGED	1.00E-03	1.00E-03		
11) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.00E+00	1.00E+00		8.25E-08
Z11	CARELESSLY THROWN CIGARETTE	3.30E-04	3.30E-04		
Z20	CONTAINER IS EXPOSED TO SOLAR RADIATION	1.00E+00	1.00E+00		
Z21	GAS IS GENERATED IN CONTAINER	1.00E+00	1.00E+00		
Z22	SUFFICIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER	2.50E-01	2.50E-01		
Z24	OPERATOR FAILS TO INSTALL VENT CLIP	1.00E-03	1.00E-03		
12) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.00E+00	1.00E+00		8.25E-08
Z13	SPONTANIOUS COMBUSTION RESULTING FROM REACTIVE CHEMICALS	3.30E-04	3.30E-04		
Z20	CONTAINER IS EXPOSED TO SOLAR RADIATION	1.00E+00	1.00E+00		
Z21	GAS IS GENERATED IN CONTAINER	1.00E+00	1.00E+00		
Z22	SUFFICIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER	2.50E-01	2.50E-01		
Z24	OPERATOR FAILS TO INSTALL VENT CLIP	1.00E-03	1.00E-03		
13) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.00E+00	1.00E+00		8.25E-08
Z13	SPONTANIOUS COMBUSTION RESULTING FROM REACTIVE CHEMICALS	3.30E-04	3.30E-04		
Z20	CONTAINER IS EXPOSED TO SOLAR RADIATION	1.00E+00	1.00E+00		
Z21	GAS IS GENERATED IN CONTAINER	1.00E+00	1.00E+00		
Z22	SUFFICIENT SOLAR ENERGY TO EXPAND GAS GENERATED IN CONTAINER	2.50E-01	2.50E-01		
Z23	VENT CLIP IS PLUGGED OR DAMMAGED	1.00E-03	1.00E-03		
14) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.00E+00	1.00E+00		6.30E-08
Z07	CORROSIVE CHEMICALS ARE DISCARDED IN CONTAINER	1.00E-02	1.00E-02		
Z08	CORROSIVE CHEMICALS CORRODE CONTAINER	1.00E+00	1.00E+00		
Z12	LIGHTNING	6.30E-04	6.30E-04		
Z26	LINER IS DEFFECTIVE	1.0E-02	1.00E-02		
15) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE	1.00E+00	1.00E+00		6.30E-08
Z05	HIGH WIND	1.00E-02	1.00E-02		
Z06	AVAILABLE PROJECTILE	1.00E-02	1.00E-02		

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CUTSET REPORT

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MODULE/EVENT NAME	DESCRIPTION	RATE	EXPOSURE	B.E. PROB.	MOD./CS. PROB.
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	Z12 LIGHTNING		6.30E-04	6.30E-04	
16) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.00E+00	1.00E+00	3.30E-08
Z07	CORROSIVE CHEMICALS ARE DISCARDED IN CONTAINER		1.00E-02	1.00E-02	
Z08	CORROSIVE CHEMICALS CORRODE CONTAINER		1.00E+00	1.00E+00	
Z11	CARELESSLY THROWN CIGARETTE		3.30E-04	3.30E-04	
Z26	LINER IS DEFFECTIVE		1.0E-02	1.00E-02	
17) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.00E+00	1.00E+00	3.30E-08
Z05	HIGH WIND		1.00E-02	1.00E-02	
Z06	AVAILABLE PROJECTILE		1.00E-02	1.00E-02	
Z11	CARELESSLY THROWN CIGARETTE		3.30E-04	3.30E-04	
18) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.00E+00	1.00E+00	3.30E-08
Z07	CORROSIVE CHEMICALS ARE DISCARDED IN CONTAINER		1.00E-02	1.00E-02	
Z08	CORROSIVE CHEMICALS CORRODE CONTAINER		1.00E+00	1.00E+00	
Z13	SPONTANIOUS COMBUSTION RESULTING FROM REACTIVE CHEMICALS		3.30E-04	3.30E-04	
Z26	LINER IS DEFFECTIVE		1.0E-02	1.00E-02	
19) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.00E+00	1.00E+00	3.30E-08
Z05	HIGH WIND		1.00E-02	1.00E-02	
Z06	AVAILABLE PROJECTILE		1.00E-02	1.00E-02	
Z13	SPONTANIOUS COMBUSTION RESULTING FROM REACTIVE CHEMICALS		3.30E-04	3.30E-04	
20) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.00E+00	1.00E+00	2.90E-08
Z04	VEHICLE CRASHES INTO CONTAINERS		4.60E-05	4.60E-05	
Z12	LIGHTNING		6.30E-04	6.30E-04	
21) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.00E+00	1.00E+00	1.52E-08
Z04	VEHICLE CRASHES INTO CONTAINERS		4.60E-05	4.60E-05	
Z11	CARELESSLY THROWN CIGARETTE		3.30E-04	3.30E-04	
22) Z01	CONTAINER CONTAINS SUFFICIENT ORGANIC FOR FIRE		1.00E+00	1.00E+00	1.52E-08
Z04	VEHICLE CRASHES INTO CONTAINERS		4.60E-05	4.60E-05	
Z13	SPONTANIOUS COMBUSTION RESULTING FROM REACTIVE CHEMICALS		3.30E-04	3.30E-04	

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APPENDIX 6C
RELEASE FRACTION ANALYSES

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RELEASE FRACTION ANALYSIS

The three basic types of radiological contamination releases are:

1. Mechanical Release which frees the contaminate from the waste material to become airborne.
2. Fire Release
3. Explosion Release

Release fractions for accident scenarios involving these types of releases are developed in the appendix.

MECHANICAL RELEASE FRACTION

To determine the release fraction that might be released as a result of a mechanical release, NUREG/CR-1759 (NRC 1981) is utilized, which provides release fraction values for intruder and environmental effects mishaps for land disposal of low-level radioactive waste. The most dispersible waste form (I5=3) in Table E-1 derived from NUREG/CR-1759 is assumed to be equivalent to soil and is assumed in NUREG/CR-1759 to have a release fraction made airborne of 0.001 (0.1%). This value is believed to be very conservative (NRC 1981) and is the same as the dispersible fraction assumed for dispersion of powdered PuO_2 packages in transportation (including aircraft) accidents. This release fraction is multiplied by a factor which accounts for the relative dispersibility of the waste form as shown in Table C-1.

Waste forms which are assumed to have a low probability of dispersion are assigned an index of 0. Waste forms which tend to crumble or fracture extensively and are subject to relatively rapid (within about 100 years) decomposition in land burial are assigned an index of 2. As an example, unsolidified light water reactor resins would be assigned a dispersibility index (I5) of 2 (NRC 1981) after 100 years in land burial, resulting in an overall release fraction of $1.0 \text{ E-}04$. Given the nature of the contained materials being handled in the SWBG (paper, plastic, metals, rubber, etc., with surface and/or internal contamination) and the packaging (multiple wraps of plastics), a significant release is not readily achievable and the dispersibility of the contents should be quite low. A dispersibility index (I5) of 1 is utilized from Table C-1, yielding a release fraction of $1.0 \text{ E-}05$ that is released as respirable due to mechanical releases.

FIRE RELEASE FRACTION

For the respirable release fraction that might be achieved as a result of a fire, NUREG-1320 is utilized. Again considering the nature of the contained materials (paper, plastic, metals, rubber, etc., with surface and or internal contamination) and the packaging, a release fraction of $5.3 \text{ E-}04$ is given for the burning of contaminated combustible solids where the contaminant is

powder. A release fraction of 1.5 E-04 for the burning of liquid contaminated combustible solids is also given, but the more conservative value of 5.3 E-04 will be used in all cases of fire in this analysis.

EXPLOSION RELEASE FRACTION

Release fraction for an explosion is estimated as follows:

- 10% waste volume is directly released from the drum and dispersed.
- 10% of dispersed material is made airborne.
- 10% of airborne material is of respirable size.
- 100% of material released but not made airborne burns.
- 50% of waste remaining in the drum burns.
- 0.053% respirable of TRU is released from burned material (NRC 1988).

Table C-1. Dispersibility Index and Overall Release Fraction.

Dispersibility Index	Dispersibility	Multiplication Factor	Overall Release Fraction
3	severe	1	1.0 E-03
2	moderate	0.1	1.0 E-04
1	low to moderate	0.01	1.0 E-05
0	low	0.001	1.0 E-06

APPENDIX 6D
GENII CALCULATIONS

ATTACHMENT 1

BASELINE UNIT RELEASE DOSES AND X/Q VALUES

Baseline Unit Release Dose and X/Q Calculations for Accident Scenarios at the Solid Waste Burial Ground

M. A. Medsker
February 25, 1994

Summary

This report contains the baseline unit release doses and the atmospheric dispersion factors (X/Qs) for use in the evaluation of accident scenarios at the Solid Waste Burial Ground (SWBG). The X/Q results are given in Table 3. The baseline unit release dose results are given in Tables 4 and 5.

Introduction

The SWBG is responsible for the disposal and temporary storage of radioactive mixed waste (MW), Low-Level Waste (LLW), and Transuranic (TRU) waste in a number of below grade trenches. This report provides input into the calculation of dose consequences for the accident analyses associated with the SWBG. The document directly supported by this report is the SWBG Interim Safety Basis (ISB).

Although the SWBG is located in the both the 200 West and 200 East Areas of the Hanford Site, this report considers only accident scenarios which are assumed to occur in the 200 West Area. The exact locations covered in the 200 West Area by this report are discussed in more detail in the Receptor Description Section below.

Source Term Description

The isotopes and isotopic distributions used in the calculations in this report, and shown in Tables 1 and 4, were specified by the customer. The isotopes in Table 3 are taken from the *Mixed Waste Lined Landfill (Project W025) Preliminary Safety Analysis Report*, Table 6-1 (WHC 1992). The dose consequences of each isotope shown in Table 4 include the doses from the daughter products specified in Appendix E of the W025 PSAR (WHC 1992). The isotopic distribution in Table 1 is taken from the *Radioisotopic Characterization of Retrievably Stored Transuranic Waste Containers at the Hanford Site* (WHC 1993c), Table 2, 12% (Nominal) ^{240}Pu , 20 Year-Aged. Two one-gram baseline unit release doses are used to model TRU material in both soluble and insoluble forms.

Table 1: 12% (NOMINAL) ^{240}Pu , 20 YR AGED FOR 1 GRAM TRU

Isotope	Weight Fraction	Specific Activity ^a (Ci/g)	Amount of Each Isotope in One Gram of TRU ^a (Ci)
Pu-238	0.0008	17.12	1.37E-02
Pu-239	0.8395	0.062	5.20E-02
Pu-240	0.1297	0.227	2.94E-02
Pu-241	0.011	103	1.13E+00
Pu-242	0.0003	0.0039	1.17E-06
Am-241	0.0175	3.42	5.99E-02

^aFrom WHC-EP-0063, Appendix E, Table C-1 (WHC 1993b).

Receptor Description

Onsite:

Specified by the customer as the receptor at 100 m in the worst-case direction or the nearest occupied facility from the point of release. The size and geographic arrangement of the SWBG make it difficult to assume particular release points for SWBG facilities. Therefore, except for the locations noted below, it is assumed that all onsite receptors are 100 m from the release point in the direction which yields the greatest dispersion (X/Q) factor. The exceptions are: the 218W-4C-01, 218W-4C-20, 218W-4C-29 trenches; the mixed waste landfill; and the alpha caissons. For these locations, shown in Figure 1, the distance and direction to the next nearest facility which yields the greatest X/Q value is used. The resulting X/Q values are given in Table 3 in the Results Section, and independent safety concurrence is given in Attachment 4.

Offsite:

Specified by the customer to be the receptor at the Hanford Site boundary in the direction which yields the greatest X/Q value. Because of the size and arrangement of the SWBG, the offsite receptor distances were found from the approximate geographic center of the 200 West Area, subtracting 1 km in each sector. This makes a circle of release points 2 km in diameter around the approximate center of the 200 West Area. The resulting X/Q values are given in Table 3 in the Results Section.

Agricultural Area:
N/A.

Figure 1: Special Release Locations

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Transport and Dose Assumptions

The X/Q values in this report are based on an acute (accidental) releases and were calculated by the GXQ code in accordance with the methodology outlined in Reg. Guide 1.145 (NRC 1982). Credit was given for some dispersion phenomena, based on specified accident scenarios, as discussed below.

The models used to calculate the X/Q values reported here are dependent on the accident scenario specified by the customer. Three separate scenarios are identified: a single drum explosion, a vehicle impact with fire, and a vehicle impact without fire. Each scenario has different models to bound the dispersion of radioactive materials once they have been released. Those models used in the analysis which are different than the standard gaussian plume model are listed below for each scenario. The model inputs are also given.

Table 2: Dispersion Models and Inputs

Accident Scenario*	Models Used in Analysis	Inputs to Models Used
Single Drum Explosion Followed by Fire	MACCS Building Wake Model (to account for drum storage arrays) for Both Explosion and Fire X/Qs	Height = 10 ft (3 m) Width = 26 ft (7.9 m)
Vehicle Accident with Fire	5th Power Plume Meander MACCS Building Wake Model Plume Rise Based on Initial Plume Density Volumetric Flowrate Correction Elevation-Corrected Ambient Wind Speed	1 Hour Release Duration Height = 10 ft (3 m) Width = 26 ft (7.9 m) Effective Diameter of Fire = 3 m Initial Plume Vertical Velocity = 1 m/s Initial Plume Temperature = 1000 F None None
Vehicle Accident without Fire	None	None

* None of the dispersion models listed in Table 2 above are applicable to a release from the alpha caissons, regardless of the accident scenario. Therefore, the X/Q values reported in Table 3 for the alpha caissons are all identical, and correspond to a simple ground-level release.

The baseline unit release doses in this report were calculated by the GENII dosimetry code (Napier, et al 1988). All GENII runs were made with an input X/Q value of 1.0 s/m³ to obtain a unit dose which could be used with any of the X/Qs also in this report. The worst-case solubilities for the isotopes was used for all isotopes and isotopic distributions. In addition to the worst-case solubility, a run was made using the PNL solubilities for the isotopic distribution representing TRU material.

Dose Consequence Methodology

This report is intended to provide the customer with a simple and easy methodology for calculating the dose consequences from accidents at the SWBG. Provided here are X/Q values and baseline unit release doses which may be multiplied together to find unit release values corresponding to numerous release points and receptor locations.

To determine the dose consequences for a particular accident, the appropriate X/Q value is selected from Table 3 and multiplied by the appropriate baseline unit release dose in Table 4 or 5. This can then be multiplied by the amount of the material released in the accident (determined by the accident analysis) to determine the dose consequences. For example, an accidental release of Sr-90 from the Mixed Waste Landfill to the maximally exposed onsite individual would have a unit release dose of

$$\left(\frac{X}{Q}\right) \cdot (\text{Baseline Unit Release Dose}) = \text{Unit Release Dose}$$

$$\left(3.8E-04 \frac{s}{m^3}\right) \cdot \left(7.0E+01 \frac{\frac{rem\ EDE}{Ci}}{\frac{s}{m^3}}\right) = 2.7E-02 \frac{rem\ EDE}{Ci}$$

If it is assumed in this example that 10 Ci of Sr-90 were released as respirable particles from the accident, then the dose consequences would be

$$\begin{aligned} \text{Dose} &= (\text{Unit Release Dose}) \cdot (\text{Amount Released}) \\ &= \left(2.7E-02 \frac{rem\ EDE}{Ci}\right) \cdot (10\text{Ci}) \\ &= 2.7E-01\ rem\ EDE \end{aligned}$$

Results

X/Q Values:

The X/Q values for the various release points and receptor locations are provided in Table 3. The various onsite values are given first and the

offsite values second. For the onsite releases, multiple distances and directions are shown for some release locations to demonstrate that all possible receptors have been taken into account. Where this happens, the maximum value should be used as this represents the maximally exposed individuals. For example, for a release from the mixed waste landfill, four receptor locations are shown for a release to the onsite receptor. This means four receptors were tested to determine which would be bounding. The greatest X/Q should be used in the dose consequence calculations, with the corresponding facility becoming the location of the maximally exposed onsite receptor.

For the 100 m and offsite receptors, the 99.5% sector X/Q is compared to the 95% site-wide X/Q as per the Reg. Guide methodology. The greater of the two values should be used in dose consequence calculations. A site-wide 95% X/Q value is not calculated for the receptors of the other release locations because receptors were not specified for all sixteen sectors.

The maximum X/Q values for the specified release locations, and thus the values which should be used in dose consequence calculations, are followed by an asterisk in Table 3.

Sample GXQ output files are provided as Attachment 3 to this report.

Table 3: X/Q Values

Release Location	Receptor	Direction and Distance	Single Drum Explosion X/Q (s/m ³)	Vehicle Fire X/Q (s/m ³)	Vehicle Impact (No Fire) X/Q (s/m ³)
Mixed Waste Landfill	241-T	E @ 730 m	1.05 E-03*	2.68 E-04	1.16 E-03*
	241-T	ESE @ 730 m	9.81 E-04	2.94 E-04*	1.11 E-03
	231-Z	SE @ 820 m	7.61 E-04	7.09 E-05	8.63 E-04
	234-5Z	SSE @ 1000 m	3.86 E-04	7.04 E-06	3.19 E-04
Trench 01	234-5Z	ESE @ 120 m	1.25 E-02*	4.10 E-03*	2.36 E-02*
	231-Z	NE @ 240 m	3.03 E-03	2.03 E-04	3.43 E-03
Trench 20	234-5Z	NE @ 150 m	5.82 E-03*	4.37 E-04*	7.68 E-03*
Trench 29	234-5Z	NE @ 210 m	3.66 E-03*	2.53 E-04*	4.30 E-03*
Misc. Packages	NA	S @ 100 m	9.94 E-03	8.09 E-04	1.56 E-02
		SSW @ 100 m	6.04 E-03	7.44 E-04	1.13 E-02
		SW @ 100 m	6.60 E-03	4.72 E-05	1.21 E-02
		WSW @ 100 m	6.65 E-03	1.30 E-05	1.22 E-02
		W @ 100 m	1.06 E-02	6.09 E-05	2.80 E-02
		WNW @ 100 m	1.02 E-02	6.32 E-05	1.60 E-02
		NW @ 100 m	1.10 E-02	4.64 E-04	2.89 E-02
		NNW @ 100 m	1.11 E-02	1.10 E-03	2.90 E-02
		N @ 100 m	1.39 E-02	9.22 E-04	3.12 E-02
		NNE @ 100 m	9.67 E-03	5.26 E-04	1.54 E-02
		NE @ 100 m	9.90 E-03	8.42 E-04	1.57 E-02
		ENE @ 100 m	1.05 E-02	1.41 E-03	2.52 E-02
		E @ 100 m	1.76 E-02	4.86 E-03	3.41 E-02
		ESE @ 100 m	1.55 E-02	5.20 E-03*	3.25 E-02
		SE @ 100 m	1.33 E-02	1.84 E-03	3.07 E-02
		SSE @ 100 m	1.00 E-02	3.79 E-04	1.58 E-02
		Site Wide	1.80 E-02*	2.82 E-03	3.44 E-02*

Release Location	Receptor	Direction and Distance	Single Drum Explosion X/Q (s/m ³)	Vehicle Fire X/Q (s/m ³)	Vehicle Impact (No Fire) X/Q (s/m ³)
Alpha* Caisson 1	231-Z 234-5Z	ENE @ 330 m ESE @ 300 m	•	•	3.25 E-03 4.91 E-03
Alpha* Caisson 2	231-Z 234-5Z	ENE @ 290 m ESE @ 260 m	*	*	4.05 E-03 6.26 E-03
Alpha* Caisson 3	231-Z 234-5Z	ENE @ 215 m ESE @ 200 m	*	•	6.72 E-03 9.78 E-03
Alpha* Caisson 4	231-Z 234-5Z	ENE @ 310 m ESE @ 270 m	*	*	3.62 E-03 5.87 E-03
Offsite - All Release Locations	Site Boundary	S @ 13600 m	7.59 E-06	2.48 E-06	7.62 E-06
		SSW @ 14000 m	4.60 E-06	2.00 E-06	4.62 E-06
		SW @ 13600 m	6.13 E-06	2.14 E-06	6.15 E-06
		WSW @ 11400 m	7.68 E-06	2.41 E-06	7.72 E-06
		W @ 11100 m	1.86 E-05*	3.31 E-06*	1.88 E-05*
		WNW @ 11400 m	1.02 E-05	2.67 E-06	1.02 E-05
		NW @ 14000 m	1.45 E-05	3.06 E-06	1.45 E-05
		NNW @ 15100 m	1.32 E-05	3.08 E-06	1.33 E-05
		N @ 16400 m	1.28 E-05	3.16 E-06	1.28 E-05
		NNE @ 24800 m	3.34 E-06	1.20 E-06	3.35 E-06
		NE @ 25900 m	3.41 E-06	1.32 E-06	3.42 E-06
		ENE @ 22900 m	6.87 E-06	2.06 E-06	6.90 E-06
		E @ 22600 m	9.36 E-06	2.85 E-06	9.38 E-06
		ESE @ 28100 m	6.85 E-06	2.26 E-06	6.87 E-06
		SE @ 23200 m	8.21 E-06	2.31 E-06	8.24 E-06
		SSE @ 18900 m	5.12 E-06	1.88 E-06	5.14 E-06
		Site Wide	1.14 E-05	2.85 E-06	1.14 E-05

* All releases from the alpha caissons are treated as ground-level releases without the benefit of any special dispersion models. This corresponds to the X/Q values for the vehicle accident without fire. Therefore, all dose consequence calculations (both onsite and offsite) performed for the alpha caissons should use the X/Q in the "Vehicle Impact (No Fire)" column of Table 3, regardless of the actual accident scenario.

Baseline Unit Release Doses:

The baseline unit release doses in Tables 4 and 5 were calculated using the GENII dosimetry code (Napier, et al 1988). For the isotopes listed in Table 4, the whole body inhalation+submersion baseline unit release dose was taken from the annual effective dose equivalent (AEDE) for each isotope. The maximum organ inhalation+submersion baseline unit release dose was taken from the committed dose equivalent for each isotope. The analyst must choose the value which is appropriate. For the isotopic distribution used to model TRU material, Table 5 shows the AEDE and maximum organ doses for both the soluble and insoluble forms of Pu. Again, it is up to the analyst to choose the appropriate value.

A sample GENII input file is Attachment 2 to this report.

Table 4: Baseline Unit Release Doses for the SWBG

Isotope	Whole Body Inhalation Baseline Unit Release Dose (rem EDE/Ci) (s/m ³)	Maximum Organ Inhalation Baseline Unit Release Dose (rem/Ci) (s/m ³)
H 3	3.0e-02	3.8e-02
C 14	6.8e-01	8.7e-01
NA22	2.8e+00	4.3e+00
P 32	5.2e+00	3.2e+01
K 40	4.0e+00	5.7e+00
CR51	1.2e-01	6.6e-01
MN54	2.3e+00	8.2e+00
FE55	9.0e-01	3.4e+00
FE59	5.1e+00	1.0e+01
CO58	3.7e+00	4.8e-01
CO60	6.6e+01	4.3e+02
NI59	4.2e-01	4.8e-01
NI63	1.0e+00	1.2e+00
ZN65	6.1e+00	2.6e+01
SE75	2.8e+00	6.7e+00
SE79	3.1e+00	1.2e+01
KR85	5.7e-04	0.0e+00
SR85	6.1e-01	1.2e+00
SR90	7.0e+01	8.0e+02
MO93	9.4e+00	7.7e+01
ZR95	7.8e+00	1.3e+02
NB94	1.3e+02	9.1e+02
TC99	3.0e+00	2.1e+01
AG110M	1.2e+02	9.4e+02
CD109	3.8e+01	4.9e+02
SB125	4.3e+00	2.8e+01
TE125M	5.5e-01	2.8e+00

Isotope	Whole Body Inhalation Baseline Unit Release Dose (rem EDE/Ci) (s/m ³)	Maximum Organ Inhalation Baseline Unit Release Dose (rem/Ci) (s/m ³)
I 125	7.4e+00	2.4e+02
I 129	5.0e+01	1.7e+03
I 131	1.0e+01	3.3e+02
CS134	1.4e+01	1.7e+01
CS137	1.0e+01	1.1e+01
CE141	2.9e+00	2.0e+01
CE144	1.2e+02	9.6e+02
PM147	1.3e+01	9.5e+01
SM151	9.9e+00	1.7e+02
EU152	6.9e+01	4.2e+02
EU154	9.1e+01	6.5e+02
EU155	1.3e+01	1.8e+02
TA182	1.5e+01	1.0e+02
PB210	4.6e+03	6.6e+04
PO210	3.2e+03	2.7e+04
TH232	5.5e+05	1.4e+07
U 235	4.1e+04	3.4e+05
U 238	3.9e+04	3.2e+05
PU239	1.4e+05	2.6e+06
AM241	1.5e+05	2.7e+06
NP237	2.1e+05	4.7e+06

Table 5: Baseline Unit Release Doses for the SWBG, TRU Material, Isotopic Distribution From Table 1

Soluble Form		Insoluble Form	
Whole Body Inhalation/Submersion Dose (rem EDE/g) (s/m ³)	Maximum Organ Inhalation/Submersion Dose (rem/g) (s/m ³)	Whole Body Inhalation/Submersion Dose (rem EDE/g) (s/m ³)	Maximum Organ Inhalation/Submersion Dose (rem/g) (s/m ³)
2.5e+04	4.6e+05	2.0e+04	2.8e+05

Code Documentation

GXQ GXQ Version 3.1 (WHC 1993a)
200 Area - 10 m - Pasquill A-G (1983-1991 average)

GENII GENII version 1.485 (12/3/90) (Napier, et al 1988)
GENII default parameter values (28-Mar-90 RAP)
Radionuclide Master Library (7/23/93 PDR)
External Dose Factor Library (5/8/90)
Internal Dose Increments, PNL Solubilities (7/23/93)
Internal Dose Increments, Worst Case Solubilities (7/23/93)

References

Napier, et al. 1988, *GENII - The Hanford Environmental Dosimetry Software System*, PNL-6584, Richland, Washington.

NRC 1982, *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants*, Regulatory Guide 1.145, Rev 1, United States Nuclear Regulatory Commission, Washington, D.C. 20555.

WHC 1992, *Mixed Waste Lined Landfill (Project W025) Preliminary Safety Analysis Report*, WHC-SD-W025-PSAR-001 Rev 0., Westinghouse Hanford Company, Richland, Washington.

WHC 1993a, *GXQ Program Users' Guide*, WHC-SD-GN-SWD-30002, Westinghouse Hanford Company, Richland, Washington.

WHC 1993b, *Hanford Site Solid Waste Acceptance Criteria*, WHC-EP-0063-4, Westinghouse Hanford Company, Richland, Washington.

WHC 1993c, *Radioisotopic Characterization of Retrievably Stored Transuranic Waste Containers at the Hanford Site*, WHC-SD-WM-TI-517, Westinghouse Hanford Company, Richland, Washington.

ATTACHMENT 2

SAMPLE GENII INPUT FILES

Program GENII Input File ##### 8 Jul 88 ###
 Title: Onsite, Inhalation & Submersion, Acute, Ground Level Release
 \SAMPL\G-AIR.AC

===== Default =====
 OPTIONS
 F Near-field scenario? (Far-field) NEAR-FIELD: narrowly-focused
 F Population dose? (Individual) release, single site
 T Acute release? (Chronic) FAR-FIELD: wide-scale release,
 Maximum Individual data set used multiple sites
 Complete
 TRANSPORT OPTIONS===== Section EXPOSURE PATHWAY OPTIONS===== Complete
 T Air Transport 1 F Finite plume, external 5
 F Surface Water Transport 2 T Infinite plume, external 5
 F Biotic Transport (near-field) 3,4 F Ground, external 5
 F Waste Form Degradation (near) 3,4 F Recreation, external 5
 T Inhalation uptake 5,6
 F Drinking water ingestion 7,8
 F Aquatic foods ingestion 7,8
 F Terrestrial foods ingestion 7,9
 F Animal product ingestion 7,10
 F Inadvertent soil ingestion
 REPORT OPTIONS=====
 T Report AEDE only
 T Report by radionuclide
 F Report by exposure pathway
 F Debug report on screen

INVENTORY #####

- 4 Inventory input activity units: (1-pCi 2-uCi 3-mCi 4-Ci 5-Bq)
 0 Surface soil source units (1- m2 2- m3 3- kg)
 Equilibrium question goes here

Use when	-----Release Terms----- transport selected			-----Basic Concentrations----- near-field scenario, optionally				
	Air	Surface	Buried	Air	Surface	Deep	Ground	Surface
Radio-nuclide	/yr	Water	Waste	/m3	Soil	Soil	Water	Water
		/yr	/m3		/unit	/m3	/L	/L
H 3	1.0E+00							
C 14	1.0E+00							
NA22	1.0E+00							
P 32	1.0E+00							
K 40	1.0E+00							
CR51	1.0E+00							
MN54	1.0E+00							
FE55	1.0E+00							
FE59	1.0E+00							
CO58	1.0E+00							
CO60	1.0E+00							
NI59	1.0E+00							
NI63	1.0E+00							
ZN65	1.0E+00							
SE75	1.0E+00							
SE79	1.0E+00							
KR85	1.0E+00							
SR85	1.0E+00							
SR90	1.0E+00							
Y 90	1.0E+00							
MO93	1.0E+00							
ZR95	1.0E+00							
NB95M	8.3E-03							
NB94	1.0E+00							
TC99	1.0E+00							

Use when	-----Derived Concentrations-----			
	measured values are known			
Release	Terres.	Animal	Drink	Aquatic
Radio-	Plant	Product	Water	Food
nuclide	/kg	/kg	/L	/kg

TIME #####

1 Intake ends after (yr)
 50 Dose calc. ends after (yr)
 1 Release ends after (yr)
 0 No. of years of air deposition prior to the intake period
 0 No. of years of irrigation water deposition prior to the intake period

FAR-FIELD SCENARIOS (IF POPULATION DOSE) #####

0 Definition option: 1-Use population grid in file POP.IN
 0 2-Use total entered on this line

NEAR-FIELD SCENARIOS #####

Prior to the beginning of the intake period: (yr)
 0 When was the inventory disposed? (Package degradation starts)
 0 When was LOIC? (Biotic transport starts)
 0 Fraction of roots in upper soil (top 15 cm)
 0 Fraction of roots in deep soil
 0 Manual redistribution: deep soil/surface soil dilution factor
 0 Source area for external dose modification factor (m2)

TRANSPORT #####

=====AIR TRANSPORT=====SECTION 1=====

0	Calculate PM	0	Release type (0-3)
1	Option: 1-Use chi/Q or PM value	F	Stack release (T/F)
	2-Select MI dist & dir	0	Stack height (m)
	3-Specify MI dist & dir	0	Stack flow (m3/sec)
1.0E+00	Chi/Q or PM value	0	Stack radius (m)
0	MI sector index (1=S)	0	Effluent temp. (C)
0.0	MI distance from release point (m)	0	Building x-section (m2)
T	Use jf data, (T/F) else chi/Q grid	0	Building height (m)

=====SURFACE WATER TRANSPORT=====SECTION 2=====

0 Mixing ratio model: 0-use value, 1-river, 2-lake
 0 Mixing ratio, dimensionless
 0 Average river flow rate for: MIXFLG=0 (m3/s), MIXFLG=1,2 (m/s),
 0 Transit time to irrigation withdrawal location (hr)
 If mixing ratio model > 0:
 0 Rate of effluent discharge to receiving water body (m3/s)
 0 Longshore distance from release point to usage location (m)
 0 Offshore distance to the water intake (m)
 0 Average water depth in surface water body (m)
 0 Average river width (m), MIXFLG=1 only
 0 Depth of effluent discharge point to surface water (m), lake only

=====WASTE FORM AVAILABILITY=====SECTION 3=====

0 Waste form/package half life, (yr)
 0 Waste thickness, (m)
 0 Depth of soil overburden, m

=====BIOTIC TRANSPORT OF BURIED SOURCE=====SECTION 4=====

T Consider during inventory decay/buildup period (T/F)?
T Consider during intake period (T/F)? 1-Arid non agricultural
0 Pre-Intake site condition..... 2-Humid non agricultural
3-Agricultural

EXPOSURE #####

=====EXTERNAL EXPOSURE=====SECTION 5=====
Exposure time:
0 Plume (hr) T Residential irrigation:
0 Soil contamination (hr) 0 Consider: (T/F)
0 Swimming (hr) Source: 1-ground water
0 Boating (hr) 0 2-surface water
0 Shoreline activities (hr) 0 Application rate (in/yr)
0 Duration (mo/yr)
0 Shoreline type: (1-river, 2-lake, 3-ocean, 4-tidal basin)
0 Transit time for release to reach aquatic recreation (hr)
1.0 Average fraction of time submersed in acute cloud (hr/person hr)

=====INHALATION=====SECTION 6=====
8766.0 Hours of exposure to contamination per year
0 0-No resus- 1-Use Mass Loading 2-Use Anspaugh model
0 pension Mass loading factor (g/m3) Top soil available (cm)

=====INGESTION POPULATION=====SECTION 7=====
0 Atmospheric production definition (select option):
0 0-Use food-weighted chi/Q, (food-sec/m3), enter value on this line
1-Use population-weighted chi/Q
2-Use uniform production
3-Use chi/Q and production grids (PRODUCTION will be overridden)
0 Population ingesting aquatic foods, 0 defaults to total (person)
0 Population ingesting drinking water, 0 defaults to total (person)
F Consider dose from food exported out of region (default=F)

Note below: S* or Source: 0-none, 1-ground water, 2-surface water
3-Derived concentration entered above

===== AQUATIC FOODS / DRINKING WATER INGESTION=====SECTION 8=====
F Salt water? (default is fresh)

USE ?	FOOD TYPE	TRAN- SIT hr	PROD- UCTION kg/yr	-CONSUMPTION- HOLDUP da	RATE kg/yr	DRINKING WATER	
F	FISH	0.00	0.0E+00	0.00	0.0	0	Source (see above)
F	MOLLUS	0.00	0.0E+00	0.00	0.0	T	Treatment? T/F
F	CRUSTA	0.00	0.0E+00	0.00	0.0	0	Holdup/transit(da)
F	PLANTS	0.00	0.0E+00	0.00	0.0	0	Consumption (L/yr)

=====TERRESTRIAL FOOD INGESTION=====SECTION 9=====

USE ?	FOOD TYPE	GROW TIME da	--IRRIGATION-- S RATE * in/yr	TIME mo/yr	YIELD kg/m2	PROD- UCTION kg/yr	--CONSUMPTION-- HOLDUP da	RATE kg/yr
F	LEAF V	0.00	0	0.0	0.0	0.0E+00	0.0	0.0
F	ROOT V	0.00	0	0.0	0.0	0.0E+00	0.0	0.0
F	FRUIT	0.00	0	0.0	0.0	0.0E+00	0.0	0.0
F	GRAIN	0.00	0	0.0	0.0	0.0E+00	0.0	0.0

=====ANIMAL PRODUCTION CONSUMPTION=====SECTION 10=====

		---HUMAN---		TOTAL	DRINK	-----STORED FEED-----						
USE		CONSUMPTION	HOLDUP	PROD-	WATER	DIET	GROW	-IRRIGATION--		STOR-		
?	FOOD	RATE	da	UCTION	CON TAM	FRAC-	TIME	S	RATE	TIME	YIELD	AGE
T/F	TYPE	kg/yr		kg/yr	FRACT.	TION	da	*	in/yr	mo/yr	kg/m3	da
		-----		-----	-----	-----						
F	BEEF	0.0	0.0	0.00	0.00	0.00	0.0	0	0.0	0.00	0.00	0.0
F	POULTR	0.0	0.0	0.00	0.00	0.00	0.0	0	0.0	0.00	0.00	0.0
F	MILK	0.0	0.0	0.00	0.00	0.00	0.0	0	0.0	0.00	0.00	0.0
F	EGG	0.0	0.0	0.00	0.00	0.00	0.0	0	0.0	0.00	0.00	0.0
						-----FRESH FORAGE-----						
	BEEF					0.00	0.0	0	0.0	0.00	0.00	0.0
	MILK					0.00	0.0	0	0.0	0.00	0.00	0.0

#####

Program GENII Input File ##### 8 Jul 88 ###
 Title: Onsite, Inhalation & Submersion, Acute, Ground Level Release
 \SAMPL\G-AIR.AC

OPTIONS===== Default =====
 F Near-field scenario? (Far-field) NEAR-FIELD: narrowly-focused
 F Population dose? (Individual) release, single site
 T Acute release? (Chronic) FAR-FIELD: wide-scale release,
 Maximum Individual data set used multiple sites

TRANSPORT OPTIONS===== Section Complete
 T Air Transport 1 F Finite plume, external 5
 F Surface Water Transport 2 T Infinite plume, external 5
 F Biotic Transport (near-field) 3,4 F Ground, external 5
 F Waste Form Degradation (near) 3,4 F Recreation, external 5
 T Inhalation uptake 5,6
 F Drinking water ingestion 7,8
 F Aquatic foods ingestion 7,8
 F Terrestrial foods ingestion 7,9
 F Animal product ingestion 7,10
 F Inadvertent soil ingestion

REPORT OPTIONS=====
 T Report AEDE only
 T Report by radionuclide
 F Report by exposure pathway
 F Debug report on screen

INVENTORY #####

4 Inventory input activity units: (1-pCi 2-uCi 3-mCi 4-Ci 5-Bq)
 0 Surface soil source units (1- m2 2- m3 3- kg)
 Equilibrium question goes here

Use when	Release Terms			Basic Concentrations				
	transport selected			near-field scenario, optionally				
Release	Air	Surface	Buried	Air	Surface	Deep	Ground	Surface
Radio-		Water	Waste		Soil	Soil	Water	Water
nuclide	/yr	/yr	/m3	/m3	/unit	/m3	/L	/L
PU238	1.4E-02							
PU239	5.2E-02							
PU240	2.9E-02							
PU241	1.1E+00							
PU242	1.2E-06							
AM241	6.0E-02							

Use when	Derived Concentrations			
	measured values are known			
Release	Terres.	Animal	Drink	Aquatic
Radio-	Plant	Product	Water	Food
nuclide	/kg	/kg	/L	/kg

TIME #####

50 Intake ends after (yr)
 50 Dose calc. ends after (yr)
 1 Release ends after (yr)
 0 No. of years of air deposition prior to the intake period
 0 No. of years of irrigation water deposition prior to the intake period

FAR-FIELD SCENARIOS (IF POPULATION DOSE) #####

0 Definition option: 1-Use population grid in file POP.IN

```

0                               2-Use total entered on this line

NEAR-FIELD SCENARIOS #####

    Prior to the beginning of the intake period: (yr)
0      When was the inventory disposed? (Package degradation starts)
0      When was LOIC? (Biotic transport starts)
0      Fraction of roots in upper soil (top 15 cm)
0      Fraction of roots in deep soil
0      Manual redistribution: deep soil/surface soil dilution factor
0      Source area for external dose modification factor (m2)
TRANSPORT #####
=====AIR TRANSPORT=====SECTION 1=====
0      0-Calculate PM                                0      Release type (0-3)
1      Option: 1-Use chi/Q or PM value                F      Stack release (T/F)
0      2-Select MI dist & dir                        0      Stack height (m)
0      3-Specify MI dist & dir                        0      Stack flow (m3/sec)
1.0    Chi/Q or PM value                             0      Stack radius (m)
0      MI sector index (1=S)                          0      Effluent temp. (C)
0.0    MI distance from release point (m)            0      Building x-section (m2)
T      Use jf data, (T/F) else chi/Q grid            0      Building height (m)

=====SURFACE WATER TRANSPORT=====SECTION 2=====
0      Mixing ratio model: 0-use value, 1-river, 2-lake
0      Mixing ratio, dimensionless
0      Average river flow rate for: MIXFLG=0 (m3/s), MIXFLG=1,2 (m/s),
0      Transit time to irrigation withdrawal location (hr)
0      If mixing ratio model > 0:
0          Rate of effluent discharge to receiving water body (m3/s)
0          Longshore distance from release point to usage location (m)
0          Offshore distance to the water intake (m)
0          Average water depth in surface water body (m)
0          Average river width (m), MIXFLG=1 only
0          Depth of effluent discharge point to surface water (m), lake only

=====WASTE FORM AVAILABILITY=====SECTION 3=====
0      Waste form/package half life, (yr)
0      Waste thickness, (m)
0      Depth of soil overburden, m

=====BIOTIC TRANSPORT OF BURIED SOURCE=====SECTION 4=====
T      Consider during inventory decay/buildup period (T/F)?
T      Consider during intake period (T/F)?           1-Arid non agricultural
0      Pre-Intake site condition.....                2-Humid non agricultural
                                                3-Agricultural

EXPOSURE #####
=====EXTERNAL EXPOSURE=====SECTION 5=====
0      Exposure time:
0          Plume (hr)                                T      Residential irrigation:
0          Soil contamination (hr)                    0      Consider: (T/F)
0          Swimming (hr)                                0      Source: 1-ground water
0          Boating (hr)                                0          2-surface water
0          Shoreline activities (hr)                    0      Application rate (in/yr)
0          Shoreline type: (1-river, 2-lake, 3-ocean, 4-tidal basin)
0          Duration (mo/yr)
0      Transit time for release to reach aquatic recreation (hr)
1.0    Average fraction of time submersed in acute cloud (hr/person hr)

=====INHALATION=====SECTION 6=====

```

8766.0 Hours of exposure to contamination per year
 0 0-No resus- 1-Use Mass Loading 2-Use Anspaugh model
 0 pension Mass loading factor (g/m3) Top soil available (cm)

=====INGESTION POPULATION=====SECTION 7=====

0 Atmospheric production definition (select option):
 0 0-Use food-weighted chi/Q, (food-sec/m3), enter value on this line
 1-Use population-weighted chi/Q
 2-Use uniform production
 3-Use chi/Q and production grids (PRODUCTION will be overridden)
 0 Population ingesting aquatic foods, 0 defaults to total (person)
 0 Population ingesting drinking water, 0 defaults to total (person)
 F Consider dose from food exported out of region (default=F)

Note below: S* or Source: 0-none, 1-ground water, 2-surface water
 3-Derived concentration entered above

===== AQUATIC FOODS / DRINKING WATER INGESTION=====SECTION 8=====

F Salt water? (default is fresh)

USE ?	FOOD T/F TYPE	TRAN- SIT hr	PROD- UCTION kg/yr	-CONSUMPTION- HOLDUP da	RATE kg/yr	DRINKING WATER	
F	FISH	0.00	0.0E+00	0.00	0.0	0	Source (see above)
F	MOLLUS	0.00	0.0E+00	0.00	0.0	T	Treatment? T/F
F	CRUSTA	0.00	0.0E+00	0.00	0.0	0	Holdup/transit(da)
F	PLANTS	0.00	0.0E+00	0.00	0.0	0	Consumption (L/yr)

=====TERRESTRIAL FOOD INGESTION=====SECTION 9=====

USE ?	FOOD T/F TYPE	GROW TIME da	--IRRIGATION-- S RATE * in/yr		TIME mo/yr	YIELD kg/m2	PROD- UCTION kg/yr	--CONSUMPTION-- HOLDUP da	RATE kg/yr
T	LEAF V	0.00	0	0.0	0.0	0.0	0.0E+00	0.0	0.0
T	ROOT V	0.00	0	0.0	0.0	0.0	0.0E+00	0.0	0.0
T	FRUIT	0.00	0	0.0	0.0	0.0	0.0E+00	0.0	0.0
T	GRAIN	0.00	0	0.0	0.0	0.0	0.0E+00	0.0	0.0

=====ANIMAL PRODUCTION CONSUMPTION=====SECTION 10=====

USE ?	FOOD T/F TYPE	--HUMAN-- CONSUMPTION RATE HOLDUP		TOTAL PROD- UCTION kg/yr	DRINK WATER CONTAM FRACT.	DIET FRAC- TION	GROW TIME da	--STORED FEED-- --IRRIGATION-- S RATE TIME		YIELD kg/m3	STOR- AGE da
		kg/yr	da					* in/yr	mo/yr		
T	BEEF	0.0	0.0	0.00	0.00	0.00	0.0	0	0.0	0.00	0.0
T	POULTR	0.0	0.0	0.00	0.00	0.00	0.0	0	0.0	0.00	0.0
T	MILK	0.0	0.0	0.00	0.00	0.00	0.0	0	0.0	0.00	0.0
T	EGG	0.0	0.0	0.00	0.00	0.00	0.0	0	0.0	0.00	0.0
							--FRESH FORAGE--				
	BEEF					0.00	0.0	0	0.0	0.00	0.0
	MILK					0.00	0.0	0	0.0	0.00	0.0

#####

ATTACHMENT 3

SAMPLE GXQ OUTPUT FILES

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 = 3/29/1994
Run Time = 13:39 18.59

INPUT ECHO:

SWBG ISB X/Q Values ---- Vehicle Fire, 99.5% Sector, Offsite

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
	0	2	2	2	0	0	1	1

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      scaling
c      release    speed      to              factor
c      height     height     exceed          (mg)
c      (m)         (m)        (%)             (mg)
c      0.00000E+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      7.90000E+00  3.00000E+00  1.00000E+00  1.00000E-03  1.00000E-03
c
c      initial    initial    sensible
c      plume      plume      heat
c      density    flow       emission
c      (g/cc)     rate       diameter   rate
c      4.36000E-04  7.07000E+00  3.00000E+00  4.56820E+04
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 xmax xmin 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 xmin = minimum scaled X/Q to calculate
c power = exponent in power function step size
c
c MODE:
c Site specific X/Q calculated
c
c LOGICAL CHOICES:
c Joint frequency used to calculate X/Q based on
c   frequency of exceedance.
c No normalization of joint frequency.
c X/Q calculated for single sector.
c Output is atmospheric dispersion coefficient.
c
c MODELS SELECTED:
c MACCS Virtual source building wake
c 5th power law plume meander
c Momentum/buoyancy plume rise based on plume density

```


Flow adjustment model.
Wind velocity corrected for average plume height.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
Created 8/26/92 KR

SWBG ISB X/Q Values ---- Vehicle Fire, 99.5% Sector, Offsite

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m2)	ATM. STAB. CLASS	WIND SPEED (m/s)
S	13600	0	6.30	1	2.48E-06	2.48E-06	E	.89
SSW	14000	0	4.53	1	2.00E-06	2.00E-06	F	4.70
SW	13600	0	2.93	1	2.14E-06	2.14E-06	F	4.70
WSW	11400	0	2.72	1	2.41E-06	2.41E-06	F	2.65
W	11100	0	4.80	1	3.31E-06	3.31E-06	G	2.65
WNW	11400	0	3.98	1	2.67E-06	2.67E-06	F	4.70
NW	14000	0	4.72	1	3.06E-06	3.06E-06	G	2.65
NNW	15100	0	4.58	1	3.08E-06	3.08E-06	G	7.15
N	16400	0	4.36	1	3.16E-06	3.16E-06	F	.89
NNE	24800	0	2.49	1	1.20E-06	1.20E-06	E	.89
NE	25900	0	3.90	1	1.32E-06	1.32E-06	E	.89
ENE	22900	0	6.17	1	2.06E-06	2.06E-06	G	2.65
E	22600	0	14.05	1	2.85E-06	2.85E-06	G	4.70
ESE	28100	0	18.80	1	2.26E-06	2.26E-06	G	4.70
SE	23200	0	10.83	1	2.31E-06	2.31E-06	F	.89
SSE	18900	0	4.78	1	1.88E-06	1.88E-06	E	.89

Execution Time = 0 hr 0 min 1.20 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 = 3/21/1994
Run Time = 13:56 42.12

INPUT ECHO:

SWBG ISB X/Q Values ---- Alpha Caissons, 99.5% Sector, Onsite
c GXQ Ver. 3.1 Input File

c mode
1

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 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 MODEL CHOICES:

c idep iwake ipm irise igrav iwash iflow iwind
0 0 0 0 0 0 0 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      scaling
c      release    speed      to             factor
c      height     height    exceed          (mg)
c      (m)        (m)       (%)            1.00000E+00
c      0.00000E+00 1.00000E+01 1.00000E+03 5.00000E-01
c
c      building   building   release      deposition   gravitational
c      width      height    duration     velocity    settling
c      (m)        (m)       (hr)         (m/s)       velocity
c      7.90000E+00 3.00000E+00 1.00000E+00 1.00000E-03 1.00000E-03
c
c      initial    initial    sensible
c      plume      plume      heat
c      plume      flow       stack
c      density    rate       diameter
c      (g/cc)     (m3/s)    (m)         (cal/s)
c      3.40000E-04 7.07000E+00 3.00000E+00 4.56820E+04
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 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 atmospheric dispersion coefficient.

MODELS SELECTED:

WARNING/ERROR MESSAGES:

```

JOINT FREQUENCY DATA:

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

Created 8/26/92 KR

SWBG ISB X/Q Values ---- Alpha Caissons, 99.5% Sector, Onsite

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)
ENE	330	0	6.17	1	3.25E-03	3.25E-03	G	2.65
ESE	300	0	18.80	1	4.91E-03	4.91E-03	F	.89
ENE	290	0	6.17	1	4.05E-03	4.05E-03	G	2.65
ESE	260	0	18.80	1	6.26E-03	6.26E-03	F	.89
ENE	215	0	6.17	1	6.72E-03	6.72E-03	G	2.65
ESE	200	0	18.80	1	9.78E-03	9.78E-03	F	.89
ENE	310	0	6.17	1	3.62E-03	3.62E-03	G	2.65
ESE	270	0	18.80	1	5.87E-03	5.87E-03	F	.89

Execution Time = 0 hr 0 min .54 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 = 3/21/1994
Run Time = 9: 0 32.35

INPUT ECHO:

SWBG ISB X/Q Values ---- Single Drum Explosion Value, 99.5% Sector, Offsite

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
0 2 0 0 0 0 0 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    exceed      scaling
c      (m)        (m)        (m)        (%)      factor
c      0.00000E+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      7.90000E+00  3.00000E+00  2.78000E-04  1.00000E-03  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      1.22000E-03  1.00000E+00  1.00000E+00  6.15400E+04
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:
MACCS Virtual source building wake

WARNING/ERROR MESSAGES:

```

JOINT FREQUENCY DATA:

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

Created 8/26/92 KR

SWBG ISB X/Q Values ---- Single Drum Explosion Value, 99.5% Sector, Offsite

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)
S	13600	0	6.30	1	7.59E-06	7.59E-06	E	.89
SSW	14000	0	4.53	1	4.60E-06	4.60E-06	F	2.65
SW	13600	0	2.93	1	6.13E-06	6.13E-06	F	2.65
WSW	11400	0	2.72	1	7.68E-06	7.68E-06	F	2.65
W	11100	0	4.80	1	1.86E-05	1.86E-05	G	2.65
WNW	11400	0	3.98	1	1.02E-05	1.02E-05	G	4.70
NW	14000	0	4.72	1	1.45E-05	1.45E-05	G	2.65
NNW	15100	0	4.58	1	1.32E-05	1.32E-05	G	2.65
N	16400	0	4.36	1	1.28E-05	1.28E-05	G	2.65
NNE	24800	0	2.49	1	3.34E-06	3.34E-06	E	.89
NE	25900	0	3.90	1	3.41E-06	3.41E-06	E	.89
ENE	22900	0	6.17	1	6.87E-06	6.87E-06	G	2.65
E	22600	0	14.05	1	9.36E-06	9.36E-06	F	.89
ESE	28100	0	18.80	1	6.85E-06	6.85E-06	F	.89
SE	23200	0	10.83	1	8.21E-06	8.21E-06	G	2.65
SSE	18900	0	4.78	1	5.12E-06	5.12E-06	G	4.70

Execution Time = 0 hr 0 min .76 sec

Stop - Program terminated.

ATTACHMENT 4

**CHECKLISTS FOR TECHNICAL PEER AND HEDOP REVIEWS
AND
INDEPENDENT SAFETY CONCURRENCE WITH
ONSITE RECEPTOR LOCATIONS**

[179] From: Mark A Medsker at -WHC276 3/11/94 11:29AM (1817 bytes: 31 ln)
To: Donald J Meyers at -WHC110
cc: Mark A Medsker
Subject: ONSITE RECEPTORS FOR THE SWBG ISB

----- Message Contents -----

As a result of a technical review comment on GENII runs, I am seeking Independent Safety concurrence for the onsite receptors used in the Solid Waste Burial Ground (SWBG) Interim Safety Basis (ISB). For most of the accidents analyzed in the ISB, the onsite receptor is taken to be 100 m in the worst-case direction. This is done for the sake of simplicity, and represents the most conservative location possible for onsite receptor calculations. For some accidents, however, the onsite receptor is taken to be at the next nearest facility. This is done for selected accidents which are assumed to occur in areas of the SWBG where the onsite receptor can easily be determined. We would like to use the next nearest facility as the onsite receptor for accidents in the following areas of the SWBG:

1. The mixed waste lined landfill (formerly Project W-025)
2. The alpha caissons in the 218W-4B burial grounds
3. Trenches -01, -20, and -29 of the 218W-4C burial ground

All nearby, non-solid waste facilities whose personnel have not had training in either the SWBG emergency response plan or facility orientation to solid waste, would be tested as being the possible onsite receptor. The facility meeting the stated criteria which yields the greatest value for the atmospheric dispersion factor (X/Q) would be used.

Please indicate concurrence with this methodology by signing below, or call me if you have any questions. Thanks.

Donald J Meyers
(reviewer printed and signed name)

3/14/94
(Date)

CHECKLIST FOR PEER REVIEW

Document Reviewed: Memo, M.A. Medsker to M.R. Harker, "Unit Releases for the Solid Waste Burial Ground Interim Safety Basis," MAM-29540-001,

Scope of Review: entire document

Yes No NA

☐	☐	☒	*	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☒	☐	☐		Problem completely defined.
☒	☐	☒		Accident scenarios developed in a clear and logical manner.
☒	☐	☐		Necessary assumptions explicitly stated and supported.
☒	☐	☐		Computer codes and data files documented.
☒	☐	☐		Data used in calculations explicitly stated in document.
☒	☐	☐		Data checked for consistency with original source information as applicable.
☒	☐	☐		Mathematical derivations checked including dimensional consistency of results.
☒	☐	☐		Models appropriate and used within range of validity or use outside range of established validity justified.
☒	☐	☐		Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
☒	☐	☐		Software input correct and consistent with document reviewed.
☒	☐	☐		Software output consistent with input and with results reported in document reviewed.
☐	☐	☒		Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
☐	☐	☒		Safety margins consistent with good engineering practices.
☒	☐	☐		Conclusions consistent with analytical results and applicable limits.
☒	☐	☐		Results and conclusions address all points required in the problem statement.
☐	☐	☒		Format consistent with appropriate NRC Regulatory Guide or other standards
☐	☐	☒	*	Review calculations, comments, and/or notes are attached.
☒	☐	☐		Document approved.

D.A. Himes & [Signature]
Reviewer (Printed Name and Signature)

3/30/94
Date

* Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

☐ ☐ ☒ Analysis entered into analysis database

Mark A. Medsker [Signature]
(Printed Name and Signature)

3/30/94
Date

HEDOP REVIEW CHECKLIST
for
Radiological and Nonradiological Release Calculations

Document reviewed (include title or description of calculation, document number, author, and date, as applicable):

Memo, M.A. Medsker to M.R. Harker, "Unit Releases for the Solid Waste Burial Ground Interim Safety Basis," MAM-29540-001,

Submitted by: M.A. Medsker

Date Submitted: 3/30/94

Scope of Review: entire document

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.
☐	☐	☒	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 and use of nonstandard methods justified.

D.A. Himes
HEDOP-Approved Reviewer (Printed Name and Signature)

3/30/94
Date

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

Westinghouse
Hanford CompanyInternal
Memo

From: WOSE 8D141-094-014
Phone: 376-8009 H4-70
Date: May 17, 1994
Subject: ADDITIONAL X/Q CALCULATIONS FOR THE SOLID WASTE BURIAL GROUND
INTERIM SAFETY BASIS

To: M. R. Harker H4-70
cc: J. P. Joyce H4-70
G. H. Saito H4-70
A .V. Savino H4-64
MAM File/LB

Reference 1: *GXQ Program User's Guide*, WHC-SD-GN-SWD-30002 Rev 0,
Westinghouse Hanford Company, Richland, Washington, 1993.

Reference 2: *Atmospheric Dispersion Models for Potential Accident
Consequence Assessments at Nuclear Power Plants*, NRC
Regulatory Guide 1.145, U.S. Nuclear Regulatory Commission,
Washington, D.C., 1982.

As requested I have completed the offsite X/Q calculations for the accident analysis of the Submarine Reactor Compartments (SRCs). These X/Q values support the Solid Waste Burial Ground (SWBG) Interim Safety Basis (ISB) and are presented in Table 1 on the following page.

No onsite X/Q calculations were requested nor performed as they are available in other analyses.

The X/Q values given in Table 1 are for a ground-level, point source release using the Gaussian plume model implemented in the GXQ computer program (reference 1). No additional models were used, such as plume meander, plume rise, etc.

The X/Q calculations were made as specified in NRC Regulatory Guide 1.145 (reference 2). 99.5% maximum sector X/Qs are provided in Table 1 in addition to the 95% site-wide X/Q. The largest value in Table 1 is denoted by an asterisk, and should be used in all dose consequence calculations.

The GXQ output files generated by this analysis are provided as Attachment 1 to this memo.

M. R. Harker
Page 2
5/17/94

8D141-094-014

Table 1: Offsite X/Q Values for the SRC Accident Analysis

Direction	Distance (m)	X/Q (s/m ²)	Stability Class	Windspeed (m/s)
S	21100	4.34E-06	E	.89
SSW	18000	3.38E-06	F	2.65
SW	19000	4.04E-06	F	2.65
WSW	20800	3.62E-06	F	2.65
W	20300	8.83E-06	G	2.65
WNW	21000	4.74E-06	G	4.70
NW	19700	9.51E-06	G	2.65
NNW	19900	9.43E-06	G	2.65
N	23000	8.44E-06	G	2.65
NNE	23300	3.63E-06	E	.89
NE	18300	5.31E-06	E	.89
ENE	15600	1.11E-05	G	2.65
E	15400	1.51E-05	F	.89*
ESE	19800	1.05E-05	F	.89
SE	23500	8.11E-06	G	2.65
SSE	21300	4.42E-06	G	4.70
Site	ALL	1.10E-05		

If you have questions pertaining to this analysis, do not hesitate to contact me.

Mark A. Medsker
WOSE

mam

Attachment

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 = 5/17/1994
Run Time = 15: 3 59.69

INPUT ECHO:

--- SWBG ISB Additional X/Q calculations for SRCs, Acute, Offsite ---

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

0 0 0 0 0 0 0 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	mixing	to	scaling
c height	height	height	exceed	factor
c (m)	(m)	(m)	(%)	(mg)
0.00000E+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	1.00000E+00	1.00000E-02	1.00000E-02

c initial	initial		sensible
c plume	plume		heat
c density	flow	stack	emission
c (g/cc)	rate	diameter	rate
4.40000E-04	(m3/s)	(m)	(cal/s)
	7.90000E-01	1.00000E+00	1.86000E+06

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:

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

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

Created 8/26/92 KR

--- SWBG ISB Additional X/Q calculations for SRCs, Acute, Offsite ---

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)
S	21100	0	6.30	1	4.34E-06	4.34E-06	E	.89
SSW	18000	0	4.53	1	3.38E-06	3.38E-06	F	2.65
SW	19000	0	2.93	1	4.04E-06	4.04E-06	F	2.65
WSW	20800	0	2.72	1	3.62E-06	3.62E-06	F	2.65
W	20300	0	4.80	1	8.83E-06	8.83E-06	G	2.65
WNW	21000	0	3.98	1	4.74E-06	4.74E-06	G	4.70
NW	19700	0	4.72	1	9.51E-06	9.51E-06	G	2.65
NNW	19900	0	4.58	1	9.43E-06	9.43E-06	G	2.65
N	23000	0	4.36	1	8.44E-06	8.44E-06	G	2.65
NNE	23300	0	2.49	1	3.63E-06	3.63E-06	E	.89
NE	18300	0	3.90	1	5.31E-06	5.31E-06	E	.89
ENE	15600	0	6.17	1	1.11E-05	1.11E-05	G	2.65
E	15400	0	14.05	1	1.51E-05	1.51E-05	F	.89
ESE	19800	0	18.80	1	1.05E-05	1.05E-05	F	.89
SE	23500	0	10.83	1	8.11E-06	8.11E-06	G	2.65
SSE	21300	0	4.78	1	4.42E-06	4.42E-06	G	4.70

Execution Time = 0 hr 0 min .82 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 = 5/17/1994
 Run Time = 15: 4 38.74

INPUT ECHO:

--- SWBG ISB Additional X/Q calculations for SRCs, Acute, Offsite ---

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 T 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

0 0 0 0 0 0 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    exceed      scaling
c      (m)        (m)       (%)         factor
c      0.00000E+00 1.00000E+01 1.00000E+03 5.00000E+00 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 1.00000E+00 1.00000E-02 1.00000E-02
c
c      initial    initial    sensible
c      plume      plume      heat
c      density    flow       emission
c      (g/cc)     rate       rate
c      4.40000E-04 7.90000E-01 1.00000E+00 1.86000E+06
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 overall site.
Output is atmospheric dispersion coefficient.

MODELS SELECTED:

WARNING/ERROR MESSAGES:

```

JOINT FREQUENCY DATA:

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

Created 8/26/92 KR

--- SWBG ISB Additional X/Q calculations for SRCs, Acute, Offsite ---

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)
ALL	21300	0	99.94	I	1.10E-05	1.10E-05	F	.89

Execution Time = 0 hr 0 min 2.14 sec

Stop - Program terminated.

CHECKLIST FOR PEER REVIEW

Document Reviewed: Additional X/Q Calculations for the Solid Waste Burial Ground Interim Safety Basis, Internal Memo 8D141-094-014, M. A. Medsker to M. R. Harker, dated May 17, 1994.

Scope of Review: Entire document

Yes	No	NA	
☐	☐	☒	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☒	☐	☐	Problem completely defined.
☐	☐	☒	Accident scenarios developed in a clear and logical manner.
☒	☐	☐	Necessary assumptions explicitly stated and supported.
☒	☐	☐	Computer codes and data files documented.
☒	☐	☐	Data used in calculations explicitly stated in document.
☒	☐	☐	Data checked for consistency with original source information as applicable.
☐	☐	☒	Mathematical derivations checked including dimensional consistency of results.
☒	☐	☐	Models appropriate and used within range of validity or use outside range of established validity justified.
☐	☐	☒	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
☒	☐	☐	Software input correct and consistent with document reviewed.
☒	☐	☐	Software output consistent with input and with results reported in document reviewed.
☐	☐	☒	Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
☐	☐	☒	Safety margins consistent with good engineering practices.
☐	☐	☒	Conclusions consistent with analytical results and applicable limits.
☒	☐	☐	Results and conclusions address all points required in the problem statement.
☐	☐	☒	Format consistent with appropriate NRC Regulatory Guide or other standards
☐	☐	☒	Review calculations, comments, and/or notes are attached.
☒	☐	☐	Document approved.

A. V. Savino / *AV Savino*
 Reviewer (Printed Name and Signature)

5/18/94
 Date

☐ ☐ ☒ Analysis entered into analysis database

Mark A. Medsker Mark A. Medsker
 (Printed Name and Signature)

5/18/94
 Date

HEDOP REVIEW CHECKLIST
for
Radiological and Nonradiological Release Calculations

Document reviewed (include title or description of calculation, document number, author, and date, as applicable):

Memo, M.A. Medsker to M.R. Harker, "Additional X/Q Calculations for the Solid Waste Burial Ground Interim Safety Basis," 8D141-094-014, May 17, 1994

Submitted by: M.A. Medsker

Date Submitted: 5/18/94

Scope of Review: entire document

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.
☐	☐	☒	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 and use of nonstandard methods justified.

D.A. Himes [Signature] 5/18/94
HEDOP-Approved Reviewer (Printed Name and Signature) Date

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

CHECKLIST FOR PEER REVIEW

Document Reviewed: Safety Classification WHC-SD-ISB-002

Scope of Review: Sect 9.6 Hazard Classification.
Sect 4.4 Classifications of Systems, Structures and
Components

Yes	No	NA	
☐	☐	☒	* Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☒	☐	☐	Problem completely defined.
☒	☐	☐	Accident scenarios developed in a clear and logical manner.
☒	☐	☐	Necessary assumptions explicitly stated and supported.
☒	☐	☐	Computer codes and data files documented.
☒	☐	☐	Data used in calculations explicitly stated in document.
☒	☐	☐	Data checked for consistency with original source information as applicable.
☒	☐	☐	Mathematical derivations checked including dimensional consistency of results.
☒	☐	☐	Models appropriate and used within range of validity or use outside range of established validity justified.
☒	☐	☐	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
☐	☐	☒	Software input correct and consistent with document reviewed.
☐	☐	☒	Software output consistent with input and with results reported in document reviewed.
☒	☐	☐	Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
☒	☐	☐	Safety margins consistent with good engineering practices.
☒	☐	☐	Conclusions consistent with analytical results and applicable limits.
☒	☐	☐	Results and conclusions address all points required in the problem statement.
☒	☐	☐	Format consistent with appropriate NRC Regulatory Guide or other standards
☐	☐	☒	* Review calculations, comments, and/or notes are attached.
☒	☐	☐	Document approved.

D. J. Johnson

Reviewer (Printed Name and Signature)

6/7/94

Date

• Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

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CHAPTER 7.0
CONDUCT OF OPERATIONS

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LIST OF TERMS

ALARA	as low as reasonably achievable
BED	building emergency director
COS	cognizant operations supervisor
DOE	U.S. Department of Energy
EACT	Emergency Action Coordinating Team
ECC	Emergency Control Center
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
JCS	Job Control System
M&O	management and operations
POP	Plant Operating Procedure
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
RL	U.S. Department of Energy, Richland Operations Office
RLIP	Richland Operations Office Implementing Procedure
RWP	radiological work permit
SEAC	Safety and Environmental Advisory Council
SWBG	Solid Waste Burial Grounds
WAC	<i>Washington Administrative Code</i>
WHC	Westinghouse Hanford Company

7.0 CONDUCT OF OPERATIONS

This section describes the ability of the management and operations (M&O) contractor to safely conduct Solid Waste Burial Grounds (SWBG) disposal operations. It describes the human resources, training, emergency planning, audit, and security provisions in place that provide the formality of operations for this facility required by the U.S. Department of Energy (DOE) Order 5480.19, *Conduct of Operations Requirements for DOE Facilities*. The DOE policy governing conduct of operations at any DOE facility requires that the facility be managed with a consistent and auditable set of requirements, standards, and responsibilities.

7.1 ORGANIZATIONAL STRUCTURE

This section discusses the functions, relationships, responsibilities, and authorities of the organizations responsible for the design, construction, testing, modification, and operation of the SWBG.

7.1.1 Management and Operations Contractor

The DOE selects the M&O contractor for the Hanford Site to perform operating and servicing functions.

7.1.2 Operations Organization

The M&O contractor policies implement the requirements of DOE Order 5480.5, *Safety of Nuclear Facilities*, governing nuclear facility nonreactor safety. These policies require that SWBG design, construction, operation, maintenance, and modification be conducted in accordance with approved documents and procedures. Line management is responsible for ensuring that SWBG safety analyses are performed, reviewed, and approved in accordance with requirements.

7.1.2.1 Principal Organization. The SWBG M&O contractor has primary responsibility for safe operation of the burial grounds. This responsibility encompasses management of the receipt, storage, and disposal of all solid waste as follows:

- Provide management and financial control of solid waste programs, program management, technology support, regulatory support, acceptance services, and generator and data services
- Provide management for the receipt, storage, and disposal of solid waste including facility engineering, administrative, work control, and operations procedures support.

7.1.2.2 Supporting Organizations. Organizations supporting the SWBG M&O contractor provide the following functions:

- Document development support for safety analysis reports, technical safety requirements, and other safety support documents as required
- Management of assigned construction projects, project activities, and other SWBG construction work as required
- General engineering systems and facility design services, configuration management, and engineering data services
- Nuclear safety, radiological safety, occupational health and safety, industrial safety, quality assurance, audit and appraisal compliance, fire protection, and emergency preparedness support for SWBG operations to ensure compliance with applicable laws and policies. Environmental compliance guidance, monitoring, and oversight are provided to ensure compliance with federal, state, and local environmental regulatory requirements.

The quality assurance program provides independent oversight, inspection, surveillance, review, and approval of SWBG activities that affect the site equipment and operations to ensure compliance with the quality assurance program requirements (DOE Order 5700.6C, *Quality Assurance*).

The radiation protection program is based on the requirements of DOE Order 5480.4, *Environmental Protection, Safety, and Health Protection Standards*, DOE Order 5480.11, *Radiation Protection for Occupational Workers*, RLIP Order 5480.4C, *Environmental Protection, Safety, and Health Protection Standards for RL*, and RLIP 5480.11, *Radiation Protection for Occupational Workers*. In implementing these orders, management has the responsibility to ensure the following.

- New or modified facilities, systems or equipment are designed in accordance with accepted radiological design principles, including as low as reasonably achievable (ALARA) principles.
- Operations involving radioactive materials and/or exposure to radiation are conducted safely and in accordance with applicable radiological control procedures and ALARA principles.
- Workers who are or may be exposed to radiation or radioactive contamination are fully trained and qualified to perform jobs safely and in accordance with applicable procedures.

The Hanford Fire Department provides the following fire protection functions:

- Maintains command of emergency response forces to perform the necessary actions to control and terminate fire-related incidents, provide emergency medical patient care, and act as the incident command agency for hazardous materials emergency incidents

- Conducts fire protection system functional testing for all Hanford Site facilities and maintains self-contained breathing apparatus
- Maintains an active fire prevention program through facility tours and inspections of all flammable and reactive waste sites
- Maintains a highly trained emergency response team certified under a 3-year Washington State approved fire fighter apprenticeship program
- Uses and maintains a modern fleet of emergency response vehicles consisting of pumper trucks, aerial ladder units, modular ambulances, command vehicles, wild land brush tankers, hazardous materials response vehicles, and specialized equipment designed to deal with the unique requirements and operations of the Hanford Site.

The Hanford Fire Department is party to mutual aid agreements with 10 surrounding fire departments and fire districts as well as contractual responsibilities for fire suppression and ambulance service to the Washington Public Power Supply System.

The Safety and Environmental Advisory Council (SEAC) provides independent advice to the president of the M&O contractor and other senior management on matters of safety and environmental protection.

The SEAC and permanent subcouncils augment the independent safety review system and ensure compliance with DOE Order 5480.23, *Nuclear Safety Analysis Reports*. Specific reviews by the Council may be performed by the full SEAC, by one of six permanent subcouncils cognizant of designated activities, or by an ad hoc subcommittee appointed for a particular review.

Operations Support Services provides heavy equipment operators and crane operators as necessary for the delivery, movement, and placement of wastes, transportation services, maintenance training, and physical security support. These services include the following:

- Operation of fabrication shops and calibration facilities
- Operation and maintenance of site utilities and transportation services
- Maintenance of grounds
- Material coordination, procurement, receiving, and storage for some Hanford Site areas
- Property and inventory accounting
- Technical training support to other organizations.

The Security Applications Center provides analytical and systems engineering support to ensure cost-effective, uniform safeguards and security systems throughout the Hanford Site.

Safeguards and Security provides protective force services, including command, control, and notification for all emergency conditions, and enforcement of applicable federal, state, and local laws on the Hanford Site.

The SWBG also receives support in the following general areas.

- **Engineering Geology** — Support in this area is provided by the Geosciences Group of the Environmental Engineering, Geotechnology and Permitting function.
- **Maintenance Support** — Operations Support Services provides maintenance support throughout the Hanford Site, including operation and maintenance of the Hanford Site roads, grounds, rail, utilities, and mobile fleet, among other responsibilities. This includes providing real property maintenance, custodial, and transportation services as well as planning for, procuring, and staging maintenance materials.

7.1.3 Personnel Qualification Requirements

The minimum requirements for all personnel are met through the preemployment process. The Basic Occupational Literacy Test, developed by the U.S. Department of Labor, is used to test for literacy. Mental and physical health qualifications are determined by the physical examination, which includes a mask fit and respirator fit. The individual must meet the security requirements for the job classification. The final steps of the preemployment process ensure absence of substance abuse and verify the employee's education and work experience.

Operation and maintenance of the SWBG requires qualified and highly trained personnel. This requires an extensive selection, training, and qualification program. The elements of the training and qualification programs are described in Section 7.3.

Minimum position requirements for the SWBG are established for all positions. For management and supervisors positions, the requirements are specified in job-specific position descriptions and are subject to the following minimum requirements:

- Managers are required to have a Bachelors degree and 2 years related experience
- Supervisors are required to have a high school diploma and 3 years related experience.

7.1.4 Liaison With Outside Organizations

Contacts are maintained with the DOE Richland Operations Office (RL) through functional and programmatic offices and with those governmental agencies that have regulatory authority over the Hanford Site solid waste programs, such as the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology).

Other onsite or offsite independent contractors provide support services as required. These support service contractors may change from time to time in the future as the DOE or the M&O contractor assign new contract responsibilities. Support services provided by these contractors include, but are not limited to, the following:

- Architect-engineer services
- Research and development services
- Personnel monitoring services
- Radiation instrumentation monitoring program services
- Site characterization services
- Personnel health and occupational medicine services
- Emergency medical services
- Emergency decontamination services.

7.2 PREOPERATIONAL TESTING AND OPERATION

The line organizations responsible for preoperational testing and operation will comply with DOE Order 4700.1, *Project Management System*, and RLIP 4700.1A of the same title.

The construction contractor for new SWBG disposal units will conduct acceptance tests through an established test verification procedure. These tests include, as a minimum, those specified in project-specific quality assurance plans.

Once the testing is completed and found acceptable, the system will be turned over to the operating organization.

7.2.1 Readiness Reviews

DOE Order 5480.5, *Safety of Nuclear Facilities*, and RL Order 5481.1, *Safety Analysis and Review System*, require that new facilities and facilities significantly modified or out of service for longer than 1 year, perform an operational readiness review before authorization of facility operation. This review is to be based on an analytical method, such as in DOE SSDC-76-45/1, *Occupancy Use Readiness Manual* (Nertney et al. 1992), or DOE SSDC-76-45/4, *MORT User's Manual* (Knox and Eicher 1992). The operational readiness review determines the readiness of facility structures, as applicable, and assesses managerial (organizational control systems) and personnel readiness (i.e., staffing, training, and procedures).

The DOE orders are implemented via WHC-CM-1-5, *Standard Operating Practices*, Section 1.2, "Operational Readiness Reviews." These require that a formal operational readiness review program be developed and used which specifies the responsibilities of the facility management, the Readiness Review Board, and the independent review organizations. The independent review organizations conduct parallel but independent review in their respective area of responsibility. The sum of these reviews constitutes the overall independent review.

7.3 TRAINING PROGRAM

A summary description of the SWBG training requirements is presented in this section.

7.3.1 Program Description

A combination of general and specific safety and operational training is provided to prepare employees to operate and maintain the SWBG in a safe, effective, efficient, and environmentally sound manner. The required training program is based on the following:

- DOE Order 5480.1B, *Environment, Safety, and Health Program for Department of Energy Operations*
- DOE Order 5480.18A, *Accreditation of Performance-Based Training for Category A Reactors and Nuclear Facilities*
- DOE Order 5480.20, *Personnel Selection, Qualification, Training, and Staffing Requirements for DOE Reactor and Nonreactor Nuclear Facilities*.

The training program requires employees to successfully complete general and job-specific self-study, classroom, and on-the-job training requirements. Most training is required on a biennial basis with hazardous waste training required annually. Training of new employees is to be completed within the first 6 months of employment. After initial training, employees must comply annually with their training program requirements. The SWBG operating contractor is responsible for ensuring that employees are trained and that training is maintained as required.

Training requirements include the following, which may be modified, upgraded, or superseded from time to time as required.

- **Hanford General Employee Training** (Interactive video, self-paced course takes approximately 4 hours annually) — Provides the basic essential industrial safety, radiation safety, security, and work policies necessary for all employees. It discusses policies regarding procedures, the employee awareness program, the employee concerns program, and work rules.
- **Radiation Worker Training (Rad Worker I)** (7 hours) — Provides fundamentals of radiation protection and the proper procedures for maintaining exposures ALARA. It includes the acute and chronic effects of exposure, protective measures, survey instrumentation, monitoring programs, contamination control, personnel decontamination, warning signs and alarms, and responsibilities of employees and management.
- **Radiation Worker Retraining (Rad Worker II)** (7 hours biennially after initial radiation worker training course) — Reviews material in the initial radiation worker training course, and provides an exercise to perform Special Work Permit clothing dress-undress and

step-off pad procedures as in the radiation worker training course. Evaluation is accomplished through a written examination and performance assessment.

- **Generator Hazards Safety Training (4 hours biennially)** — Provides the hazardous material waste worker with the fundamentals for use and disposal of hazardous materials. Information on the federal and M&O contractor hazard communication programs, the use of material safety data sheets, labeling requirements for manufacturers and Hanford Site labels, general chemical handling, safety, health effects, waste minimization, waste management regulations, the M&O contractor waste management system, and an overview of mixed waste requirements is provided.
- **Hazardous Materials and Waste Job-Specific Training (Duration depends on the job. Provided annually by the supervisor)** — Provides specific information and guidance for the safe handling of hazardous materials and waste.
- **Hazardous Waste Site Operator (Basic) (16 hours)** — Provides information for the safe operation of hazardous waste treatment, storage, and disposal facilities regulated under 40 CFR 264 and 265 pursuant to the *Resource Conservation and Recovery Act of 1976* (RCRA). This course plus the initial radiation worker training course satisfies the 29 CFR 1910.120 24-hour safety training requirement for operations under RCRA.
- **Hazardous Waste Site Operator (Retraining) (8 hours annually after completing basic course)** — Reviews the material covered in the basic course and includes updates and lessons learned.
- **Hazardous Waste Site Supervisor (Manager) (8 hours annually)** — Provides safety management training required for supervisors and managers of hazardous waste sites or operations covered by 29 CFR 1910.120.

Required training is based on an analysis of tasks and responsibilities for each job position and includes emergency preparedness training to respond effectively to events such as emergency monitoring equipment alarms, container failures, vehicle accidents, earthquakes, fires, or groundwater contamination.

Operations Training. Operator job certification will be identified in the SWBG training plan. Certification will meet the requirements identified in DOE Order 5480.20. The certification will include documented formal and on-the-job training examinations and satisfactory demonstrations of job knowledge. The certification will be the basis by which individuals will be assigned to perform work independently. Employees will be expected to certify on a variety of jobs as directed by management. Documentation of proficiency will be required every 2 years for recertification. Employees will be given a reasonable length of time, as specified by management, to certify each job assignment.

Operations Manager/Supervisor Training. Continuing education incorporates new management methods and technical advances, provides guidance for compliance with regulatory requirements, and provides application and maintenance information for specific items of equipment. These educational and training courses are an important supplement to the site-wide and facility-specific training programs. Continuing education resources are used to maintain current skills of personnel. This training will be in addition to site-specific and facility-specific training identified in the SWBG training plan.

The staff training manager is responsible for the overall coordination and administration of the on-the-job programs under the direction of the appropriate manager. The staff training manager may request assistance from and coordinate with other training managers to provide needed instruction, test administration, and training manual approval.

Manufacturer/vendor training is usually included as part of a procurement arrangement for technical systems not previously used at the Hanford Site. Manufacturer/vendor personnel are either accompanied by trained escorts or have received basic training in subjects such as safety, security, radiation safety, and appropriate alarm response. This training will be in addition to site-specific and facility-specific training identified in the SWBG training plan.

Incidental site visitors must watch the "Visitor/Vendor Orientation," which is a 13-minute video with handouts that covers essential safety and security topics, such as the master safety rules, hazard warning signs, and response to emergency alarms. Visitors to the SWBG must be escorted.

Maintenance Training. The SWBG utilizes maintenance personnel from a variety of skilled trades for repair, modification, and maintenance of equipment and facilities. These trades may include instrument technicians, laborers, electricians, and carpenters. WHC-CM-8-7, *Operations Support Services*, provides the implementation requirements for the maintenance training program. The following maintenance training activities may be assumed by the staff training manager:

- Assignment of technical instructors to meet training requirements
- Indoctrination and training of assigned instructors
- Development and updating of maintenance training internal procedures manuals and lesson plans
- Preparation and maintenance of applicable skills checklists
- Maintenance of training records.

Maintenance, crafts, management, and maintenance engineering personnel assigned to SWBG maintenance must be trained in generic procedures of nuclear safety and site orientation. This training will be in addition to site-specific and facility-specific training identified in the SWBG training plan.

7.3.2 Retraining Program

The program of continued training through presentation of refresher training and additional materials was briefly described in Section 7.3.1. For each job classification, future job task analyses will define specific subjects that will require continuing training. The retraining and requalification requirements of DOE Order 5480.5 will be met.

Operations Retraining. All managers will ensure that personnel are retrained within the time allowed by the course requirements for any specific training subject. The retraining sequence for each course will be listed on the computer-based training system. A list from the computer-based training system identifying the retraining requirements for each employee will be periodically routed to all managers. Managers will review the retraining required for each employee and will schedule retraining in those areas that are still applicable for the employee's job function.

Maintenance Retraining. Retraining at 2-year intervals will be mandatory for maintenance personnel applying maintenance or repair procedures to essential systems or equipment. Essential systems or equipment are those that, if improperly maintained or calibrated, could jeopardize employee safety, result in an unacceptable release of hazardous or radioactive material to the environment, or in some way jeopardize public safety. Maintenance on these types of equipment or systems is restricted to maintenance personnel who have completed an equipment- or system-specific qualification program. Essential equipment and systems will be identified in the SWBG maintenance plan. Retraining will be required before working on essential systems or equipment if a craftsperson has been reassigned to work outside of that particular maintenance specialty for 1 year or longer. Retraining will be required at 2-year intervals for each maintenance craftsperson in the support (safety-related) subjects applicable to the specific trade specialties.

7.3.3 Administration and Records

Written job descriptions for each position at the facility are maintained together with the training requirements by position. Training records are reviewed annually to ensure that task assignments and training received are appropriate for the assigned individuals. The job-specific training packages are reviewed every 2 years and after any significant program change to ensure that the work content has not changed. Individual training documentation is maintained by Technical Training Support. Training records are kept for at least 3 years after an employee stops working at the SWBG. For new facilities constructed in the active SWBG, the existing training program for SWBG workers will incorporate guidance relative to the operation and maintenance of the new facilities. This training will be included in the certification of new operators and the recertification of existing operators.

Compliance with the SWBG training program is documented by the following, which may be modified, upgraded, or superseded from time to time as required.

- **Initial Training Record** — documents initial training required for an employee newly hired into the SWBG.

- **Employee Training Checklist** — documents training required and received to qualify an employee for certification/qualification.
- **On-the-Job Training Checklist** — records completion of required task items.
- **Oral Examination Form** — used during oral boards to record both questions and answers given during oral board examinations.
- **Letters or statements** — indicate the acceptance or denial of a request for waiver or exemption to training.

These forms are maintained in each employee's training file.

7.4 NORMAL OPERATIONS

The SWBG M&O contractor is responsible for the day-to-day management and operation of the SWBG. These responsibilities include the development and documentation of detailed operating procedures.

7.4.1 Operating Procedures

Because it is classified as a nonreactor nuclear facility, all operations in the SWBG are conducted in accordance with detailed, written, operating procedures. Operating procedures for the SWBG, which may also be in the form of work plans discussed previously in Chapter 3.0, include the offloading and emplacement of waste packages in the SWBG; inspection of instrumentation and liquid levels in the collection tank (for mixed waste lined trenches); maintenance of the SWBG and its equipment and instrumentation; and surveillance of the SWBG. Radiological work permits (RWPs) are posted in a location accessible to SWBG workers. Administrative procedures provide rules and instructions to SWBG personnel to provide a clear understanding of operating philosophy and management policies. All operating procedures are written, approved, and controlled in accordance with the procedures in WHC-CM-6-2, *Project Management*, and will comply with DOE Order 5480.19, *Conduct of Operations Requirements for DOE Facilities*.

The SWBG procedures are reviewed annually or whenever a change in operations has a significant impact on the procedures. Procedures are reviewed by appropriate support organizations.

All SWBG operations, procedures, and associated documentation are audited to ensure overall safety of operations. The audit may include the following, which may be modified, upgraded, or superseded from time to time as required:

- Technical safety limits
- Criticality
- Industrial safety
- Fire protection
- Industrial hygiene

- Radiological safety
- Emergency preparedness
- Environmental compliance.

Any unusual occurrences, spills, injuries, occupational illnesses, or accidents are investigated as soon as possible to determine the cause of the incident and the necessary corrective action.

7.4.1.1 Annunciator Procedures. Annunciator procedures are not required for SWBG disposal activities. Annunciator procedures will be developed, if required, for future SWBG activities.

7.4.1.2 Work Authorization System. The Work Authorization/Job Control System (JCS) is used to control corrective maintenance and modification of existing facilities and equipment and sometimes used for receiving waste packages. The JCS lead document is WHC-CM-8-8, *Job Control System*. The JCS provides the procedures needed to ensure that work for the SWBG is adequately planned, reviewed, authorized, performed, evaluated, closed out and documented in a controlled manner. The JCS will meet the requirements identified in DOE Order 4330.4A, *Maintenance Management Program*.

7.4.1.3 Health Physics Procedures. Health physics procedures are used to implement the radiation protection program (described in Chapter 4.0). Manual WHC-IP-0718, *Health Physics Procedures Manual*, has been prepared and delineates radiation protection procedures, including monitoring of employee exposures, radiation surveys, radiation measurements, evaluation of radiation hazards, and records maintenance. These procedures are for the information and use of health physics technicians.

Specific RWPs are prepared for unique operations involving the SWBG. Specific requirements in the RWP are established to ensure that a health physics technician is present for all operations within the SWBG. Health physics technicians have the responsibility of coordinating corrective actions when radiological limits are exceeded. Health physics safety is incorporated into the work plan for each specific job and into the RWP. An RWP may be a stand-alone document or may be used with a work plan.

7.4.1.4 Maintenance Procedures. Periodic or routine maintenance activities for the SWBG will be conducted in accordance with DOE Order 5820.2A, *Radioactive Waste Management*. Corrective action will be taken if visual inspections or surveillances identify abnormalities in the condition of waste containers or trenches. The action taken depends on the severity of the abnormality or degradation and will follow established maintenance procedures.

7.4.1.5 Operating Procedures. The elements of plant operating procedures are discussed in Chapter 3.0. The SWBG procedures address the following, which may be modified, upgraded, or superseded from time to time as required.

- Systems operation procedures
- Waste receipt and inspection procedures
- Waste handling, storage, and disposal procedures
- Environmental monitoring, sampling, and testing procedures.

Information contained in these operating procedures provides the basis for the occupational dose estimates given in Chapter 4.0. SWBG plant operating procedures and actual SWBG operations must comply with the SWBG technical safety requirements (WHC 1994), as required by DOE Order 5480.22, *Technical Safety Requirements*.

7.4.1.6 Test Procedures. Test procedures are not required for SWBG disposal activities. Test procedures will be developed, as required, for future SWBG activities.

7.4.1.7 Preoperational Test Procedures. Refer to Section 7.2.

7.4.1.8 Quality Assurance Procedures. Quality assurance procedures have been established to ensure that the operations of the SWBG are performed in accordance with the quality assurance program described in Chapter 8.0.

7.4.2 Plant Records

A records management program is established as directed by WHC-CM-1-3, *Management Requirements and Procedures*, MRP 3.3. The program is also controlled by WHC-CM-3-5, *Document Control and Records Management Manual*, and complies with the applicable 1324 series of DOE and RL orders. The purpose of this program is to ensure that important and necessary information is properly identified and easily retrieved when needed and information is disposed of when it no longer serves a useful purpose.

Managers are responsible for identifying all record and nonrecord material for their operation. Any organization retaining records for the SWBG follows the guidelines in WHC-CM-3-5 where records are listed in the Record Inventory and Disposal Schedule or Machine Generated Record Inventory and Disposal Schedule. These guidelines also specify retention periods. Retention periods are established for records of temporary or nonrecord value (material that other organizations are responsible for retaining which an organization is retaining only for reference purposes and which can be discarded without authority, [i.e., catalogs, trade journals, transmittal sheets]). Nonrecord items are evaluated to determine their retention periods. Short periods (less than 3 years and not less than 1 year) are established for nonrecord items because they are for convenience or reference only and are usually duplicated elsewhere within the plant or organization. These retention periods are a maximum rather than a minimum; therefore, the items may be discarded before the end of the retention period.

Records that pertain to an organization's function, policies, decisions, procedures, operations, or other activities of the SWBG are considered record material. This material may be preserved for legal record purposes or for the value of its data.

Some operational records, such as Job Controlled Maintenance and Operational Safety Requirement compliance records, are considered quality assurance documentation and are controlled according to the guidelines in WHC-CM-4-2, *Quality Assurance Manual*. The Quality Assurance organization

concur in classifying records as quality assurance records. Quality assurance records are controlled throughout their life from the time of authentication.

Records may be transferred to records storage areas for a predetermined storage period. The organization generating the records is responsible for determining the required storage period and indexing and logging records that are transferred to storage. The records can be retrieved and reviewed at the storage area and copies may be made for official use. Quality assurance records cannot be removed from the records storage area.

7.5 EMERGENCY PLANNING

The SWBG has an emergency plan that is contained in WHC-IP-0263-LLBG, *Building Emergency Plan for Low-Level Burial Grounds* (WHC 1993) and is designed to minimize the consequences of any potential emergency condition that could occur in this area. The plan applies to all personnel and visitors in the SWBG. The plan conforms to the *Hanford Emergency Response Plan* (RL 1994). It complies with DOE Order 5500.1B, *Emergency Management System*; DOE Order 5500.2B, *Emergency Categories, Classes, and Notification and Reporting Requirements*; and DOE Order 5500.3A, *Planning and Preparedness for Operational Emergencies*, and includes the following:

- General description of the facility operation
- Description of the emergency response organization
- Description of how the contingency plan will be implemented
- General description of the emergency control measures
- Description of responses to specific postulated facility emergencies
- Summary of support agreements with offsite agencies
- Evacuation plan
- List of required reports
- Location of the contingency plan
- Conditions that require the emergency plan to be amended.

The plan applies to all operations, vendors, visitors, and other site tenants in SWBG facilities. The plan establishes an emergency response organization to manage and respond to credible emergency conditions, a method for requesting emergency assistance, and a method for informing SWBG management, the RL, and other site tenants of such events. The plan will be coordinated with the emergency preparedness plans of the RL, other RL contractors, and local and state authorities. Taken as a whole, these plans provide an integrated emergency response capability for the Hanford Site.

In the following functional descriptions, titles may be modified, upgraded, or superseded from time to time as required.

Employees are required to promptly report any real or potential emergency condition to the Patrol Operations Center and the building emergency director (BED). Any events occurring in the SWBG would be reported by hand-held or vehicle two-way radios, which are routinely used to maintain internal communications with shift supervisors located in the operations support buildings.

The BED has overall responsibility for protection of a particular facility. For the SWBG, the functional equivalent of the BED is the cognizant operations supervisor (COS). The COS functions as the emergency coordinator and leads from that facility emergency response organization personnel, who assist in emergency response actions. Line management assists the COS in protecting personnel, property, and the environment during an emergency event. If an emergency occurs outside of normal business hours, the emergency duty officer or the area emergency director takes over the responsibilities of the COS.

The Patrol Operations Center has a current list of these emergency management personnel for around-the-clock notification. The emergency duty officer responsibility rotates through a select group who are trained and available to provide support, 24 hours per day, 7 days per week. The emergency duty officer is provided with a vehicle equipped with a mobile telephone, a multichannel radio, and a scanner. The emergency duty officer has responsibility for responding to the emergency until the COS arrives. The emergency duty officer then assists the COS and acts as the link between the field command post and the area Emergency Control Center (ECC), if it is activated.

The area emergency director is a senior manager responsible for dealing with any event with onsite personnel or facility safety consequences. The area emergency director activates and directs the area emergency center and its response organization. When an area emergency center is activated, the emergency management center is also activated to provide top level management with current information and to overview the area response when the response is limited. The emergency management center coordinates site-wide response and resources in coordination with the RL Emergency Action Coordinating Team (EACT) when an emergency condition may have potentially significant onsite or offsite impacts. The RL EACT provides all offsite notifications of emergency conditions and provides assistance and expertise as required.

The Patrol Operations Center is operated around the clock to receive emergency or security calls and provides notification to appropriate emergency response organizations and personnel. It operates as the initial communications center until a field command post is established by the COS. The Hanford Patrol activates alarms, as necessary, facilitates access of emergency personnel through security gates, and provides barricades if warranted.

The Hanford Fire Department has trained personnel to respond to medical emergencies, fires or explosions. In addition, a management response team is assisted by Operational Health Physics and other personnel as required to evaluate any SWBG emergency event and generate a recovery plan. Industrial Safety and Fire Protection identifies hazards associated with cleanup and helps develop procedures and requirements for personnel protective clothing and equipment. The EPA provides guidance for events involving a loss of environmental control and makes the necessary notifications through RL to Ecology or the National Response Center that an event has occurred. Nuclear process operators and support personnel implement the recovery plan.

Emergency Preparedness is responsible for establishing and conducting the training program for emergency organizations and is responsible for the documentation and retention of training program results. Emergency Operations Support is responsible for program development and also provides some of the training.

Operations Support Services facilitates emergency planning efforts by the following, which may be modified, upgraded, or superseded from time to time as required.

1. Providing for systems implementation of occurrence reporting processes, including, but not limited to the following:
 - a. Ensuring 24-hour, timely, accurate occurrence notification, information, and performance monitoring
 - b. Assisting line management in the completion of occurrence notification and reporting requirements.
2. Developing and overseeing the emergency management program through the following:
 - a. Planning and coordinating comprehensive emergency response actions to mitigate the consequences of an emergency in a timely and efficient manner by the following:
 - Developing emergency plans and implementing procedures
 - Providing appropriate coordination between RL and other Hanford Site contractors to ensure the protection of onsite personnel, public health and safety, and the environment
 - b. Establishing and maintaining emergency programs to ensure timely, efficient and effective response to emergencies involving WHC facilities, operations and activities by:
 - Maintaining emergency response facilities and equipment in a state of operational readiness
 - Providing emergency preparedness training, drills and exercises; addressing program coordination needs; and corrective action recommendations to maintain M&O contractor emergency assurance in a high state of readiness
 - c. Implementing readiness assurance programs to ensure the following:
 - Emergency plans, implementing procedures, and capabilities are adequate, effectively exercised, and periodically evaluated

- Appropriate improvements and corrective actions are taken as a result of exercises, appraisals, and self-assessment evaluations.

The SWBG is included in the domain of the Solid Waste Management Complex. All personnel within the Solid Waste Management Complex will be required to be trained on potential hazards, emergency alarms, and emergency procedures.

The primary considerations in response to emergencies or off-normal conditions at the SWBG will be the safety of the facility workers, others in the vicinity, and the public, and impacts to the environment. A secondary consideration will be the protection of the facility equipment. The SWBG emergency plan will identify alarms or other indicators that require personnel evacuation and the proper response to each. Continued worker presence in the SWBG area will not be required under emergency or accident conditions. For conditions not requiring prompt evacuation, the operating procedures will define the appropriate responses. Training in response to various events will be provided as part of the emergency response training and operator training programs.

Other functions or individuals that assume some responsibility for the management of emergency situations include the following.

Emergency Duty Officer. The responsibilities of the emergency duty officer include the following:

- Contacting the BED/COS to aid in an emergency if not already present at the affected site
- Notifying the area emergency director of the emergency
- Assisting in activating the area ECC
- Acting as a communications link between the event command post and the area ECC
- Assisting in obtaining resources to mitigate the emergency
- Ensuring a team emergency response effort.

Area Emergency Director. The area emergency director is responsible for activation of the area ECC, normally for the following reasons:

- An event that could have a significant negative impact on onsite personnel safety and/or facilities, public health, public relations or the environment
- An incident having multiple major injuries and/or fatalities, or in which the facility emergency response organization requires assistance to mitigate emergency events
- At the request of the M&O contractor, RL, or another Hanford Site contractor.

The area emergency director is also responsible for the following:

- Activating the ECC and acting as its director
- Directing the area emergency response organization and the area ECC operations
- Communicating with the emergency director
- Notifying the emergency director of event progress and changes in emergency conditions
- Activating the area ECC staff.

Emergency Director. The emergency director provides overall emergency management and is responsible for the following:

- Communicating directly with senior management within the RL EACT
- Recommending appropriate protective action and event classifications to the RL EACT
- Activating the emergency management center and acting as director if this level of response is required.

Emergency Management Center. The area ECCs communicate with the emergency management center staff, who, in turn, communicate with the RL EACT. When the emergency management center is activated, the staff responsibilities include the following:

- Providing top-level management with information on events involving facilities on the Hanford Site
- Overview/monitoring of area response
- Managing site-wide response and resources
- Interfacing with the RL EACT.

RL EACT. The RL EACT provides all offsite notifications of emergency conditions, provides the M&O contractor with assistance and expertise, and has ultimate responsibility for Hanford Site emergency responses and actions. The RL EACT normally convenes in the following instances:

- When a Hanford Site emergency condition involves potentially significant onsite or offsite consequences
- When the incident involves a security event
- When a significant natural disaster occurs, such as an earthquake or a tornado
- When threats or acts of terrorism occur or when a national emergency is declared

- When requested by the Federal Emergency Management Agency
- When requested by RL or contractor management.

The RL EACT responsibilities include the following:

- Managing offsite interfaces and overview of onsite emergency management
- Providing offsite notification and protective response recommendations to federal, state, and local agencies
- Continuously updating the status of ongoing events to federal, state, and local agencies
- Providing offsite notifications and press releases
- Obtaining assessment data from the Unified Dose Assessment Center for the emergency incident.

7.5.1 Emergency Incident Identification and Initial Response

When an event occurs, the emergency incident or altered process must first be identified and the initial actions to control the incident must be taken. This subsection discusses these initial activities. Potential emergency incidents may be identified through routine inspections, alarms, chemical odors, visible fires, explosions, spills, or detection of dangerous constituents. Reporting requirements are identified in WHC-CM-1-3, MRP 5.14, and comply with DOE Order 5000.3B, *Occurrence Reporting and Processing of Operations Information*.

7.5.1.1 Initial Response Activities. Initial response activities will minimize exposure of personnel, protect the environment, and protect facility property and equipment to the extent feasible. Response actions communicate the hazards of the incident immediately to workers and the emergency response organization. This communication is crucial for ensuring that resources are available to mitigate the emergency condition and for management to make decisions. The employee identifying the incident is responsible for initiating the response actions. The emergency response organization responds as follows:

- Assess the potential hazards or consequences
- Warns personnel and minimizes exposure to the emergency
- Attempts to stop the emergency, if feasible
- Isolates the affected area.

7.5.1.2 Hazard Assessment. In an imminent or actual emergency situation, the COS or emergency duty officer will assess the possible hazards to human health and the environment. If evacuation is advisable, the COS will implement the evacuation plan. In the event of a spill or release, the COS will identify the material, character, source, quantity, and affected area as accurately as

the situation will allow. In the event of a fire or explosion, the COS and the Hanford Fire Department will assess the threat to human health and the environment.

The COS will recommend the appropriate event classification and the type of response through the applicable chain of command to the emergency management center. The emergency director will recommend the designated event classification to RL. The RL will provide offsite notifications and response recommendations to the RL EACT. Various other groups within the emergency response organization will be available, as necessary, to assist in determining if the emergency action levels have been reached, and to recommend onsite protective responses. The event classification or levels of emergency are as follows:

- Unusual event
- Alert
- Site emergency
- General emergency.

There are nonclassified incidents of less consequence that may require assistance from the facility emergency response organization or from outside the affected site. The emergency response procedures allow for escalation or deescalation when new data pertaining to the nature and magnitude of the incident are obtained. These event classifications and emergency action levels are described in the following paragraphs.

Unusual Event. An unusual event requires response actions but normally would not constitute an emergency situation. It indicates a potential reduction of safety. Activation of offsite emergency response organizations is not expected. Emergency response actions are limited to the onsite emergency response organization.

Alert. An alert involves an actual or potential substantial reduction in the level of facility safety. Limited offsite releases of radioactive materials, which do not exceed permissible standards, may occur. Initiation of an alert is intended to ensure that emergency response personnel are notified of the event and confirmatory monitoring is initiated.

Hanford Site Emergency. A Hanford Site emergency involves actual or possible failures of major facility functions. A Hanford Site emergency involves radioactive material (not exceeding protective response recommendation guides) or dangerous materials potentially exceeding release limits. Declaration of a Hanford Site emergency is intended to ensure that the affected area ECCs are manned, monitoring teams are dispatched, personnel responsible for determining onsite protection requirements are at their duty stations, and appropriate protective measures are initiated.

General Emergency. A general emergency involves an actual or imminent substantial reduction of facility safety systems. Offsite releases of radioactive materials exceeding protective response recommendation guidelines

are occurring or are expected to occur, and releases of dangerous materials are expected to exceed offsite protective action guidelines. The objectives for declaration of a general emergency are as follows:

- To initiate the planned measures to protect the health and safety of onsite personnel, potentially affected individuals offsite, and the environment
- To provide continuous assessment of emergency conditions and to exchange information with onsite and offsite organizations
- To activate DOE-wide resources required to effectively mitigate the emergency condition.

7.5.1.3 Notification. The emergency plan provisions are carried out immediately, whenever there is a fire, explosion, or container rupture that results in the release of radioactive or dangerous waste that could threaten human health or the environment.

The COS ensures that the appropriate notifications are made within line management and RL. If the situation requires assistance from fire, ambulance or patrol personnel, notification of the Patrol Operations Center is made via the Hanford Site emergency response number (911) or through portable radio (car phone) equipment, as applicable.

Depending on the severity of the incident, the RL immediately notifies Ecology and the on-scene coordinator for the southeastern Washington area of the National Response Center. In the event of a fire, explosion, or release that could threaten human health or the environment outside the facility, the COS or line management immediately notifies RL. In the case of any unplanned release of mixed or dangerous materials, the COS immediately notifies Environmental Protection who, in turn, notifies RL. The COS or line management documents the information provided to RL on an event fact sheet. A copy of the event fact sheet is retained in the SWBG records.

7.5.1.4 Response to Fires and Explosions. The employee discovering a fire or explosion must evaluate its severity. The employee activates the contingency plan through notification of the Patrol Operations Center. This employee also notifies the COS of the incident, providing all available details. If the opportunity exists, consult with the COS regarding the implementation of evacuation procedures or other protective measures. Other personnel in the affected area who may not be aware that the emergency exists are warned immediately. The COS proceeds directly to the scene to make an initial assessment of the situation.

Personnel at the affected area evacuate, assemble at the designated staging area, and await instructions. The Hanford Fire Department and the Hazardous Materials Response Team proceed to the affected area. If warranted, the Hanford Patrol sets up roadblocks to prevent unauthorized persons from entering the site of the emergency and emergency medical personnel are contacted, as appropriate, for medical aid.

7.6 DECOMMISSIONING

This section briefly describes the decommissioning activities applicable to the SWBG. It should be noted that final closure of the SWBG is addressed in the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1994). Until the time of closure, filled trenches will be backfilled, where appropriate to do so, the backfill material will be stabilized, and the site will be monitored.

7.6.1 Decommissioning Program

While a RCRA-compliant cover will ultimately be placed over the SWBG trenches, the cover design has not been completed. Therefore, this section briefly describes the basic requirements for site closure and stabilization plan and design features that facilitate site closure and eliminate the need for continuous active maintenance. The site closure plan addresses DOE site closure and postclosure requirements (DOE Order 5820.2A) together with the EPA and Ecology requirements described in this section.

7.6.1.1 Site Stabilization. The cover will comply with the requirements for dangerous waste disposal as defined by 40 CFR 264 and *Washington Administrative Code* (WAC) 173-303. Radiation dose rates at the surface of the cover will not exceed limits specified in 10 CFR 20.105. This cover is expected to cover all the radioactive waste disposal areas in the SWBG.

Surface Drainage and Erosion Protection. The RCRA-compliant cover will be designed to control infiltration and drainage. Natural runoff from adjacent areas will be controlled by drainage ditches.

7.6.1.2 Decontamination and Decommissioning. At closure, a radiologic site survey will be conducted to characterize the site grounds. This survey will become a part of the permanent decommissioning record and will be used to judge compliance with applicable radiation standards.

7.6.1.3 Postoperational Environmental Monitoring and Surveillance. Leachate and groundwater monitoring will give an indication of the integrity of the cover and waste packages. The groundwater monitoring program is overseen by a DOE contractor.

7.6.2 Decontamination

Decontamination of most areas of the SWBG likely will not be required. Disposed waste packages will be backfilled with noncontaminated soil to prevent potentially contaminated soil from blowing out of trenches and to reduce the likelihood that an accident or external event could damage waste packages and result in dispersal of radioactive material. Contamination will be limited to the trenches so no significant decontamination activities are anticipated. Spills of radioactive material outside the trenches will be decontaminated as appropriate. Formal procedures are available for responding to radioactive material spills.

Decontamination of the leachate storage and pumping equipment at the mixed waste lined landfills may be necessary.

7.6.3 Agreements with Outside Organizations

The Tri-Party Agreement (Ecology et al. 1994) has been approved by the DOE, EPA, and Ecology.

7.6.4 Arrangements for Funding

The DOE and its contractors are not obligated to provide the types of financial assurances required of the private sector by the Ecology and EPA. WAC 173-303-620 and 40 CFR 264 contain financial commitments required by owners and operators of hazardous waste facilities to ensure proper closure. In accordance with 40 CFR 264.140(c), the Federal Government is exempt from these requirements. The Hanford Site is a federal facility and therefore the financial assurance requirements are not applicable to the SWBG.

Article XLVIII of the Tri-Party Agreement between DOE, EPA, and Ecology indicates that DOE will request the funds necessary to meet the milestones of the agreement. Because specific milestones are associated with many activities within the SWBG, the DOE is obligated to request the necessary funding for its construction, operation, and closure. When the landfill cover design is finalized, the closure cost estimate will be provided to Ecology.

7.7 CHAPTER CRITERIA

A summary of the information in the chapter is provided with acceptance criteria derived from appropriate guidance documents. Separate subsections are provided for the review criteria for the different subsections of this chapter.

7.7.1 Organizational Structure

7.7.1.1 Summary Description. This section describes the organizational structure, responsibilities, functions, and authorities of the M&O contractor for the Hanford Site.

7.7.1.2 Acceptance Criteria. The acceptance criteria used for all sections (7.1 through 7.8) of this chapter are taken primarily from the following:

1. DOE Order 5480.5, *Safety of Nuclear Facilities*
2. DOE Order 5480.19, *Conduct of Operations Requirements*
3. DOE Order 5480.20, *Personnel Selection, Qualification, Training, and Staffing Requirements for DOE Reactor and Nonreactor Nuclear Facilities*
4. DOE Order 5480.18A, *Accreditation of Performance-Based Training*

5. DOE Order 4700.1, *Project Management System*
6. *Hanford Federal Facility Agreement and Consent Order* (Safety Analysis Report, Section 10.8)(Ecology et al. 1994).

The specific criteria used for this section are as follows.

1. Management provides and maintains a technically competent and safety oriented staff.
2. An adequate organization is responsible for operation, maintenance, and safety of the SWBG.
3. Defined lines of responsibility and authority are provided.
4. Organizational configuration ensures safety review and safety support.

7.7.2 Preoperational Testing and Operation

7.7.2.1 Summary Description. This section describes the scope, objectives and conduct of the readiness review.

7.7.2.2 Acceptance Criteria. The specific criteria used for this section are that it adequately demonstrates the following:

1. That the operational readiness review will encompass all hardware, personnel and documentation necessary to certify the readiness of the SWBG to operate in accordance with all required regulations
2. Specific objectives of a readiness review and specific certification requirements
3. How the readiness review will be conducted in relation to the quality assurance, safety, and environmental organizations
4. Specific criteria for the completion of the readiness review.

7.7.3 Training Program

7.7.3.1 Summary Description. This section begins with a brief program description so that one can better understand the rationale of the training program. The operator training, manager/supervisor training, and process engineer training are described in detail. The training requirements for SWBG management and support staff in addition to nuclear operators are listed both in terms of what is required and requalification. A section covering retraining and requalification is included.

7.7.3.2 Acceptance Criteria. The specific acceptance criteria used for this section are that it adequately demonstrates the following:

1. A training program which is complete in the areas of evaporator operation, instrumentation, and control while being able to deal with process malfunctions, and emergency procedures
2. A program containing refresher and continued training
3. Specific identification of training requirements for both nuclear operators and management/support staff
4. A description of the administrative controls on training records.

7.7.4 Normal Operations

7.7.4.1 Summary Description. This section describes SWBG operating procedures. The following areas are covered: shift routines and operating practices, control area activities, communications, control of equipment and system status, facility records, event reporting, and investigation.

7.7.4.2 Acceptance Criteria. The specific criteria used for this section are that it adequately describes the following:

- The process in which operating, maintenance, and testing procedures are developed, reviewed, implemented and changed (provides details on operator inspections, facility status and response to instrumental or other indications)
- The procedures for control of equipment and facility records.

7.7.5 Emergency Planning

7.7.5.1 Summary Description. This section describes a plan which has been developed to provide for the protection of onsite and offsite individuals, the environment and property during emergency conditions. The areas of coverage for the emergency plans include the following:

- Emergency organization
- Assessment action
- Activation of emergency organization
- Notification procedures
- Emergency facilities and equipment
- Training
- Maintaining emergency preparedness
- Recovery.

7.7.5.2 Acceptance Criteria. The specific criteria used for this section are that it describes the following:

- A complete emergency preparedness plan
- An emergency incident identification and initial response plan

- An evacuation plan
- Coordination agreements.

7.7.6 Decommissioning

7.7.6.1 Summary Description. The section on decommissioning describes the overall decontamination and decommissioning requirements as well as the decommissioning plans for the SWBG.

7.7.6.2 Acceptance Criteria. The specific criteria used for this section are that it adequately describes the following:

- Elements of a SWBG decommissioning program
- Elements of a SWBG decontamination program.

7.8 REFERENCES

7.8.1 Acts, Codes, and Standards

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

WAC 173-303, 1990, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

10 CFR 20, "Standards for Protection Against Radiation," *Code of Federal Regulations*, as amended.

29 CFR 1910, "Occupational Safety and Health Standards," *Code of Federal Regulations*, as amended.

40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.

7.8.2 Documents

Ecology, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Nertney, R. J., J. L. Clark, and R. W., Eicher, 1992, *Occupancy-Use Readiness Manual*, DOE SSDC-76-45/1, Rev. 1, System Safety Development Center, Idaho Falls, Idaho.

- Knox, N. W., and R. W. Eicher, 1992, *MORT User's Manual*, DOE SSDC-76-45/4, Rev. 3, System Safety Development Center, Idaho Falls, Idaho.
- RL, 1994, *Hanford Emergency Response Plan*, DOE/RL-94-02, U.S. Department of Energy, Richland Operations Office, Richland, Washington.
- WHC, 1993, *Building Emergency Plan for Low-Level Burial Grounds*, WHC-IP-0263-LLBG, Rev. 2, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1994, *Solid Waste Burial Grounds Interim Operations Safety Requirements*, WHC-SD-WM-TSR-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

7.8.3 U.S. Department of Energy Orders

- DOE Order 1324 series, as applicable, U.S. Department of Energy, Washington, D.C.
- DOE Order 4330.4A, *Maintenance Management Program*, U.S. Department of Energy, Washington, D.C.
- DOE Order 4700.1, *Project Management System*, U.S. Department of Energy, Washington, D.C.
- DOE Order 5000.3B, *Occurrence Reporting and Processing of Operations Information*, U.S. Department of Energy, Washington, D.C.
- DOE Order 5480.1B, *Environment, Safety, and Health Program for Department of Energy Operations*, U.S. Department of Energy, Washington D.C.
- DOE Order 5480.4, *Environmental Protection, Safety, and Health Protection Standards*, U.S. Department of Energy, Washington D.C.
- DOE Order 5480.5, *Safety of Nuclear Facilities*, U.S. Department of Energy, Washington D.C.
- DOE Order 5480.11, *Radiation Protection for Occupational Workers*, U.S. Department of Energy, Washington D.C.
- DOE Order 5480.18A, *Accreditation of Performance-Based Training for Category A Reactors and Nuclear Facilities*, U.S. Department of Energy, Washington, D.C.
- DOE Order 5480.19, *Conduct of Operations Requirements for DOE Facilities*, U.S. Department of Energy, Washington, D.C.
- DOE Order 5480.20, *Personnel Selection, Qualification, Training, and Staffing Requirements for DOE Reactor and Nonreactor Nuclear Facilities*, U.S. Department of Energy, Washington, D.C.
- DOE Order 5480.22, *Technical Safety Requirements*, U.S. Department of Energy, Washington, D.C.

DOE Order 5480.23, *Nuclear Safety Analysis Reports*, U.S. Department of Energy, Washington D.C.

DOE Order 5500.1B, *Emergency Management System*, U.S. Department of Energy, Washington D.C.

DOE Order 5500.2B, *Emergency Categories, Classes and Notification and Reporting Requirements*, U.S. Department of Energy, Washington D.C.

DOE Order 5500.3A, *Planning and Preparedness for Operational Emergencies*, U.S. Department of Energy, Washington D.C.

DOE Order 5700.6C, *Quality Assurance*, U.S. Department of Energy, Washington, D.C.

DOE Order 5820.2A, *Radioactive Waste Management*, U.S. Department of Energy, Washington D.C.

7.8.4 U.S. Department of Energy, Richland Operations Office Orders and Implementing Procedures

RL Order 1324 series, as applicable, U.S. Department of Energy, Richland Operations Office, Richland Washington.

RL Order 5481.1, *Safety Analysis and Review System*, U.S. Department of Energy, Richland Operations Office, Richland Washington.

RLIP 4700.1A, *Project Management System*, U.S. Department of Energy, Richland Operations Office, Richland Washington.

RLIP 5480.4C, *Environmental Protection, Safety, and Health Protection Standards for RL*, U.S. Department of Energy, Richland Operations Office, Richland Washington.

RLIP 5480.11, *Radiation Protection for Occupational Workers*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

7.8.5 Controlled Manuals

WHC-CM-1-3, *Management Requirements and Procedures*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-1-5, *Standard Operating Practices*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-3-5, *Document Control and Records Management Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-1, *Emergency Plan*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-2, *Quality Assurance Manual*, Westinghouse Hanford Company,
Richland, Washington.

WHC-CM-6-2, *Projects Management*, Westinghouse Hanford Company,
Richland, Washington.

WHC-CM-8-7, *Operations Support Services*, Westinghouse Hanford Company,
Richland, Washington.

WHC-CM-8-8, *Job Control System*, Westinghouse Hanford Company,
Richland, Washington.

WHC-IP-0718, *Health Physics Procedures Manual*, Westinghouse Hanford Company,
Richland, Washington.

CHAPTER 8.0
QUALITY ASSURANCE

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LIST OF TERMS

DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy-Headquarters
M&O	management and operations
PMD	Project Management Division
QA	quality assurance
QC	quality control
RL	U.S. Department of Energy, Richland Operations Office
SRC	submarine reactor compartment
SWBG	Solid Waste Burial Grounds

8.0 QUALITY ASSURANCE

This chapter describes the quality assurance (QA) program established by the management and operations (M&O) contractor for the design, construction, and operation of the Solid Waste Burial Grounds (SWBG). The criteria for the QA program are described in this chapter, and a broad overview of program implementation methodology is also provided. As used in this chapter, QA comprises all those planned and systematic actions necessary to provide confidence that a structure, system, or component will perform satisfactorily in service. The QA program includes quality control (QC), which are the activities related to the physical characteristics of a material, structure, component, or system that provide a means to control the quality of these items to predetermined requirements. The documents by which the QA program is implemented, both by Quality Assurance and other organizations that perform or direct activities potentially affecting functions important to the safety and quality of the SWBG, are listed.

The QA program described in this chapter applies to all activities that could affect the safety and reliability of the SWBG disposal activities. The extent to which quality requirements are applied to these activities is dependent on the importance of the activity and its potential impact on quality attainment. The details of the quality-related activities of suppliers, contractors, subcontractors, vendors, and any other organization that provides equipment, services, or support to the solid waste disposal operations are also described in this chapter.

8.1 ORGANIZATION

This section describes the organizational responsibilities and interfaces with respect to QA. The project organization is based on the team concept, using both onsite and offsite resources. The M&O contractor performs day-to-day project management and technical direction for the U.S. Department of Energy (DOE), Richland Operations Office (RL). Specific responsibilities are described in WHC-SD-MP-PMP-001, *Generic Project Management Plan* (WHC 1990). When more detailed project information is required, a specific plan is issued to supplement WHC-SD-MP-PMP-001. The key active participants in the project are RL, the M&O contractor, and other Hanford Site contractors. The project team is enhanced by support services from safety, quality, environmental, and health organizations to fulfill the project objectives in a safe, quality, and environmentally responsible manner.

8.1.1 U.S. Department of Energy-Headquarters

The U.S. Department of Energy-Headquarters (DOE-HQ) provides programmatic direction and overall surveillance of project performance through RL. The DOE-HQ maintains an overview of project performance to ensure achievement of technical, costs, and schedule baselines through the project reporting system and periodic project review meetings, and ensures that all required DOE-HQ activities in support of projects are accomplished, including the assistance and guidance from other government offices.

8.1.2 U.S. Department of Energy, Richland Operations Office

Overall management and execution of projects in accordance with RL Order 4700.1, *Project Management Systems*, are the responsibilities of the RL Project Management Division (PMD). The PMD coordinates with other RL divisions and staff. Authorization and funding for project activities are provided by the PMD. The PMD is the RL single point of contact with the M&O contractor during design and construction. The PMD reviews, approves, and/or coordinates approval of key documents, such as the following:

- Conceptual design report
- Project management plan
- Quality assurance program plan
- Work orders required by the project management plan
- Inspection plan(s)
- Engineering change notices
- Official acceptance of construction.

The PMD does the following:

- Issues project authorization for work performance
- Reviews cost estimates and supporting materials before initiation of design, procurement, or construction
- Provides technical overview of project to ensure compliance with directives, design criteria, and DOE requirements
- Ensures that construction projects are executed in a manner consistent with DOE policies, orders, criteria, and standards
- Coordinates design reviews within RL and serves as the single point of contact
- Approves all changes that affect the approved project baseline.

8.1.3 Management and Operations Contractor

The M&O contractor is responsible for the day-to-day technical direction and management of the Hanford Site as described in RL Order 4700.1.

The project manager is responsible for ensuring that program or user interfaces are maintained and that the project complies with technical, quality, safety, safeguards/security, and environmental requirements.

More specifically, the M&O contractor is responsible for the following:

- Prepare, control, and implement written policies, procedures, and instructions that control the performance of activities affecting quality
- Ensure adequate QA planning for projects and programs

- Evaluate personnel performing activities affecting quality to ensure that proficiency is maintained, provide appropriate indoctrination and training, and ensure that training records are maintained
- Develop quality improvement objectives and implementing actions to accomplish these objectives and measure progress
- Ensure performance of regular management assessment of the QA program
- Provide oversight and coordination of movement of solid wastes within the Hanford Site and authorize movement termination if it is deemed unsafe or otherwise incompatible with Hanford Site activities
- Construct the SWBG and support systems, including roadways, electric power (where needed), monitoring wells, etc.
- Provide oversight of the solid waste packages and disposal facilities.

8.1.3.1 Project Management. The primary responsibilities of project management is for the management and integration of activities related to design and procurement tasks of the SWBG.

The project manager is responsible for the following:

- Providing technical and daily project management coordination and control of design, procurement, scheduling, engineering, and inspection services
- Developing and submitting to RL all required documents defined in RL Order 4700.1
- Providing technical direction and administration of the architectural engineer design
- Ensuring definitive design is in compliance with the functional design criteria, project baseline, safety, operability, and cost effectiveness requirements. Involve environmental, safety, operations, engineering, process control, QA, architectural engineer, and DOE in design review
- Administering change control for design, procurement, and construction activities
- Coordinating and integrating the project team to ensure compliance with the technical baseline
- Ensuring that the design is in compliance with applicable codes, standards, criteria, regulations, and DOE management directives
- Maintaining official project files
- Providing technical and QA requirements to the project team members.

8.1.3.2 Engineering. The primary responsibility of Engineering is to develop engineering drawings and specifications for construction, modification, operation, and maintenance of the SWBG. The documents prepared by Engineering include safety classifications and criteria used for procurement, construction, QA, and operation activities.

8.1.3.3 Solid Waste. The responsibility of the SWBG operating contractor is to operate the SWBG in accordance with the DOE-approved authorization basis.

8.1.3.4 Emergency, Safety, and Quality Services. The Emergency, Safety, and Quality Services organizations provide guidance, review, and audit support to ensure compliance relating to industrial safety, fire protection, nuclear safety, equipment security, material safeguards, and QA requirements.

The QA manager is responsible for the following activities:

- Providing a documented QA program that controls program activities consistent with the importance of the activity or item
- Approving QA-related procedures and plans
- Establishing and maintaining the qualification of personnel performing tests and examinations, which verify conformance to specified acceptance requirements
- Establishing and conducting indoctrination and training for personnel performing and verifying activities affecting quality
- Verifying that QA indoctrination, training, and qualification records are maintained for personnel whose work can affect quality or who are responsible for verifying quality
- Ensuring a regular management assessment is performed on the QA program.

8.1.4 Engineer/Constructor

The engineer/constructor contractor provides construction management and force account construction services. The contractor is responsible for ensuring that any subcontractor work satisfies the requirements of the appropriate letter of instruction, quality assurance program plan, or statement of work. The Hanford contractor is responsible for the following activities:

- Providing design services as described in the letter of instruction, quality assurance program plan, or statement of work to meet project quality objectives and functional design criteria requirements
- Review and provide vendor data submittal. Maintain and distribute record of status

- Provide design, cost, and schedule baseline, change documentation and nonconformance reports, provide distribution, and maintain a record of status
- Initiate and process engineering change notices, provide accompanying documentation, and maintain a record of status
- Provide field engineering services; perform acceptance inspections for equipment and construction according to plan
- Provide as-built design for completed construction projects
- Prepare procedures for acceptance tests, witness such testing, and document results
- Maintain complete architectural engineer project design files.

The onsite construction contractor is responsible for the following activities:

- Provide onsite construction and construction management services, including QA, QC, safety review, scheduling, estimating, and cost control during construction
- Provide supervision and QC of force account construction
- Provide construction procurement services
- Maintain required project files on the construction activities
- Provide cost estimates, special construction procedures, and construction schedules
- Provide construction site safety inspections and surveillances
- Ensure that construction activities are performed in a quality manner.

8.1.5 U.S. Navy

A dedicated landfill has been constructed for disposal of defueled, decommissioned submarine reactor compartments (SRCs). The U.S. Navy or its contractors are responsible for the placement of the SRCs on foundations. These responsibilities include, but are not limited to, the following:

- Ensuring that SRC packaging is in conformance with applicable criteria in WHC-EP-0063, *Hanford Site Solid Waste Acceptance Criteria* (WHC 1993)
- The design of the foundation on which the SRC units are placed.

8.2 QUALITY ASSURANCE PROGRAM PLAN

This section provides a description of the QA program that is established for the design, construction, and operation of the SWBG. It is M&O contractor policy that achievement of quality in fulfilling the responsibilities for the solid waste disposal activities is essential to successful operation of the SWBG. To meet this objective, effective networks of management plans and procedural controls are established. Also, the necessary actions to demonstrate the ability to safely and efficiently dispose of the radioactive solid waste are taken. Concurrently, compliance with the DOE requirements for control and documentation of quality will be demonstrated using a QA program, consistent with RL Order 4700.1A and U.S. Environmental Protection Agency 530-SW-86-031 (EPA 1986).

The QA program consists of all planned and systematic actions that are necessary to provide adequate confidence that the SWBG will operate satisfactorily. The QA program applies to all activities that could affect safety and reliability at the SWBG. The QA program includes QC, which are the QA activities related to the physical characteristics of the material, structure, component, or system. QC verification provides a means by which to control the quality of the material, structure, component, or system to predetermined requirements. QA provides a multidisciplinary system of QC backed by verification activities that demonstrate the completeness and appropriateness of achieved quality.

The assurance of quality is recognized as a multidisciplinary activity involving many organizational components and is not the sole domain of one organization. Also, all project staff are responsible to plan, perform, and document activities affecting quality according to written procedures. The staff will also develop and implement the verification and self-assessment activities to ensure compliance with these requirements. Each QA department representative participating in the project is responsible for describing, monitoring, and verifying satisfactory accomplishment of quality-related project activities.

The QA approach ensures that activities and items are assigned a control and documentation safety classification that is consistent with the relative impact of offsite, onsite, and occupational safety-related items and activities. This approach classifies items and activities into one of four classifications (Safety Class 1, 2, 3, or 4) and further selects the QA requirements and measures to be applied to these items and activities consistent with their importance. This classification is accomplished by deliberate quality planning and selective application of QA requirements to the item or activity performed, with varying degrees of QA applied depending on function, complexity, consequence of failure, reliability, replicability of results, and economic considerations.

The safety classification of the SWBG is included in Chapter 1.0. The safety class assignment is performed in accordance with the criteria in WHC-CM-1-3, *Management Requirements and Procedures*, MRP 5.46, Rev. 1, "Safety Classification of Systems, Components, and Structures."

Quality Assurance is responsible for verifying the effective implementation of the entire QA program. A verification review is provided through annual audits conducted by Quality Assurance. The audit process for maintaining implementation of the QA program is described in Section 8.2.16. The responsibility of the Quality Assurance department includes verification of the quality of items that affect the SWBG. This verification can be accomplished through inspections or tests performed by Quality Assurance. Quality verification can also be accomplished through Quality Assurance overview and surveillance of compliance verification activities that are performed by other persons or organizations that are not directly responsible for the work features being verified. The Quality Assurance overview includes the review of procedures, work documents, inspection, and test instructions with subsequent surveillance and audits to verify compliance.

Quality Assurance is responsible for and has the authority to identify quality problems; initiate, recommend, or provide solutions through designated channels; and verify the implementation of solutions. Quality Assurance is responsible for and has the authority per WHC-CM-1-3, MRP 5.2, "Quality Assurance," and WHC-CM-4-2, *Quality Assurance Manual*, to order work suspended when continuation can result in violation of approved work requirements, product damage, or personnel injury.

8.2.1 Design Control

The M&O contractor is responsible for the design of systems, structures and components for the SWBG. Engineering policies, standards, design guides, procedures, and instructions are employed for control of engineering design work to meet technical requirements. These controls include (1) identifying responsibilities and providing procedures to ensure that the design requirements are correctly translated into the final design, (2) providing for the preparation of appropriate documentation, (3) providing for the identification and specification of appropriate quality standards and control of changes and design interfaces, and (4) permitting review of the process used, and of the results obtained. The design functions are controlled by the management control systems described in WHC-CM-4-2 and WHC-CM-6-1, *Standard Engineering Practices*.

Engineering provides the technical inputs for preparing new design documents or changes to existing documents, including the assignment of the appropriate safety classes as described in Section 8.2. New or revised designs will utilize the materials and equipment already proven as acceptable for use in the SWBG whenever possible. When the design requires the use of new materials, engineering will provide data to validate acceptance for use in the facility.

8.2.2 Procurement Document Control

8.2.2.1 Procurement Requirements. Procurement procedures ensure that regulatory requirements, design and site investigation bases, and other necessary quality requirements are included or referenced in the documents for

procurement of material, equipment, and services for the SWBG. Procurement documents covered in this chapter include purchase orders, requisition orders, external work orders, and store orders.

Procedures for preparation, review, approval, issue, control, and retention of procurement documents are contained in WHC-CM-1-3, WHC-CM-4-2, and WHC-CM-6-1.

These procedures identify the requirements to be met by each supplier's QA system, and the instructions for submitting documents for information or approval. The procedures also establish the right of access to supplier facilities for source inspection and audits, including requirements for advance notification of inspection or tests to be witnessed by a QA engineer.

Procurement documents require that the supplier have a documented QA program that implements the applicable portions of WHC-CM-4-2. The extent of the program required depends on the type and use of the item or service being procured.

Quality Assurance reviews procurement documents to ensure that the appropriate procurement clauses in WHC-CM-4-2, QI 4.1, "Procurement Document Control," Appendix 2, related to quality are referenced or included in procurement documents. These clauses generally specify requirements applicable to the following:

- Materials used in the fabrication or modification of facilities or equipment
- Special services to be performed (laboratory services, material/component qualification, or acceptance testing)
- Facility design associated with building alteration/modification
- The QA inspection, test, or surveillance practices applied to the procurement.

8.2.2.2 Spare and Replacement Parts. Procurement documents require the identification of appropriate spare and replacement parts or assemblies, and the delineation of the technical and quality-related data required for ordering these parts or assemblies. The spare parts will equal or exceed the requirements for the original parts. If the QA or technical requirements of the original item cannot be determined, then an engineering evaluation is conducted by qualified personnel to establish the requirements.

8.2.2.3 Procurement Document Review. A review of the procurement documents and any changes to these documents is made by Quality Assurance personnel based on the impact level designation, to verify that the supplier(s) documents verify that items or services meet the specified requirements. Any changes to procurement documents are reviewed/approved by the same level of personnel as the initial procurement document. This review is performed by the assigned QA engineer, with assistance from the requisitioner/cognizant engineer and documented in accordance with WHC-CM-4-2, QI 4.1, before a contract is awarded. This review is conducted to ensure the following:

- The QA requirements are correctly stated, inspectable, and controllable
- There are adequate acceptance and rejection criteria
- Procurement documents have been prepared, reviewed, and approved in accordance with the QA manual, WHC-CM-4-2, requirements.

Procurement and Materials Management ensures that approved procedures are followed in the procurement process, the required supplier documents are submitted for appropriate action, and records affecting quality are maintained in accordance with WHC-CM-4-2, QR 17.0, "Quality Assurance Records."

8.2.3 Instructions and Procedures

Documentation affecting quality is prescribed by, and performed in accordance with, instructions or procedures appropriate to the circumstances described in WHC-CM-4-2, QR 5.0, "Instructions, Procedures, and Drawings." The policies and procedures through which those activities that affect the quality of the SWBG are controlled provide for the preparation, review, approval, distribution, and change control of work-defining documents and include or reference appropriate quantitative or qualitative acceptance criteria for determining that prescribed activities have been satisfactorily accomplished (WHC-CM-1-3). These instructions, procedures, and drawings affecting quality contain all of the necessary provisions to ensure that, when followed, activities are properly performed and meet requirements.

The Engineering Standards Board is responsible for the development and approval of standard engineering practices according to WHC-CM-1-3, MRP 6.1, "Standard Engineering Practices," which provide the control for the content and use of design documents. WHC-CM-6-1 identifies the requirements and organizational responsibilities for the preparation, review, and approval of engineering instructions, procedures, and drawings. These documents incorporate appropriate acceptance criteria provisions for safety and quality to verify that important activities have been accomplished. Documents WHC-CM-1-3 and WHC-CM-6-1 are required to be available at the work location before work starts. Changes to these documents are reviewed and approved by the same organization that reviewed and approved the original documents. Instructions and procedures also include a section that identifies the QA records that are generated during the implementation of the document. Quality Engineering monitors the use of documents affecting quality-related activities at the SWBG through a scheduled and unscheduled surveillance and inspection series carried out by the Quality Assurance organization.

8.2.4 Control and Identification of Purchased Material, Equipment, and Services

The identification and control of items is by WHC-CM-4-2, Section 8, "Identification and Control of Items."

Purchasing ensures that purchased material, equipment, and services conform to the procurement documents. Established measures include provisions for source evaluation and selection, objective evidence of inspection at the contractor or subcontractor source, examination of products upon delivery, and audits. Documentary evidence that materials and equipment conform to code, regulation, or contract procurement requirements is made available before installation where the material or equipment is to be used or before use of such materials or equipment. Specific requirements for the control of purchased materials, equipment, and services in accordance with WHC-CM-1-3 are listed.

8.2.5 Inspection, Surveillance, and Testing

WHC-CM-4-2 provides for inspection, surveillance, and testing of items and activities affecting quality during procurement, construction, repair, modification, maintenance, and installation. Suppliers and contractors are expected to inspect their own work, and surveillance will be performed to ensure that the test is adequately and competently performed.

The inspection, surveillance, and testing program of the SWBG is initiated by the Quality Engineering organization. Quality Engineering will establish hold points and develop checklists or inspection planning documents that are implemented by the QC organization.

8.2.5.1 Inspection. Inspection and acceptance criteria are derived from engineering design documents, supplier information, construction procedures, and maintenance procedures. Inspection procedures or instructions and records identify the following:

- References to applicable documents such as drawings, specifications, and procedures
- Characteristics to be inspected
- Individuals or groups responsible for performing the inspection
- Acceptance criteria (explicit or by reference) obtained for specifications, drawings, supplier instructions, and standards
- A description of the inspection method and equipment to be used or referenced to an appropriate procedure
- Frequency of inspection or sampling plan.

The instruction procedures or instructions and records provide the following:

- A record of results of the inspection, including any special documentation, and signoff by the inspector
- A verification that all inspection operations are completed and acceptable.

The inspection program provides for inspection of the following:

- Material and equipment at the time of receipt and/or use
- Material and equipment in storage to guard against deterioration
- Modifications, maintenance, repairs, and reworked items
- Equipment during installation.

The Quality Engineering organization is responsible for conducting specified inspections in the suppliers' shops during fabrication of material or equipment to ensure that all procurement requirements are being met. The inspections initiated by Quality Engineering may appropriately include unannounced plant visits, verification that the agreed-upon hold points are met, witnessing, testing, performing final inspections before shipment, reviewing quality documentation, and approving the suppliers' shipping arrangements. The frequency and scope of these inspections will vary with the complexity of work and the degree of competence demonstrated by the contractor or supplier.

The QC organization inspects material and equipment received at the SWBG to ensure that it meets procurement requirements, was not damaged during shipment, has necessary documentation in order, and has all material and equipment adequately identified. In addition to the previously mentioned independent inspections, Engineering inspects certain procured items to determine if the necessary technical requirements were met.

The QC supervisor and inspection staff conduct site inspections as required by inspection documents. The inspectors have no other collateral duties during the performance of assigned QC functions and will be independent of the personnel performing the work being inspected. Inspection personnel will meet the approved training, experience, and qualification procedures established in WHC-CM-4-2. Qualification procedures for inspection personnel include a provision to maintain and periodically review records of the inspectors qualifications to ensure that they are kept current.

Required inspections will not be waived without the approval of the Quality Engineering organization.

8.2.5.2 Surveillance. The Quality Assurance organization has implemented a surveillance program to monitor or observe items or activities for verification of conformance to specified requirements. These surveillances are conducted by a Quality Assurance organization that is independent of the work being performed and are scheduled or implemented on a random basis. Surveillances are scheduled and conducted based on the activity's relative impact and/or importance to the SWBG. All deficiencies, nonconformances, and potential quality problems identified during surveillances are documented and monitored until verification of effective corrective action is made.

Surveillances are performed to written checklists or surveillance plans whenever practical. The documentation identifies characteristics, methods, and acceptance criteria and accuracy of the equipment necessary to perform the surveillance, and provides for recording objective evidence of results. The acceptance criteria related to surveillances may be as simple as verifying proper implementation of procedures or conformance to requirements.

8.2.5.3 Testing. WHC-CM-4-2 requires that appropriate tests be performed and documented to ensure satisfactory performance of structures, systems, and components. Engineering is responsible for identifying required tests to be conducted at the SWBG. Test acceptance limits are set to equal or exceed the original design specification. In instances where less restrictive acceptance limits are set, the justification for this action will be documented by Engineering.

When testing is required to demonstrate that a system or component will perform satisfactorily in service, the requirements of WHC-CM-6-1, EP 4.2, "Testing Practices," are implemented. The testing program is centered around five testing categories: development, acceptance, qualification, preoperational, and operational. Each test program requires the preparation of test plans and test procedures that typically designate the type of test required, performing organization, qualifications needed for performing the test, acceptance or rejection criteria, methods of recording test data, and post-test examination requirements.

The Quality Assurance organization monitors the application of the test program through planned inspection and surveillance at various test levels to evaluate the effectiveness of the test program.

8.2.6 Nonconforming Materials, Components, Fabrication, and Construction Features

The system for control of nonconforming items requires that spare parts, materials, equipment, and components that do not conform to procurement requirements, lack required documentation, or fail in performance are controlled to prevent their inadvertent installation or use in the SWBG. The control of nonconformances are implemented by WHC-CM-4-2, QR 15.0, "Control of Nonconforming Items," and QR 15.2, "Nonconformance Report Processing" procedures. Nonconformances are reported to the respective cognizant engineer through nonconformance reports as specified by the procedure. All personnel are required to report nonconformances to their supervisors.

The nonconforming items are identified by marking, tagging, or other methods that will not adversely affect the use of the item. When marking the item is not practical, identification methods will be stated in the work document or on the nonconformance report. When possible, nonconforming items are placed in segregated storage until such time as a disposition can be obtained from engineering to either correct the nonconforming condition or justify the condition of the item as acceptable for use in the SWBG.

Nonconformances are reported to Engineering for disposition. Engineering will decide whether the nonconforming item will be rejected, repaired to an acceptable condition, or accepted, or whether another disposition will be completed. The disposition must have Quality Assurance acceptance (concurrent). The final disposition will be documented on the nonconformance report form as required in the procedure. Specialists, such as metallurgists or nondestructive testing experts, may be invited to participate with engineering in determining the disposition of the nonconforming item.

Items that have been repaired or reworked are inspected or tested before use. The QC organization examines the items after they have been repaired or reworked in accordance with the original acceptance criteria unless the nonconformance report disposition has established alternate criteria. Quality Engineering prepares a surveillance checklist to ensure that as-built records are adjusted to reflect the accepted deviation.

8.2.7 Corrective Action

The corrective action system provides procedures for prompt identification and correction of conditions adverse to quality, which may require corrective action. These procedures provide for systematically obtaining commitments for corrective action from responsible management and followup to verify completion and effectiveness of such action. System emphasis is placed on taking the true corrective action (i.e., eliminating the root cause of the condition), as contrasted to remedial action (i.e., fixing the specific situation).

With the QA program, situations that need corrective action are identified through review and trending of nonconformance reports, supplier surveillance activities, QA surveillance and monitoring programs, QA audits, event fact sheets, trend analysis, and unusual occurrence reports. Corrective action is controlled and documented by means of corrective action reports as implemented by WHC-CM-4-2, QR 16.0, "Corrective Action," and QI 16.2, "Corrective Action Reporting," procedures. The procedure provides for the following activities:

- Identifying and reporting situations or occurrences that warrant corrective action
- Determining the cause and the corrective action to be taken by the responsible organization
- Reporting the cause and corrective action to the proper level of management
- Making a final verification by the Quality Assurance department to ensure that corrective action has been completed
- Reviewing, by QA management, for implication or affect on other work.

When corrective action requests have been initiated, Quality Assurance will schedule surveillances to monitor the efforts associated with the work to be accomplished. The responsible QA engineer will recommend management closure of the corrective action request when the work to prevent recurrence of the condition is satisfactorily accomplished. Closure of the corrective action request will be provided by Quality Assurance management when all actions are complete and validated through the established surveillances.

8.2.8 Quality Assurance Records

8.2.8.1 General. Records that furnish documentary evidence of quality are specified, prepared, maintained, and stored in accordance with WHC-CM-1-3; WHC-CM-3-5, *Document Control and Records Management Manual*; WHC-CM-4-2; and WHC-CM-6-1. Procedures require that all documents be legible, identifiable, accurate, complete, and retrievable.

8.2.8.2 Definition. Documents are considered authentic QA records if stamped, signed, or otherwise authenticated by responsible personnel. QA records include the following:

- Individual documents that have been executed, completed, and approved and that furnish evidence of the quality and completeness of data (including raw data) and activities affecting quality
- Documents prepared and maintained to demonstrate implementation of QA programs (e.g., audit, surveillance, and inspection reports)
- Procurement documents
- Other documents (e.g., plans, correspondence, documentation of telephone conversations, specifications, technical data, books, maps, papers, photographs, and data sheets)
- Magnetic media
- Other materials that provide data and document quality, regardless of the physical form or characteristic.

8.2.8.3 Classification. QA records are classified as "lifetime" or "nonpermanent" in accordance with WHC-CM-4-2. Lifetime QA records are defined as those that would be of significant value to the following:

- Demonstrate a capability for safe operation
- Maintain, rework, repair, replace, or modify an item
- Determine the cause of an accident or malfunction
- Substantiate development or major decisions involving questions of design safety, environmental protection, or program direction
- Provide required baseline data for inservice inspection
- Establish conformance to governing code and specification requirements.

Nonpermanent QA records are defined as those that furnish evidence of the quality of items and activities affecting quality and do not meet the criteria for lifetime records. There are two types of nonpermanent QA records: product nonpermanent QA records and programmatic nonpermanent QA records.

The product nonpermanent QA records show that specific structures, systems, and components of a facility have been designed and constructed in accordance with applicable requirements. These QA records include design verification data; receiving, calibration, maintenance, and inspection records; radiographs not associated with inservice inspection; and test records that are not otherwise designated as lifetime QA records.

The programmatic nonpermanent QA records are used to prescribe activities affecting quality but are not considered lifetime records. These records include documents prescribing the planning, execution, and auditing of activities affecting quality. QA records such as audit checklists, audit results, and actual examination used to qualify inspection and test personnel are included in this category.

8.2.8.4 Retention. Lifetime QA records are maintained until the item they pertain to is no longer used, or until specified by the controlling procedure.

The retention time for product nonpermanent QA records is 10 years from the date of delivery, or for the life of the item if this time is less.

The retention time for programmatic nonpermanent QA records is 3 years from the completion of the activity.

DOE Order 1324.2A, *Records Disposition*, sets forth mandatory use of the General Records Schedules, published by the National Archives and Records Administration. In addition, DOE Record Schedules, which have been approved by the Administration and included in DOE Order 1324.2A, are mandatory for scheduling records unique to the DOE. Both the General Records Schedules and the DOE Record Schedules are used for scheduling records. When different retention requirements are specified in these documents, the most stringent requirement is used to determine final disposition.

8.2.8.5 Storage and Retrieval. The Documentation and Records Management organization is responsible for maintaining and operating a uniform record management system and designated central storage facilities for QA records in accordance with WHC-CM-3-5 and WHC-CM-4-2.

Documentation and Records Management has procedures in place to protect QA records stored in designated facilities from deterioration or loss and procedures for maintaining, indexing, and retrieving records when necessary. Ultimately, Documentation and Records Management will transfer the records to the Federal Records Center in Seattle, Washington for permanent storage.

8.2.9 Audits

This section describes the QA audit program that is applied to the SWBG. This program is in effect for design, procurement, fabrication, construction, operation, and maintenance activities. The program includes planning for the audits (e.g., identification, scheduling, and preparation), criteria for audit team selection, procedures for conducting and reporting the audits, and provisions for corrective action. The program applies externally to audits of SWBG suppliers and contractors and internally to audits of organizational activities.

8.2.9.1 Responsibilities. The Quality Assurance Organization is responsible for the establishment and implementation of the audit program as implemented by the procedures identified in WHC-CM-4-2. Other departments furnish engineers and specialists as audit team members.

Audits are conducted under the direction of a qualified lead auditor and by qualified personnel who are familiar with the requirements but are independent of the activity to be audited. Teams consisting of a QA engineer and design engineer typically conduct audits with appropriate support from technical specialists.

M&O contractor policies provide Quality Assurance full authority to identify and perform audits, with full access to records and personnel. Contractual documents require suppliers and contractors to make their facilities, records, and personnel available for audit. Suppliers and contractors are obligated to define and implement corrective actions to resolve deficiencies discovered through the conducted audits.

8.2.9.2 Planning. Audits are identified and scheduled through the use of a master audit schedule that covers a 12-month period. The schedule is prepared by the Quality Assurance organization and revised quarterly. The schedule identifies the audits to be performed, affected organizations, audit scope and requirements, and lead auditor. In scheduling audits, preference is given to known or suspected problem areas and areas that are particularly quality sensitive.

Audit frequencies vary depending on the nature and importance of the activity being performed and results achieved. The audit process is initiated early enough in the project cycle to ensure effective implementation of the QA program, typically within 3 to 6 months after the start of work on activities affecting quality, and continues at regular intervals throughout the duration of the activity.

For each audit, checklists are prepared that cover the scope of the audit. The checklists identify the procedural requirements to be verified, observations to be made, items or characteristics to be reinspected, and any process or operating parameter to be verified.

8.2.9.3 Reporting and Corrective Actions. Findings and observations are reviewed with responsible management at the conclusion of each audit. These findings and observations are subsequently incorporated into an audit report, which is formally transmitted to the audited organization. Management of the audited organization is required to determine the appropriate corrective actions, schedule the corrective actions for completion, and periodically report in writing on such actions until complete. Quality Assurance reviews these actions for adequacy and implementation. Followup audits or other verification activities are scheduled as necessary to verify the completeness and effectiveness of corrective actions.

8.3 QUALITY ASSURANCE PROGRAM FOR SOLID WASTE BURIAL GROUND OPERATION

This section provides a description of the QA program that is established for the modification and operation of the SWBG.

8.3.1 Design Control

Section 8.2.1, Design Control, will be applied to the SWBG.

Engineering provides controlled documented design definition in accordance with WHC-CM-5-5, *Operations--General Administration*, GA-1.5, and WHC-CM-6-1, EP-1.7, "Engineering Document Approval and Release Requirements."

The requirements and procedures governing design verification are defined in WHC-CM-6-1, EP-4.1, "Design Verification Requirements." The procedures identify the positions responsible for verification and require that design errors are identified and corrected. Checkers are required to verify the incorporation of corrections. Documents cannot be released without verification. Verification of design documents is accomplished by individual or interdisciplinary design reviews, alternate calculations to verify the correctness of the original design calculations, or qualification testing to demonstrate adequacy of performance under conditions that simulate the most adverse design conditions.

Design verification is accomplished by an individual other than the originator or the immediate supervisor of the originator who has adequate qualifications to have originated the work. If the originator's immediate supervisor is the only technically qualified individual available, the design verification is conducted by the supervisor, with justification individually documented and approved by the next level of supervision. All QA audits will review the frequency and effectiveness of immediate supervisor verification to ensure that this provision is used only in exceptional circumstances.

Design changes, including field changes, are subject to design control measures commensurate to those applied to the original design, as described in WHC-CM-6-1, EP-2.2, "Engineering Document Change Control." Verification and review of design changes are performed by engineering to the same level as that of the original design. As-built changes are usually documented by means of drawings marked onsite and sent to the Engineering department to be incorporated into the original design.

8.3.2 Procurement Document Control

Section 8.2.2, Procurement Document Control, will be applied to the SWBG.

8.3.3 Instructions, Procedures, and Drawings

Section 8.2.3, Instructions and Procedures, will be applied to the SWBG.

Additional procedures of note that control operations of the SWBG include WHC-CM-8-2, *200 Area Support Services*, Section 200, "Calibration Procedures;" Section 300, "Operating Procedures;" and Section 500, "Preventive Maintenance Procedures." These procedures control calibration, maintenance, operations, and preventative maintenance activities. All facilities are operated in accordance with the formalized, approved procedures in WHC-CM-5-5, GA-2.4, "Procedure Compliance."

8.3.4 Control and Identification of Purchased Material, Equipment, and Services

Section 8.2.4, Control and Identification of Purchased Material, Equipment, and Services, will be applied to the SWBG.

Procurement activities are planned and requirements documented to ensure a systematic approach to the procurement process. Procurement planning results in the documented identification of procurement methods and organizational responsibilities. The design, design basis, and other supporting requirements necessary to ensure adequate quality are included or referenced in the procurement package. Quality Assurance participation is provided for evaluation and selection of suppliers, verification of suppliers' activities, and receiving inspections.

Supplier capability to provide items or services is evaluated before selection and the results of the evaluation are documented. The evaluation and selection of procurement sources include one or more of the following:

- Evaluation of each supplier's quality history of providing an identical or similar product that performs satisfactorily in actual use (supplier's history will reflect current capability)
- Each supplier's current QA records supported by documented qualitative and quantitative information that can be objectively evaluated
- Each supplier's technical and quality capability as determined by a direct evaluation of their facilities and personnel and the implementation of the QA program.

Suppliers providing commercial-grade items do not require a source evaluation unless determined necessary based on complexity and importance to safety. Commercial-grade items satisfy the following criteria.

- The items are not subject to design or specification requirements that are unique to nuclear facilities.
- The items are used in application other than nuclear facilities.
- The items will be ordered from the manufacturer/supplier on the basis of specifications set forth in the manufacturer's published catalog.

After receipt of a commercial-grade item, the purchaser will determine that the following conditions have been met.

- Damage was not sustained during shipment.
- The item received was the item ordered.
- Inspection and/or testing is accomplished by the purchaser, in accordance with written procedures, to ensure conformance with the manufacturer's published specifications.
- The item documentation was received and is acceptable.

Methods used to accept an item or service from suppliers will be one or more of the following:

- Supplier certification and release (certificate of conformance)
- Source verification
- Receiving inspection
- Postinstallation testing.

A combination of these methods may be used; however, when postinstallation testing is used, test requirements and acceptance documentation will be mutually agreed on by the buyer and the supplier.

In certain cases involving procurement of services only, such as third party inspection; engineering and consulting services; and installation, repair, overhaul, or maintenance work; any or all of the following methods will be used to accept the service:

- Technical verification of the data produced
- Surveillance and audit of the activity
- Review of objective evidence (i.e., certifications, stress reports) for conformance to the procurement document requirements.

Supplier nonconformances are controlled by established procedures that provide for the following:

- Evaluation of nonconforming items
- Submittal of supplier nonconformance notice including recommended disposition (e.g., use as-is or repair) and technical justification
- Disposition of supplier recommendations and verification of the implementation of the disposition
- Maintenance of supplier-submitted nonconformance records.

Items found defective at receiving inspections are tagged and placed in segregated storage for dispositioning by the cognizant engineer. Part of this disposition is the determination to return the item to the supplier or repair onsite. If onsite repair is selected, the item is transported to the appropriate repair area for rework.

Items found defective and dispositioned for return to the supplier for repair or replacement are processed in accordance with requirements. Requirements for nonconformance control are found in WHC-CM-4-2, QI 4.1, "Nonconformance Documentation and Reporting," and QR 15.0, "Control of Nonconforming Items."

The installation of system or subsystem equipment items at the SWBG is controlled by equipment installation instructions, which describe the requirements for installation of equipment and also contain the QA requirements. The preparation, review, approval, release and revision of equipment installation instructions is controlled by WHC-CM-6-1, EP-5.6, "Equipment Installation Instructions."

8.3.5 Inspection, Surveillance, and Testing

Section 8.2.5, Inspection, Surveillance, and Testing, will be applied to the SWBG. These surveillances are conducted in accordance with WHC-CM-5-5, GA-2.7, "Internal Surveillance Program Requirements." This surveillance system is used to ensure that SWBG activities are in compliance with applicable directives, documents, and procedures. Surveillances are performed by personnel that are familiar with the area of surveillance but not directly responsible for records, compliance, or reporting.

To ensure that each surveillance is properly conducted and documented, appropriate checklists are used to record the findings. These checklists provide a uniform means for documenting and tracking survey recommendations and action items.

Functional, operability, and acceptance testing is performed to ensure that equipment maintenance work is performed correctly. This testing is controlled by WHC-CM-5-5, EI-015, "Functional Tests." Work completion and retest requirements are also defined and controlled using WHC-CM-8-8, *Job Control System*, Section 5.8, "Work Completion and Retest."

8.3.6 Nonconforming Materials, Components, Fabrication, and Construction Features

Section 8.2.6, Nonconforming Materials, Components, Fabrication, and Construction Features, will be applied to the SWBG.

8.3.7 Corrective Action

Section 8.2.7, Corrective Action, will be applied to the SWBG.

8.3.8 Quality Assurance Records

Engineering Configuration Management ensures that controlled operating documents are available at work locations when released; that affected personnel are made aware of controlled document changes; and that no obsolete, void, or outdated controlled operating documents exist at the work locations. In addition, Engineering Configuration Management maintains a centralized accounting of controlled documents and their locations; assigns document numbers; reproduces, releases, tracks, and removes controlled copies; and is responsible for recordkeeping, surveying, and other activities associated with controlling operating documents as detailed in WHC-CM-5-5, GA-3.1, "Operating Document Control System."

8.3.9 Audits

Section 8.2.9, Audits, will be applied to the SWBG.

8.4 CHAPTER CRITERIA

A summary of the information in the chapter is provided with acceptance criteria derived from appropriate guidance documents.

8.4.1 Summary Description

This chapter summarizes the QA program for the design, construction, modification, and operation of the SWBG. The QA program complies with DOE Order 5700.6C, *Quality Assurance*. A compliance plan required by DOE Order 5700.6C is described.

8.4.2 Acceptance Criteria

Acceptance criteria for this chapter are based on the following:

1. DOE Order 6430.1A, *General Design Criteria*
2. DOE Order 5700.6C, *Quality Assurance*
3. ASME NQA-1, *Quality Assurance Program Requirements for Nuclear Facilities* (ASME 1989).

Specific acceptance criteria are as follows.

- 1: The Quality Assurance organization will be responsible for performing verification of work using persons who are not directly responsible for performing the work.
2. The responsible QA authority will have direct access to responsible management at a level where appropriate action can be effected for resolution of quality problems.

3. Those responsible for QA will report to a management level that will provide required authority and organizational freedom to resolve problems effectively and be independent of production and cost considerations.
4. External interfaces between organizations and internal interfaces between organization units are described to effect efficient management.
5. The QA program requires technical and QA indoctrination, training, and retraining programs to ensure that persons involved in safety-related activities are knowledgeable in technical and QA requirements and demonstrate a high level of competence and skill in the performance of their activities.

8.5 REFERENCES

8.5.1 Documents

- ASME, 1989, *Quality Assurance Program Requirements for Nuclear Facilities*, ASME NQA-1, American Society of Mechanical Engineers,
- EPA, 1986, *Technical Guidance Document: Construction Quality Assurance for Hazardous Waste Land Disposal Facilities*, EPA/530-SW-86-031, U.S. Environmental Protection Agency, Washington, D.C.
- WHC, 1990, *Generic Project Management Plan*, WHC-SD-MP-PMP-001, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1993, *Hanford Site Solid Waste Acceptance Criteria*, WHC-EP-0063, Rev. 4 (or current revision), Westinghouse Hanford Company, Richland, Washington.

8.5.2 U.S. Department of Energy Orders

- DOE Order 1324.2A, *Records Disposition*, U.S. Department of Energy, Washington, D.C.
- DOE Order 5700.6C, *Quality Assurance*, U.S. Department of Energy, Washington, D.C.
- DOE Order 6430.1A, *General Design Criteria*, U.S. Department of Energy, Washington, D.C.

8.5.3 U.S. Department of Energy, Richland Operations Office Orders

- RL 4700.1, *Project Management System*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

8.5.4 Controlled Manuals

WHC-CM-1-3, *Management Requirements and Procedures*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-3-5, *Document Control and Records Management Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-2, *Quality Assurance Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-5-5, *Operations--General Administration*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-6-1, *Standard Engineering Practices*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-8-2, *200 Area Support Services*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-8-8, *Job Control System*, Westinghouse Hanford Company, Richland, Washington.

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