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Regulatory Closure Options for the Residue in the Hanford Site Single-Shell Tanks

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Regulatory Closure Options for the Residue in the Hanford Site Single-Shell Tanks

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ABSTRACT

Liquid, mixed, high-level radioactive waste (HLW) has been stored in 149 single-shell tanks (SSTs) located in tank farms on the U.S. Department of Energy's (DOE's) Hanford Site. The DOE is developing technologies to retrieve as much remaining HLW as technically possible prior to *physically* closing the tank farms. In support of the Hanford Tanks Initiative, Sandia National Laboratories has addressed the requirements for the *regulatory* closure of the radioactive component of any SST residue that may remain after physical closure. There is significant uncertainty about the "end state" of each of the 149 SSTs; that is, the nature and amount of wastes remaining in the SSTs after retrieval is uncertain. As a means of proceeding in the face of these uncertainties, this report links possible end-states with associated closure options.

Requirements for disposal of HLW and low-level radioactive waste (LLW) are reviewed in detail. Incidental waste, which is radioactive waste produced incidental to the further processing of HLW, is then discussed. If the low activity waste (LAW) fraction from the further processing of HLW is determined to be incidental waste, then DOE can dispose of that incidental waste onsite without a license from the U.S. Nuclear Regulatory Commissions (NRC). The NRC has proposed three Incidental Waste Criteria for determining if a LAW fraction is incidental waste. One of the three Criteria is that the LAW fraction should not exceed the NRC's Class C limits.

This report presents an analysis of the actions necessary to demonstrate that any unretrievable SST residue should be classified as incidental waste. This report also presents a set of potential

issues related to direct application of the incidental waste concept to the SST residue. One issue is that approximately 21 of the 149 SSTs are anticipated to exceed the NRC's Class C limits (assuming 99% retrieval prior to stabilizing with 10 inches of grout). In the extreme case, one SST, AX-102, will require stabilization with 25 feet of grout to meet the Class C limits (assuming 99% retrieval prior to grouting).

The NRC, under 10 CFR 61.58, allows a facility to petition the NRC to establish site-specific Class C limits. The technical details and defense of developing Hanford site-specific Class C limits are described later in this report. A list of potential issues related to development of site-specific Class C limits is also presented. Some of the potential issues are significant. This report presents a set of alternative closure options if closure using the site-specific Class C limits and the incidental waste concept is not desirable or not possible:

- Disposal as Greater-Than-Class-C Equivalent LLW;
- Disposal as HLW, Three Interpretations;
- Cleanup under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) using "Risk-Balancing;" and
- Decontamination and Decommissioning.

Each option is presented in a standard format that includes an overview; regulatory standard(s) for long-term closure; regulator(s); discussion; advantages; and disadvantages. As detailed in this report, closure under CERCLA offers the best alternative closure option. Implementation of CERCLA does not require amending existing laws, and "risk-balancing" is integrated into the CERCLA criteria for selecting a final remedy.

If the SST residue meets the NRC's Incidental Waste Criteria, then closure of the tank residue as incidental waste is the best closure option. Based on the analysis presented in this report, a combination of 99% retrieval, grout stabilization, Hanford site-specific Class C limits, and use of the incidental waste concept will be necessary to justify in-place closure of the radioactive component of the SST residues.

EXECUTIVE SUMMARY

Liquid, mixed, high-level radioactive waste (HLW) has been stored in 149 single-shell tanks (SSTs) located in tank farms on the U.S. Department of Energy's (DOE's) Hanford Site. The DOE is developing technologies to retrieve as much remaining HLW as technically possible prior to *physically* closing the tank farms. In support of the Hanford Tanks Initiative, Sandia National Laboratories has addressed the requirements for the *regulatory* closure of the radioactive component of any SST residue that may remain after physical closure. There is significant uncertainty about the "end state" of each of the 149 SSTs; that is, the nature and amount of wastes remaining in the SSTs after retrieval is uncertain. As a means of proceeding in the face of these uncertainties, this report links possible end-states with associated closure options. Regulations important to final closure of the radioactive component of any unretrievable SST residue include the Hanford Tri-Party Agreement (TPA), which requires "retrieval of as much tank waste as technically possible, with tank waste residues not to exceed ... [1% of the volume of the tank, on average] ... or the limit of waste retrieval technology capability, whichever is less ..." The TPA also requires that closure of an entire tank farm or operable unit will be addressed in a single closure plan.

This report provides background information on regulations governing the disposal of radioactive wastes, including:

- General background on the different types of radioactive waste;
- General background on legislation governing disposal of radioactive waste;
- A discussion of regulations governing disposal of low-level radioactive waste (LLW);
- General background on regulations governing disposal of HLW;
- A comparison between LLW and HLW disposal standards; and
- A discussion of the incidental waste concept and associated Incidental Waste Criteria.

LLW is defined as "radioactive material that is not HLW, spent nuclear fuel (SNF), transuranic (TRU) waste or by-product materials." *LLW is defined by what it is not.* The DOE sets and enforces its own standards for disposal of LLW from "atomic energy defense activities." The DOE standards for post-1988 LLW disposal are contained in Chapter III of DOE Order 5820.2A, which requires protection of the member of public (MOP), the inadvertent human intruder (IHI), workers, and groundwater resources. Compliance with the DOE Order is demonstrated through a site-specific study or performance assessment (PA). DOE also prepares a "composite analysis," or CA, which addresses all interactive source terms (not just the post-1988 LLW). The metrics for a PA and a CA are different. DOE Order 435.1 has been proposed to replace Order 5820.2A as the DOE Order governing the disposal of radioactive waste.

The U.S. Nuclear Regulatory Commission (NRC) sets and enforces standards for disposal of LLW from commercial facilities (e.g., hospitals and power reactors). The NRC licensing and disposal standards are contained in 10 CFR 61, which requires protection of the MOP, the IHI, and workers. The NRC's dose-based standards to protect the MOP are similar to the DOE's dose-based standards to protect the MOP. To protect the IHI, the NRC and DOE have taken different approaches. The NRC protects the IHI by requiring different disposal standards for each

of the four classes of commercial LLW (Class A, Class B, Class C, and Greater-Than-Class-C). As detailed in Appendices A and G, the Class C waste concentration limits were derived from calculated doses to an IHI assuming the LLW is not recognizable as waste after 500 years.

HLW is waste that results from the reprocessing of SNF to recover unfissioned uranium and plutonium. Although the legal definitions of HLW vary, the variations are not relevant; the common elements in each definition include: (1) radioactive waste material; (2) from the reprocessing of SNF; and (3) the lack of concentration- or specific activity-based limits. *HLW is defined by origin, not constituents; therefore, there is no concentration below which HLW ceases to be HLW.* Section 202 of the Energy Reorganization Act gives the NRC authority for licensing HLW disposal facilities. The EPA's general standard for the disposal HLW is 40 CFR 191 and the NRC's 10 CFR 60 sets forth the NRC's licensing criteria for disposal of HLW in geologic repositories. Chapter II of DOE Order 5820.2A also governs disposal of DOE-titled HLW. A comparison between the standards for disposal of LLW and HLW is contained in Appendix B. A discussion of the possible impacts of implementing the current draft of DOE Order 435.1 is presented in Appendix C.

Because HLW is defined by origin and not by content, must all the Hanford tank waste be managed as HLW? Not necessarily, because the low-activity waste (LAW) generated incidental to the further treatment of HLW could, possibly, remain in a SST and be disposed as if it were LLW. The concept of incidental waste was formally presented in 1969 by the Atomic Energy Commission (AEC). In that discussion, the AEC noted that the term HLW should not include "incidental wastes" resulting from SNF reprocessing plant operations. Unfortunately, incidental wastes were not specifically excluded from the definition of HLW promulgated by the AEC in 1970. However, the AEC from 1970 onward, has applied the concept of incidental waste.

If the LAW fraction from the further processing of HLW is determined to be incidental waste, then DOE can dispose of that incidental waste onsite without a license from the NRC. Incidental waste is not a "category" of radioactive waste; rather, incidental waste is a concept that the AEC/NRC and DOE have used to separate HLW from the LAW fraction generated during the further treatment of HLW.

The boundary between HLW and incidental waste was defined by the NRC in response to a petition from Washington State, Oregon State, and the Yakama Indian Nation. The NRC has defined a set of three tests to determine if a LAW fraction is incidental waste:

- The HLW has been processed (or will be further processed) to remove key radionuclides to the maximum extent that is technically and economically practical.

- The incidental wastes will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C LLW as set out in 10 CFR part 61.

- The incidental wastes are to be managed, pursuant to the Atomic Energy Act, so that safety requirements comparable to the performance objectives set out in 10 CFR part 61 are satisfied.

In this report, these three tests are identified as the Incidental Waste Criteria. On three occasions, the NRC has provisionally agreed that the LAW fraction from a treatment facility for Hanford tank waste meets the criteria for incidental waste. The DOE's Savannah River Site (SRS) recently closed two tanks which had been used to store mixed HLW and the DOE requested NRC concurrence that the stabilized tank residue was incidental waste. In a letter dated June 30, 1998, the NRC requested additional information from DOE. An initial review of this NRC information request provides a number of observations about the NRC's perspective on the closure of HLW tanks and these initial observations are presented in the body of this report.

This report also describes how the Incidental Waste Criteria might be interpreted for application to the SST residue at Hanford. In addition, it proposes a format for an Incidental Waste Petition to the NRC. Potential issues related to direct application of the incidental waste concept include:

- The outcome of the NRC review on the closure of SRS's Tanks 17 and 20 will have a significant bearing on the closure of the Hanford SSTs and should be closely monitored.

- In 1993, the NRC noted that, "there was no fundamental challenge to the concept of incidental wastes." However, some stakeholders still question the concept of incidental waste because incidental waste is defined by policy and not by rule. This issue should be discussed with the NRC.

- Much of this report focuses on the NRC's Class C limits. However, the ability to comply with the third criterum (meeting safety standards comparable to 10 CFR 61) should be assessed simultaneously. Meeting safety standards comparable to 10 CFR 61 is linked to (1) a 1,000- or 10,000-year, 25 mrem/year dose standard to protect the hypothetical MOP, and (2) a 1,000- or 10,000-year standard to protect groundwater resources.

- Meeting safety standards comparable to 10 CFR 61 requires clarification of two issues. The first is whether the analysis should consider the next 1,000 years or the next 10,000 years. The second issue is whether the source term should be limited to the radionuclides in the SST residue, or whether the source term should include all interacting sources of radiation.

- Any SST residue which is not retrievable will be mixed waste. Therefore, closure of the hazardous component and closure of the radioactive component are interrelated. The role that Washington State Department of Ecology (and the Environmental Protection Agency (EPA)?) will play in closing the radioactive component should be clarified.

- There is a need for an integrated approach to regulatory closure of all HLW residue (SST residue, residue in ancillary equipment, and contaminated soil).

- Based on 99% retrieval and 10 inches of stabilizing grout (and other assumptions presented), 86% of all SSTs will meet the Class C limits. However, 21 tanks (14%) may fail to meet Class C limits. In the extreme case, one SST, AX-102, will require stabilization with 25 feet of grout to meet the Class C limits (assuming 99% retrieval prior to grouting). Therefore, another closure strategy maybe needed for those 21 tanks.

The NRC, under 10 CFR 61.58, allows a facility to petition the NRC to establish site-specific Class C limits. The technical details and defense of developing Hanford site-specific Class C limits are described in the body of the report and detailed in Appendices A and G. Based on these preliminary analyses, defense of site-specific Class C limits seems favorable. There are however, some potential issues related to development of site-specific Class C limits:

- Under the EPA's definition of TRU waste, the NRC has the authority to approve disposal of wastes exceeding 100 nCi/g of TRU radionuclides as LLW on a case-by-case basis in accordance with 10 CFR 61. The NRC's ability to apply this authority to DOE-titled wastes should be thoroughly analyzed.

- The authors are not aware of NRC having accepted a site-specific Class C analysis in the past. Therefore, DOE would have to work with NRC staff to develop a one-of-a-kind petition.

- The development of site-specific Class C limits could be viewed by stakeholders as an attempt to leave waste onsite that historically has been unacceptable for shallow land burial based on existing Class C limits.

- A number of important issues should be discussed with the NRC; therefore, DOE and the NRC may want to formalize a working agreement. One option is for the DOE and NRC to enter into a memorandum of understanding (MOU) similar to the MOU between DOE and NRC at the SRS.

Some of the potential issues are significant. This report presents a set of alternative closure options if closure using the site-specific Class C limits and the incidental waste concept is not desirable or not possible:

- Disposal as Greater-Than-Class-C Equivalent LLW;

- Disposal as HLW, Three Interpretations;

- Cleanup under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) using "Risk-Balancing;" and

- Decontamination and Decommissioning.

Each option is presented in a standard format that includes an overview; regulatory standard(s) for long-term closure; regulator(s); discussion; advantages; and disadvantages. As detailed in this report, closure under CERCLA offers the best alternative closure option. Implementation of CERCLA does not require amending existing laws, and "risk-balancing" is integrated into the CERCLA criteria for selecting a final remedy.

If the SST residue meets (or can be further treated to meet) the NRC's Incidental Waste Criteria, then closure of the tank residue as incidental waste is the best closure option. This path is defined, acceptable, and has been used recently at Hanford and the SRS. Based on analyses presented in this report, a combination of 99% retrieval, grout stabilization, Hanford site-specific Class C limits, and use of the incidental waste concept will be necessary to justify in-place closure of the radioactive component of the SST residues.

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LIST OF ACRONYMS & ABBREVIATIONS

AEA	Atomic Energy Act
AEC	Atomic Energy Commission
ALARA	As Low As Reasonably Achievable
ARARs	Applicable or Relevant and Appropriate Requirements
CA	Composite Analysis
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
D&D	Decontamination and Decommissioning
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DOE/RL	DOE, Richland Operations Office
DQOs	Data Quality Objectives
DST	Double-Shell Tank
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
EDE	Effective Dose Equivalent
EPA	U.S. Environmental Protection Agency
FY	Fiscal Year
GTCC	Greater than Class C Waste
HDW	Hanford Derived Waste
HDW-EIS	Environmental Impact Statement for the Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes
HLW	High-Level radioactive Waste
ICRP	International Commission on Radiological Protection
IHI	Inadvertent Human Intruder
l	liter
LAW	Low-Activity Waste
LLBG	Hanford Low-Level Burial Ground
LLW	Low-Level Radioactive Waste
m	meter
MCLs	maximum contaminant levels
mrem/yr	10^{-3} rem per year
MOP	Member of the Public
MOU	Memorandum of Understanding
NA	Not Applicable
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NPL	National Priorities List
NRC	U.S. Nuclear Regulatory Commission
NWPA	Nuclear Waste Policy Act

Order 5820.2A	DOE Order 5820.2A, Radioactive Waste Management
pCi	pico Curies or 10^{-12} Curies
PA	Performance Assessment
PATT	Performance Assessment Task Team
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
Sandia	Sandia National Laboratories
SNF	Spent Nuclear Fuel
SRS	Savannah River Site
SST	Single-Shell Tank
TEDE	Total Effective Dose Equivalent
TPA	Tri-Party Agreement
TRU	Transuranic
TWRS	Tank Waste Remediation System
USDW	Underground Source of Drinking Water
WVDP	West Valley Demonstration Project

DEFINITIONS

Applicable or Relevant and Appropriate Requirements - "Applicable" requirements are those clean-up standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site. "Relevant and appropriate" requirements are those clean-up standards which, while not "applicable" at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. ARARs can be action-specific, location-specific, or chemical-specific." (EPA, December 1991)

Atomic Energy Defense Activity - "any activity of the Secretary performed in whole or part in carrying out any of the following functions: ... (D) defense nuclear materials production (E) defense nuclear waste and materials by-products management..." (Nuclear Waste Policy Act of 1982 (NWPA))

Byproduct material - "... means (1) any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the processing of producing or utilizing special nuclear material, and (2) the tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content." (Section 11e of the Atomic Energy Act)

Cancer Risk - "Incremental probability of an individual's developing cancer over a lifetime as a result of exposure to a potential carcinogen." (EPA, December 1991)

Decommissioning - "to remove a facility or site safely from service and reduce residual radioactivity to a level that permits -- (1) Release of the property for unrestricted use and termination of the license; or (2) Release of the property under restricted conditions and termination of the license." (10 CFR 20.1003, see 62 FR 39057)

Disposal - "the emplacement in a repository of high-level radioactive waste, spent nuclear fuel, or other highly radioactive material with no foreseeable intent of recovery ..." (NWPA)

Disposal - "Emplacement of waste in a manner that assures isolation from the biosphere for the foreseeable future with no intent of retrieval and that requires deliberate action to regain access to the waste." (DOE Order 5820.2A (9-26-88), Attachment 2)

Exposure Scenario - (for LLW disposal) a particular set of hypothetical circumstances involving the transport of contaminants from the disposal location to a receptor.

Final Site Closure - "Those actions that are taken as part of a formal decommissioning or remedial action plan, the purpose of which is to achieve long-term stability of the disposal site and to eliminate to the extent practicable the need for active maintenance so that only surveillance, monitoring and minor custodial care are required." (DOE Order 5820.2A (9-26-88), Attachment 2)

Hard Heel - "A hard heel is defined as solid material that has consolidated and is cemented or bonded to the tank such that removal can only be accomplished by direct high pressure water jets or mechanical removal (scraping)." (Grams, W.H., 1995)

Heel - "A heel is defined as the residue remaining in a tank after its contents have been retrieved to the maximum extent practical and before the tank is either refilled or cleaned of hazardous material before final closure and landfill disposal. A heel can consist of solid waste, free liquids and sludges." (Grams, W.H., 1995)

High Level Waste - "(For the purposes of this statement of policy, "high-level liquid radioactive waste" means those aqueous wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuels.)" 10 CFR 50 Appendix F (35 FR 17533)

High-Level Radioactive Waste - "(A) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in process and any solid material derived from such liquid that contains fission products in sufficient concentration; and (B) other highly radioactive material that the Commission, consistent with existing law, determines by rule requires permanent isolation." (NWPA)

High-Level Waste - "The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic waste and fission products in concentrations requiring permanent isolation." (DOE Order 5820.2A (9-26-88), Attachment 2)

High-Level Waste Facility - "a facility subject to the licensing and related regulatory authority of the Commission pursuant to Sections 202(3) and 202(4) of the Energy Reorganization Act of 1974." (10 CFR 60.2)

Inadvertent Human Intruder - "A person who might occupy the disposal site after closure and engage in normal activities such as agriculture, dwelling construction or other pursuits in which the person might be unknowingly exposed to radiation from the waste." (10 CFR 61.2, U.S. NRC, 1996b)

Low-Activity Waste - "Low-activity waste at the Hanford Site is produced by treating the tank wastes. Low-activity waste is produced by treating the tank wastes and are "low-level" tank wastes that have not yet received the NRC concurrence as incidental." (Westinghouse Hanford Company, 1996, page Terms-ii)

Low-Level Radioactive Waste - "radioactive material that (a) is not high-level, spent nuclear fuel, transuranic waste or by-product materials as defined in section 11e(2) of the Atomic Energy Act of 1954; (b) the Commission, consistent with existing law, classifies as low-level radioactive waste." (NWPA)

Member of Public - a hypothetical individual who might occupy the area near the disposal site after closure and engage in normal activities such as agriculture, dwelling construction or other pursuits in which the person might be unknowingly exposed to radiation from the waste. The member of public exposure scenario and the inadvertent intruder scenario are exclusive of each other. Guidance found in Wood *et al.* (1994, p.21) develops the idea of a 100 m buffer zone separating the hypothetical member of public from the disposal site.

Model - A conceptual description and the associated mathematical representation of a stated system, subsystem, component, or condition. A model describes the relationships between stated variables as a function of time, space, initial or boundary conditions for a given purpose.

Near Surface Disposal Facility - "a land disposal facility in which radioactive waste is disposed of in, or within, the upper 30 meters of the earths surface." (10 CFR 61.2)

Passive institutional control - "(1) permanent markers placed at a disposal site, (2) public records and archives, (3) government ownership and regulations regarding land or resource use, and (4) other methods of preserving knowledge about the location, design, and contents of a disposal system." (40 CFR 191.12)

Performance Assessment - "The quantitative process of evaluating the behavior of a disposal system and its components under a variety of expected and hypothetical conditions. Modeling is conducted to simulate the events and processes that might affect the ability of the disposal system to limit releases to acceptable limits. A performance assessment is usually conducted to support decision making." (Cochran *et al.*, 1997)

Release - "any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment, including the abandonment or discarding of barrels, containers and other closed receptacles containing any hazardous substance or pollutant or contaminant, but excludes (A) any release which results in exposure to persons solely within a workplace ... (b) emissions from the engine exhaust of a motor vehicle ... " CERCLA Section 101(22)

Sludge - "At the Hanford Site, the term sludge is applied to those solids that settle and accumulate at the bottom of a storage tank; solids formed by precipitation or self-concentration, primarily insoluble metal hydroxides and oxides precipitated from neutralized waste. Sludge usually was in the form of suspended solids when the waste was originally received in the tank from the waste generator. The sludges are considered to be HLW." (Grams, 1995)

Spent nuclear fuel - "means fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing" (40 CFR 191.02(g))

Storage - "retention of high-level radioactive waste, spent nuclear fuel, or transuranic waste with the intent to recover such waste or fuel for subsequent use, processing or disposal." (NWPA)

Transuranic waste - "waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes with half-lives greater than twenty years, per gram of waste except for: (1) high-level radioactive wastes; (2) wastes that the Department of Energy has determined, with the concurrence of the EPA Administrator, do not need the degree of isolation required by 40 CFR 191 or (3) wastes that the NRC has approved for disposal on a case-by-case basis in accordance with 10 CFR 61." (40 CFR 191.02(i))

1.0 INTRODUCTION

1.1 Overview of the Report

A number of concurrent activities are being undertaken to close the high-level radioactive waste (HLW) tanks at the U.S. Department of Energy's (DOE's) Hanford Site. This report is part of those activities and addresses the identification of regulatory closure options for the radioactive component of the residue that may remain in the single-shell tanks (SSTs) after retrieval operations.

A total of 149 SSTs have been used to store liquid, mixed HLW at the Hanford Site. Technologies are being developed and/or tested to retrieve mixed HLW that currently remains in the SSTs. These technologies may retrieve some or all of the remaining mixed HLW. At this time, the "end-state" of each SST is unknown.

This report addresses several broad topics:

- background on the Hanford Site and the SSTs;
- a review of regulations that govern disposal of radioactive wastes;
- a detailed discussion of the requirements to close the residue as "incidental waste;"
- a review of the Class C limits and justification for site-specific Class C limits; and
- a review of other regulatory closure options, coupling different closure options with different end-states.

Interactions between representatives of the Washington State Department of Ecology (Ecology), the U.S. Nuclear Regulatory Commission (NRC), the U.S. Environmental Protection Agency (EPA), DOE, other stakeholders, and Hanford Site contractors will allow a more complete determination of regulatory drivers for Hanford tank closure.

This analysis has identified several issues that will help DOE close the SSTs in a timely and deliberate fashion.

1.2 Scope of the Report

This report addresses a very specific topic, *the identification of regulatory closure options for the final closure of the radioactive component of any SST residue that may remain after retrieval, with a focus on site-specific Class C limits and use of the NRC's incidental waste concept.*

This report does not address closure of the associated ancillary equipment or contaminated soil, nor does this report address regulations governing the hazardous waste component of the mixed HLW. The reader is referenced to Cochran and Shyr (1998) for a discussion of the regulatory requirements for closure of the contaminated ancillary equipment, and to Jacobs Engineering Group (1998), Rosenthal (1997), and DOE (1995a) for information on the hazardous waste component. Clearly, *an integrated closure strategy is necessary* to address the closure of the 149 SSTs, and this report provides a key component to help develop that integrated approach.

2.0 BACKGROUND, HANFORD SITE AND TANK CLEANUP

2.1 Hanford Site History

The Hanford Site, located near Richland, Washington, is a DOE installation encompassing about 600 square miles. The following overview of the Hanford Site history is extracted from recent DOE Environmental Impact Statement (EIS) (DOE, 1996a, p. S-3):

> From 1943 to 1989, the Hanford Site's principal mission was the production of weapons-grade plutonium. To produce plutonium, uranium metal was irradiated in a plutonium production reactor. The irradiated uranium metal, also known as spent nuclear fuel, was cooled and treated in a chemical separations, or reprocessing plant, where plutonium was separated from uranium and many other radioactive by-products. The plutonium was then used for nuclear weapons production. Large amounts of spent fuel were generated to produce enough plutonium to make a nuclear weapon. The chemical separations process generated large volumes of radioactive waste. The Hanford Site processed approximately 100,000 metric tons of uranium and generated several hundred thousand metric tons of wastes.

Waste that results from the reprocessing of spent nuclear fuel (SNF) is classified as HLW. From the 1940s through the early 1960s, 149 SSTs with capacities of 55,000 gallons to 1,000,000 gallons were built to store HLW in a region near the center of the Hanford Site. One hundred thirty-three of these tanks are 75 feet in diameter and 30 to 54 feet high; the remainder of the SSTs are smaller. The SSTs had a design life of 20 years. By the late 1980s, 67 of the SSTs were known or suspected leakers (DOE, 1996a, p. S-5).

To address concerns with the integrity of the SSTs, the Hanford Site built 28 double-shell tanks (DSTs) between 1968 and 1986. Much of the free-standing liquid contained in the SSTs has been transferred to the DSTs, leaving approximately 36,000,000 gallons of waste in the SSTs. This current SST waste consists of salt cake (23,000,000 gallons), sludge (12,000,000 gallons), and supernatant liquids (600,000 gallons) (DOE, 1995 page 1-3). The radioactive components consist of fission product radionuclides, such as strontium-90, cesium-137, and iodine-129, and actinide elements such as uranium, neptunium, plutonium, thorium, and americium. The radioactive components remaining in the SSTs sum to 104,000,000 curies (National Research Council, 1996, p. 14).

After this current SST waste is subjected to further retrieval activities, the SSTs will be closed. Regulatory closure options for the radioactive component remaining in the SSTs after retrieval are the subject of this report.

2.2 Previous Actions to Identify Closure Options for SSTs

DOE and its predecessor agencies have conducted a number of studies related to the long-term management of HLW at the Hanford Site. In 1977, a report was prepared on "Alternatives for Long-Term Management of Defense High-level Waste, Hanford Reservation." That report, along with several follow-on studies, established the basis for the alternatives evaluated in the "Environmental Impact Statement for the Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes" (DOE, 1987). An alternative evaluated in that 1987 EIS was the onsite disposal of SST wastes that were not readily retrievable. However, the Record of Decision (Volume 53, Federal Register, page 12449 (53 FR 12449)) selected the option of conducting additional development and evaluation before making decisions on the closure of SST wastes that were not readily retrievable.

After completion of the 1987 EIS, DOE/RL made three major changes to its strategy for management of the tank waste. First, concerns about the stability of low-level radioactive waste (LLW) grout resulted in the decision to vitrify the LLW fraction. Second, the facility planned for pretreatment of tank wastes (B-Plant) was concluded to be impractical to upgrade to meet RCRA and seismic standards. Third, DOE decided that SST wastes (in addition to the DST wastes) would be treated to separate the high-level and low-activity waste fractions.

Reflecting these three major changes in strategy, DOE Richland (DOE/RL) and Ecology renegotiated provisions of the Tri-Party Agreement (TPA) relative to the tank wastes and subsequently prepared the "Hanford Site Tank Waste Remediation System (TWRS) Final Environmental Impact Statement" (DOE, 1996a). However, the scope of the 1996 EIS did not include closure of the SSTs.

Closure of the SSTs, ancillary equipment, and contaminated soils is the subject of the Single-Shell Tank Closure Work Plan (DOE/RL, 1995). This extensive closure work plan includes a summary of the closure process:

> The Tri-Party Agreement was also revised to stipulate that the single-shell tank farm operable units, including tanks, contaminated soil, and ancillary equipment, will be closed as treatment, storage, and disposal units under a single set of regulatory standards pertaining to the hazardous waste constituents, i.e., Washington Administrative Code (WAC) 173-303 Dangerous Waste Regulations. Previously, contaminated soil and ancillary equipment were to have been remediated under RCRA past practice regulations. The radioactive constituents continue to be managed in accordance with the Atomic Energy Act of 1954. (DOE/RL June 1995, p. 1-5)
>
> The closure strategy assumes that waste retrieval will remove sufficient waste from the SSTs that the residual waste following retrieval, the SSTs themselves, tank farm ancillary equipment, and contaminated soil will be considered by the U.S. Nuclear Regulatory Commission (NRC) to be non-HLW, and may be disposed of in place in accordance with applicable regulations and agreements. (DOE/RL, 1995, p. 1-7)

The SST Closure Work Plan (DOE/RL, 1995a) includes the comprehensive identification of "Closure Issues" and notes in the Issues Section that 99% retrieval may, or may not, be adequate for the NRC to classify the SST residue as non-HLW. The SST Closure Work Plan is complemented by this report, which provides a detailed development of closure options for the radioactive component that may remain in the SSTs after retrieval. Hanford Site cleanup is complicated and the overarching descriptions of activities, milestones, and regulatory authorities is provided by the TPA.

2.3 Tri-Party Agreement

To provide a comprehensive framework for the remediation of the Hanford Site, the EPA, the DOE, and Ecology entered into the Hanford Federal Facility Agreement and Consent Order (the Hanford TPA). TPA milestone M-45-00 is the most significant to this report, because M-45-00 establishes the intent of the parties to *retrieve* as much mixed HLW from the SSTs as is technically possible and then "... all units located within the boundary of each tank farm will be *closed* in accordance with WAC 173-303-610." Because of its importance, sections of milestone M-45-00 are repeated here.

M-45-00	COMPLETE CLOSURE OF ALL SINGLE SHELL TANK FARMS.	9/30/2024
LEAD AGENCY: ECOLOGY	CLOSURE WILL FOLLOW RETRIEVAL OF AS MUCH TANK WASTE AS TECHNICALLY POSSIBLE, WITH TANK WASTE RESIDUES NOT TO EXCEED 360 CUBIC FEET (CU. FT.) IN EACH OF THE 100 SERIES TANKS, 30 CU. FT. IN EACH OF THE 200 SERIES TANKS, OR THE LIMIT OF WASTE RETRIEVAL TECHNOLOGY CAPABILITY, WHICHEVER IS LESS. ...	

FOLLOWING COMPLETION OF RETRIEVAL, SIX OPERABLE UNITS (TANK FARMS), AS DESCRIBED IN APPENDIX C (200-BP-7, 200-PO-3, 200-RO-4, 200-TP-5, 200-TP-6, 200-UP-3), WILL BE REMEDIATED IN ACCORDANCE WITH THE APPROVED CLOSURE PLANS. FINAL CLOSURE OF THE OPERABLE UNITS (TANK FARMS) SHALL BE DEFINED AS REGULATORY APPROVAL OF COMPLETION OF CLOSURE ACTIONS AND COMMENCEMENT OF POST-CLOSURE ACTIONS.

FOR THE PURPOSES OF THIS AGREEMENT ALL UNITS LOCATED WITHIN THE BOUNDARY OF EACH TANK FARM WILL BE CLOSED IN ACCORDANCE WITH WAC 173-303-610. THIS INCLUDES CONTAMINATED SOIL AND ANCILLARY EQUIPMENT ... IN EVALUATING CLOSURE OPTIONS FOR SINGLE-SHELL TANKS, CONTAMINATED SOIL, AND ANCILLARY EQUIPMENT, ECOLOGY AND EPA WILL CONSIDER COST, TECHNICAL PRACTICABILITY, AND POTENTIAL EXPOSURE TO RADIATION. CLOSURE OF ALL UNITS WITHIN THE BOUNDARY OF A GIVEN TANK FARM WILL BE ADDRESSED IN A CLOSURE PLAN FOR THE SINGLE-SHELL TANKS.

Retrieval of 99% of the average volume of tank waste will leave approximately one inch of waste in the bottom of each tank, which is approximately 360 cubic feet in a Series 100 tank and 30 cubic feet in a Series 200 tank (DOE, 1995a, p. xii).

The TPA Milestone M-45-00 sets a number of requirements that have a strong influence on regulations applicable to final closure of any residue which may remain after retrieval. First, the requirement to close all units within a tank farm boundary under WAC 173-303-610 means that the tank farms will be closed as Resource Conservation and Recovery Act (RCRA) hazardous waste management units. Second, Ecology will be the lead agency for closure (this is discussed below). Third, when evaluating closure options for tank farms, Ecology and the EPA will consider cost, technical practicability, and potential exposure to radiation.

Fourth, closure of an entire tank farm, or operable unit (or groups of operable units) will be addressed by a single closure plan. This means that under the TPA, the SSTs, any unretrievable waste in the SSTs, contaminated soil, and ancillary equipment will be addressed simultaneously. Although it is beyond the scope of this report, a single closure strategy is necessary to address all HLW residue remaining in the SSTs, the ancillary equipment, and soil at the time of closure (a preliminary, integrated closure strategy is presented in section 5.4 of Cochran and Shyr, 1998).

Lead Regulatory Agency Concept

To facilitate implementation of the TPA, the TPA designates "lead agencies." As the title implies, the lead agency has the lead for a particular action. However, the non-lead agency does not forfeit its regulatory authority to the lead agency. Therefore, Ecology will involve the EPA in approving the final closure plan for the AX Tank Farm.

Chapter 5 of the Hanford TPA Action Plan states that:

> Regulatory authority shall remain with the regulatory agency having legal authority for those decisions, regardless of whether that agency is the lead regulatory agency for the work. The lead regulatory agency shall oversee the work, and brief and obtain any necessary approvals from the agency with regulatory authority. For example, where Ecology is the lead regulatory agency at a CERCLA site, it shall brief EPA as necessary to obtain EPA approval before a remedial action is selected.

A subtle, but important point is that, by agreement, *tank farm closure will proceed under Ecology's lead and Washington's Dangerous Waste regulations*. However, the underlying Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) authority still exists, and this regulatory report would be amiss if it did not note that the EPA has not relinquished it's CERCLA authority. Additionally, the NRC is not a party to the TPA; therefore, negotiations with the NRC are conducted outside of the scope of the TPA.

2.4 Memorandum of Understanding

In 1996, the DOE and Ecology entered into a Memorandum of Understanding (MOU) to address the question "What degree of waste removal should be used as the basis for waste retrieval systems technology development, retrieval systems engineering, and definition of completion of retrieval operations?" In this MOU, the parties concurred that:

> It has not been established that 99% waste retrieval as defined in TPA Milestone M-45-00 will be sufficient to allow closure of the tank farms. Nor has it been determined that 99% retrieval is technically achievable, or represents a performance objective that considers cost, technical practicability, exposure to radiation, and Nuclear Regulatory Commission (NRC) requirements.

This report provides information to address some of the concerns raised in the MOU.

2.5 Uncertainty in End-States

There is significant uncertainty about the "end state" of each of the 149 SSTs; that is, the nature and amount of wastes remaining in the SSTs after retrieval (and subject to closure) is uncertain. There are also uncertainties in effectiveness of technologies to retrieve wastes, uncertainties in how to manage associated contaminated soil and ancillary equipment, uncertainties in the costs and short-term health consequences of retrieving tank residue, uncertainties in the future land uses and long-term hazards associated with wastes remaining onsite, and uncertainties in future regulation (National Research Council, 1996). As a means of proceeding in the face of these uncertainties, this report links possible end-states with associated closure options.

3.0 REGULATIONS GOVERNING DISPOSAL OF RADIOACTIVE WASTE

This section provides background information on regulations governing the disposal of radioactive wastes. The following topics, which could potentially impact closure of the SST residue, are addressed:

- general background on the different types of radioactive waste;
- general background on legislation governing disposal of radioactive waste;
- regulations governing disposal of LLW;
- regulations governing disposal of HLW;
- a comparison between LLW and HLW disposal standards; and
- a discussion of the incidental waste concept and associated Incidental Waste Criteria.

3.1 Types of Radioactive Waste

In the United States, radioactive waste is divided into five types:

- SNF;
- HLW;
- TRansUranic (TRU) Waste;
- Byproduct Material[1]; and
- LLW.

Closure of the SST residue involves the definitions and disposal standards for LLW, TRU, and HLW. LLW and HLW are discussed in detail below. Issues associated with TRU wastes are discussed in Chapters 4 and 5 of this report. Closure does not require a discussion of SNF or byproduct material.

Two facts should be noted; first, SNF, HLW, and byproduct material are defined by their origin and not by how much radioactivity these wastes contain. Of the five types of waste, only TRU waste is defined by how much radioactivity is in the waste. Second, if a waste meets the definition of TRU waste and the waste also meets the definition of HLW, the waste will be managed as HLW and not TRU waste (see exception (1) in the definition of TRU waste, as presented in the Definitions provided at the beginning of this report).

3.2 Major Legislation Governing Disposal of Radioactive Waste

Regulations governing the disposal of radioactive waste are complicated; therefore, this section provides only an overview of some of the major pieces of relevant legislation.

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[1] DOE manages Naturally Occurring Radioactive Material as if it were byproduct material under Chapter IV of DOE Order 5820.2A.

Three federal entities have the majority of the regulatory authority for the disposal of the five types of radioactive waste: the EPA, the DOE, and the NRC. Each of these entities has codified various laws, Orders, Directives, guidance documents, and Branch Technical Positions that govern the various types of radioactive wastes.

In very simple terms, the EPA has authority to write standards, the DOE has authority to write and enforce standards for radioactive wastes from "atomic energy defense activities," and the NRC has authority to write and enforce regulations for disposal of commercially-generated LLW and for disposal of HLW. However, regulatory authority may depend on whether the radioactive waste has yet to be disposed (or emplaced) or the waste has already been released to the environment (e.g., a spill or a leak). This topic is discussed later. The EPA has the lead role for writing regulations and the DOE and NRC regulations/Orders cannot be inconsistent with EPA standards. There are many notable exceptions to these generalizations.

Nuclear energy became subject to federal regulation with the passing of the Atomic Energy Act (AEA) of 1946. Through the AEA, Congress gave control of the production and use of fissile materials to the Atomic Energy Commission (AEC). The AEA has been amended a significant number of times over the past 50 years. A good overview of energy-related legislation, including a dozen significant amendments to the AEA, is provided by Oak Ridge National Laboratory (1992).

When the EPA was created in 1970 by Reorganization Plan No. 3, President Nixon transferred to EPA jurisdiction the functions of the Atomic Energy Commission for establishing generally applicable environmental standards for the protection of the environment from radioactive materials "... in the general environment *outside the boundaries of locations under the control of persons possessing or using radioactive material*," (emphasis added, Reorganization Plan No. 3 section 2(a)6). Thus, EPA was granted the authority to set release standards, but not granted authority to implement the release standards. (Later, Congress granted EPA authority to address the cleanup of radioactive materials under CERCLA to regulate air emissions of some radionuclides and Congress also asked EPA to "certify" DOE compliance with 40 CFR 191 and 40 CFR 194 for the disposal of TRU wastes in the Waste Isolation Pilot Plant.)

In 1974, the Energy Reorganization Act redirected federal energy efforts. The AEC was abolished and replaced by the NRC and the Energy Research and Development Agency (the Energy Research and Development Agency was later abolished and became the DOE). Section 202 of the Energy Reorganization Act also gave the NRC licensing authority for facilities used primarily for the receipt and storage of HLW. Under this Section 202 authority, the NRC will license the disposal of HLW.

The Nuclear Waste Policy Act (NWPA) of 1982 established federal responsibility for the development of repositories for the disposal of HLW and SNF.

The Low-Level Radioactive Waste Policy Amendments Act of 1985, Public Law 99-240, established DOE responsibility for the disposal of commercially generated wastes with radionuclide concentrations exceeding the limits established in 10 CFR 61 for Class C LLW (i.e., Greater-Than-Class C (GTCC) LLW). These Amendments require the NRC to license the DOE facility for disposal of commercially-generated GTCC LLW.

DOE implements its AEA authority through a set of Directives, DOE Orders (which are not codified), and regulations. The most relevant of these is DOE Order 5820.2A, which establishes "... policies, guidelines and minimum requirements by which the DOE manages its radioactive and mixed waste and contaminated facilities." This Order is divided into Chapters, with Chapter I addressing the management of HLW and Chapter III addressing management of LLW. These two chapters are discussed in detail later in this report. Order 5820.2A has been in effect since September 1988 and is being revised. DOE Order 435.1 is currently available in draft and will eventually replace Order 5820.2A as the DOE Order governing the disposal of radioactive waste.

All of the above laws are applicable to the disposal of radioactive waste. A second set of laws and guidance documents is applicable to cleanup of radioactive wastes. Of these laws, the CERCLA and the regulations created to implement the statute (i.e., the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) 55 FR 8712) are the broadest. CERCLA provides the EPA with authority to address releases and threatened release of hazardous substances, including radioactive wastes. The EPA's CERCLA Program has created a system to designate the highest priority sites for cleanup, and those sites are National Priorities List (NPL) sites.

The Hanford Site is on the EPA's NPL. At Hanford, the overarching description of activities and regulatory authorities is provided by the TPA. The TPA, which combines RCRA and CERCLA requirements, has designated that Ecology will be the lead agency for "closure" of the SST farms under the state version of RCRA.

3.3 Low-Level Radioactive Waste

3.3.1 Definition of LLW

LLW is defined in the NWPA as "radioactive material that (a) is not high-level, spent nuclear fuel, transuranic waste or by-product materials as defined in section 11e(2) of the Atomic Energy Act of 1954; (b) the Commission (the NRC), consistent with existing law, classifies as low-level radioactive waste."

LLW is defined by what it is not (it is not HLW, SNF, TRU, or byproduct material). The NWPA also grants the NRC the authority to classify other wastes as LLW. Although the title implies that LLW is not very radioactive, there is no quantitative upper limit. Some very radioactive wastes (e.g., excess cobalt sources) are legally classified as LLW.

3.3.2 Regulations Governing Disposal of LLW

The EPA has the authority to set standards for disposal of LLW; however, EPA has yet to finalize 40 CFR 193 as the general disposal standard for LLW.

DOE Standards for LLW Disposed after 1988

The DOE sets and enforces its own standards for disposal of LLW from "atomic energy defense activities" (stakeholders are involved in the DOE LLW disposal process through the NEPA process). The DOE standards are contained in Chapter III of DOE Order 5820.2A. Paragraph 3(a) of Chapter III states that DOE LLW shall be disposed in a manner that meets four criteria (emphasis added):

> 1. Protect public health and safety in *accordance with standards* specified in applicable EH Orders and other *DOE Orders.*
>
> 2. Assure that external exposure to the waste and concentrations of radioactive material which may be released into surface water, ground water, soil, plants, and animals results in an effective dose equivalent that does not exceed *25 mrem/yr to any member of the public. Releases to the atmosphere shall meet the requirements of 40 CFR 61.* Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.
>
> 3. Assure that the committed effective dose equivalents received by individuals who inadvertently may intrude into the facility after the loss of active institutional control (100 years) will not exceed *100 mrem/yr for continuous exposure or 500 mrem for a single acute exposure.*
>
> 4. Protect *ground water resources, consistent with Federal, State, and local requirements.*

In summary, the DOE Order sets standards to protect the member of public (MOP), the inadvertent human intruder (IHI), and groundwater resources. Compliance with the DOE Order is demonstrated through a *site-specific study or* performance assessment (PA). Sometimes DOE facilities ship LLW to NRC-licensed facilities for disposal, in which case the DOE generators must meet the NRC facility-specific waste acceptance criteria.

DOE Order 5820.2A also requires that doses to workers and the MOP shall be As Low As Reasonably Achievable (ALARA). An ALARA analysis is an optimization; are there cost-effective actions which can be taken to reduce projected doses even further? For example, would burial of the waste in a different, and more expensive, container reduce the projected doses to the MOP, and is the extra cost justified by the reduced doses?

Many important performance objectives are not defined in Chapter III of DOE Order 5820.2A. For example, the time frame of compliance is not specified. This problem was recognized and DOE/HQ/EM-35 established a Performance Assessment Task Team (PATT) to integrate the activities of the DOE facilities that are preparing PAs for the disposal of new LLW as required by Chapter III of the Order. The PATT guidance is documented in Wood *et al.* (1994). The time frame of compliance is also discussed at some length in Wood *et al.* (1994), which recommends using a 10,000-year compliance period. The PA (Mann *et al.*, 1996), which supported the November 7, 1996 Hanford request for incidental waste classification, used a 10,000-year time frame of compliance. For commercial LLW, the NRC guidance recommends a 10,000-year time frame for the PA (NRC, 1997a, p. 3-11).

Under a cover memorandum dated October 31, 1996, DOE issued more recent guidance on the interpretation of the requirements of Chapter III of DOE Order 5820.2A. This guidance, *Interim Content and Format Guide and Standard Review Plan for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments,* suggests the use of a 1,000-year compliance time frame.

DOE guidance found in Wood *et al.* (1994, p.21) and the more recent (1996) DOE guidance develop the idea of a buffer zone separating the hypothetical MOP from the disposal site. Therefore, the typical point of compliance for protection of the MOP and groundwater resources is the boundary of a buffer zone around the LLW disposal facility. The concept of a buffer around a LLW disposal facility is also endorsed in the NRC guidance (NRC, 1997a).

DOE Standards for LLW Disposed Before 1988

The DOE requirements for disposal of LLW contained in Chapter III of DOE Order 5820.2A are only applicable to LLW disposed after 1988 (the effective date of DOE Order 5820.2A). An external oversight board (the Defense Nuclear Facilities Safety Board (DNFSB)) found in DNFSB 94-2 that DOE should assess the possible impact to human health from both pre- and post-1988 LLW. The DNFSB noted that DOE cannot demonstrate protection of the MOP and groundwater if DOE excludes the pre-1988 wastes from the PA.

In response to DNFSB 94-2, the DOE committed to prepare "composite analyses" (CA). Guidance for preparation of the all-source-terms CA was issued in 1996 as *Guidance for a Composite Analysis of the Impact of Interacting Source Terms on the Radiological Protection of the Public from DOE LLW Disposal Facilities.*

The standards for the CA are similar to the standards for disposal of post-1988 LLW, with four major exceptions:

1. the source term for the CA includes all sources of radioactive contamination that could interact to affect the dose to the MOP (not just the post-1988 LLW);
2. the dose limit for the MOP is 100 mrem/yr (not 25 mrem/yr);
3. there is no requirement to protect the IHI; and
4. the point of compliance is a future DOE land use boundary, not the 100-m boundary typically assumed for post-1988 LLW (the DOE 1996 guidance is vague on this important topic, deferring to each DOE facility to defend a future land use boundary).

Like the DOE standard for post-1988 LLW, the DOE requirements for a CA require protection of groundwater resources consistent with state and Federal standards. In summary, DOE LLW disposal facilities must complete a PA for post-1988 LLW and CA for all interacting sources of radioactive contamination. A PA and a CA are separate analyses because the performance objectives are very different.

Proposed DOE Standard for Disposal of LLW

As previously discussed, DOE Order 435.1 has been proposed, and, once finalized, Order 435.1 will replace the existing DOE Order 5820.2A. The July 31, 1998 version of DOE Order 435.1 (DOE O 435.1) consists of three levels or tiers. At the top is the actual Order 435.1, which requires: (1) compliance with applicable Federal, state, and local laws; (2) compliance with applicable DOE Orders; and (3) compliance with DOE M 435.1, "Radioactive Waste Management Manual."

The second tier, the Radioactive Waste Management Manual (DOE M 435.1), is similar to the current DOE Order 5820.2A, with some exceptions. The third tier is a set of nonbinding guidance documents. Two notable changes are that the draft 435.1 M proposes to reduce the time period of compliance from 10,000 years to 1,000 years (IV.P.(2)) and the draft manual also allows LLW *disposal* to proceed under CERCLA, in lieu of a LLW PA (I.2.E.(5)). Additional impacts of proposed DOE O and M 435.1 on closure of the radioactive component in the SSTs are addressed later in this report under the requirements for management of HLW.

NRC Standards

The NRC sets and enforces standards for disposal of LLW from commercial facilities (e.g., hospitals and power reactors). The NRC licensing and disposal standards are contained in 10 CFR 61. As allowed by Section 274 of the AEA, the NRC also grants authority to "agreement states" to regulate LLW disposal facilities.

The NRC's 10 CFR 61 sets standards to protect the MOP, the IHI, workers, and standards for long-term site stability. The NRC's dose-based standards to protect the MOP are similar to the DOE's dose-based standards to protect the MOP. The NRC standards, like the DOE standards, require a site-specific analysis or PA to demonstrate protection of the MOP.

To protect the IHI, the NRC and DOE have taken different approaches. The DOE demonstrates protection of the IHI through a *site-specific PA*, using a 100 mrem/year chronic dose standard and a 500 mrem acute dose standard. The NRC demonstrates protection of the IHI through an analysis of a *generic* disposal site, using a 500 mrem acute and chronic dose standard. Based on the analysis of the generic disposal site, the NRC divides LLW into four classes and sets different disposal requirements for each of the four classes (Class A, Class B, Class C, and Greater-Than-Class-C). The generic analysis and the four classes of wastes are discussed in the following sections.

3.3.3 Class C Limits

Development of the Concentration Limits for Class A, B, and C Wastes

Because the NRC was developing a disposal standard (10 CFR 61) for sites that had not yet been identified, the NRC created a hypothetical or generic disposal site and calculated the dose consequences from three hypothetical exposure scenarios. The exposure scenarios used for developing the class limits are: discovery; intruder-construction; and intruder-agriculture.

Combining these exposure scenarios with assumptions about the timing of intrusion and the ability of the intruder to recognize the wastes, the NRC calculated the numerical limits for the waste classes to ensure that doses to an IHI would not exceed either 500 mrem to the whole body or the bone or 1500 mrem to other organs.

For the intruder-construction scenario, the IHI builds a house on top of a generic and unrecognized LLW landfill by digging a 3-m deep foundation hole. The top 2 m are excavated into landfill cover material, and the bottom 1 m is excavated into the waste. During the construction phase, inadvertent intruders would be exposed to external irradiation and contaminated airborne dust. Following construction, the excavated mixture of soil and waste is used as backfill around the house and is also used in the gardening bed. Inadvertent intruders living in the house are exposed to external irradiation, airborne radionuclides, and radionuclides in food grown in the garden. This is considered to be the intruder-agriculture scenario.

The models and parameters used to calculate doses through both of these exposure scenarios are detailed in Appendix A.

When developing the Class A limits, the NRC assumed that the intruder does not recognize the LLW 100 years after site closure and is exposed through both the intruder-construction and intruder-agriculture exposure scenarios. Based on the calculated dose consequences of these exposures, the NRC back-calculated concentrations of radionuclides that would not result in unacceptable dose to the IHI. In simple terms, the IHI can safely garden in Class A wastes 100 years after site closure.

Class B wastes are radioactive wastes with short half-lives, which would be recognizable to an intruder 100 years after site closure. Because the waste package is recognizable, the intruder does not engage in the intruder-construction and intruder-agriculture exposure scenarios, and the "discovery" dose is acceptable. The NRC's 10 CFR 61 disposal requirements for Class B wastes set special requirements for the waste form to ensure that the waste package will be recognizable to the intruder.

Class C waste concentration limits were derived based on calculated doses to inadvertent intruders, assuming the LLW is recognizable as waste for 500 years. The NRC then assumed that the intruder would not recognize the LLW at year 500 and is exposed through both the intruder-construction and intruder-agriculture exposure scenarios. The NRC then back-calculated concentrations of radionuclides that would not result in unacceptable doses to the IHI under the exposure conditions modeled. In simple terms, the intruder can safely garden in Class C wastes 500 years after site closure. NRC's 10 CFR 61 disposal requirements for Class C wastes set special requirements for the waste form to ensure that the waste package will be recognizable to the intruder. Wastes that would result in unacceptable doses beyond 500 years are classified as GTCC. GTCC LLW needs special disposal methods and requires NRC's approval on waste form and disposal configuration.

Concentration Limits for Class A and C Waste from 10 CFR 61

Given the upper limits for waste classification (Table 1), NRC regulation 10 CFR 61 requires the following approach to determine waste class. For any waste containing multiple radionuclides, the sum-of-fractions for individual radionuclides needs to be used.

If radioactive waste does not contain any of the radionuclides listed in Table 1, it is Class A waste. Otherwise, long-lived radionuclides should be assessed first to classify the waste. If the waste contains only long-lived radionuclides and the concentration does not exceed 0.1 times the limit in Table 1, the waste is Class A. If the concentration exceeds 0.1 times the limit, but is less than the limit, the waste is Class C, unless the short-lived radionuclides exceed the Class C upper limit. The waste cannot be Class B if the waste contains only long-lived radionuclides.

If only short-lived radionuclides are present in the waste, and their concentrations are between the Class B and C limits, the waste is Class C. The information to separate Class A and B wastes, based on short-lived radionuclides, is not presented here. If either the short-lived or long-lived radionuclides exceed their Class C upper limits, the waste will be classified as GTCC LLW. If both long- and short-lived radionuclides are present, the most restrictive (highest) classification applies.

Table 1. Concentration Upper Limits for Classification

Long-Lived Radionuclides	Class C Upper Limits	**Short-Lived Radionuclides**	Class B Upper Limits	Class C Upper Limits
C-14	8 Ci/m^3	Ni-63	70 Ci/m^3	700 Ci/m^3
C-14 in activated metal	80 Ci/m^3	Ni-63 in activated metal	700 Ci/m^3	7000 Ci/m^3
Ni-59 in activated metal	220 Ci/m^3	Sr-90	150 Ci/m^3	7000 Ci/m^3
Nb-94 in activated metal	0.2 Ci/m^3	Cs-137	44 Ci/m^3	4600 Ci/m^3
Tc-99	3 Ci/m^3			
I-129	0.08 Ci/m^3			
Alpha emitting transuranic with $t_{1/2}$ > 5 years	100 nCi/g			
Pu-241	3500 nCi/g			
Cm-242	20000 nCi/g			

Site-Specific Class C Limits

In addition to setting generic class limits, the NRC also allows for the development of site-specific Class C limits. The NRC:

... may, upon request, or on its own initiative, authorize other provisions for the classification and characteristics of wastes on a special case basis, if, after evaluation, of the *specific characteristics of the waste, disposal site, and method of disposal*, it finds reasonable assurance of compliance with the performance objectives in subpart C of this part" (emphasis added, 10 CFR 61.58).

The DOE has always developed site-specific limits that protect the IHI. Deriving site-specific Class C limits for the Hanford Site would be no different, except that the analysis may have to be presented in the format that the NRC used to develop the existing Class C limits. Site-specific Class C limits are discussed in detail later in this report.

3.4 High-Level Radioactive Waste

3.4.1 Definition of HLW

HLW is the waste that results from the reprocessing of SNF to recover unfissioned uranium and plutonium. The legal definitions of HLW are provided in the Definitions section of this report. One definition of HLW is from 10 CFR 50 Appendix F (November 1970, 35 FR 17533), and another definition of HLW is provided by the NWPA. A third definition is from DOE Order 5820.2A, Radioactive Waste Management. Order 5820.2A is not promulgated or codified, but does serve to meet DOE's obligations under the AEA.

Although the definitions of HLW vary, the variations are not relevant to this report. The common elements in each definition include: (1) radioactive waste material; (2) from the reprocessing of SNF; and (3) the lack of concentration- or specific activity-based limits. *HLW is defined by origin, not constituents; therefore, there is no concentration below which HLW ceases to be HLW.* The definitions of HLW include phrases like "highly radioactive" and "in concentrations requiring permanent isolation." However, these terms are never quantitatively defined.

In 1987, the NRC formally discussed the possibility of setting the lower boundary of HLW at the Class C limits for concentrations of short-lived radionuclides that exceeded Table 2 of 10 CFR 61 (52 FR 5992). Rather than setting a lower boundary for HLW, the NRC decided instead to require that GTCC LLW be disposed in a geologic repository, unless disposal elsewhere has been approved by the NRC. Thus, the definition of HLW continues to be based solely on the origin of the waste and not the content or specific activity of the waste.

In that same ruling, the NRC noted that disposal of GTCC wastes in a geologic repository would be governed by 10 CFR 60 and that disposal of GTCC LLWs in facilities other than a repository would be governed by 10 CFR 61. The following section describes regulations governing the disposal of HLW.

3.4.2 Regulations Governing Disposal of HLW

Nuclear Waste Policy Act

The NWPA of 1982 establishes the national program for the disposal of SNF and HLW. The NWPA does not set quantitative standards for disposal of HLW; rather, the NWPA defines U.S. policies and assigns responsibilities. The NWPA assigns three agencies responsibility for disposal of HLW:

- EPA is to set the standards for the disposal;
- DOE is to develop and operate the mined geologic repository;
- NRC is to license the repository; and
- EPA and NRC are to regulate the disposal program (National Research Council, 1995).

Does the NWPA Apply to the Unrecoverable Residue in the SSTs?

If HLW were closed *in situ* at the Hanford Site, would the NWPA be applicable? The DOE's 1987 EIS for the "Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes" states that the NWPA does not require that all materials regarded as HLW be disposed in a geologic repository (DOE, 1987, Vol. 1, p. 6.8). The NRC expressed concern about the DOE's 1987 consideration of *in situ* disposal of significant volumes of HLW at the Hanford Site (DOE, 1987, Vol. 5, Record No. 239), and the Natural Resource Defense Council took a strong exception to the DOE position, noting that "Nowhere in this elaborate plan (NWPA) did Congress authorize a single alternative to geologic disposal of HLW" (DOE, 1987, Vol. 5, Record No. 240).

The 1988 DOE Order 5820.2A, which also governs disposal of HLW, differentiates between "new and readily retrievable HLW" and HLW that is not readily retrievable, stating that the NWPA applies to the new and readily retrievable HLW and that other HLW may be suitable for onsite stabilization. This section of the DOE Order implies that the NWPA may not apply to all HLW.

In the 1996 Final EIS for the "Hanford Tank Waste Remediation System" (DOE, 1996a, Volume 1, Section 6.1.3), the DOE states that "... DOE does not view disposal (of HLW) in a national repository as being legally required, and DOE intends to determine the appropriate disposition of HLW on a case-by-case basis."

Finally, Sections 8(a), 8(b), and 8(c) of the NWPA seem to imply that disposal of HLW from atomic energy defense at Hanford is exempt from the requirements of the NWPA. Sec. 8.(a) of the NWPA states:

> ATOMIC ENERGY DEFENSE ACTIVITIES- Subject to the provisions of subsection (c), the provisions of this Act shall not apply with respect to any atomic energy defense activity or to any facility used in conjunction with any such activity.

Under Sec. 8.(b), the President did not find the need for a defense-only repository, and finally, under Sec. 8.(c):

> APPLICABILITY TO CERTAIN REPOSITORIES - The provisions of this act shall apply with respect to any repository not used exclusively for the disposal of high-level radioactive waste or spent nuclear fuel resulting from atomic energy defense activities, research and development activities of the Secretary, or both.

Therefore, it appears that a "repository" for HLW that is only from atomic energy defense activity is exempt from the requirements of the NWPA. However, the DOE does not raise this defense in any of the above-cited DOE documents and this issue should be further researched before a final conclusion can be drawn.

At this time, it is not clear if the NWPA applies to the disposal of all HLW; therefore, this report presents options for closure under both sets of assumptions (the NWPA does apply and the NWPA does not apply). Even if the NWPA does apply, it is important to remember that the NWPA sets *policy, not disposal standards.* The EPA is responsible for developing standards for disposal of HLW, and the NRC is responsible for writing and enforcing licensing standards for the HLW disposal facility.

<u>EPA Standard for Disposal of HLW</u>

The EPA's general standard for the disposal HLW is 40 CFR 191, "Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes." Refer to Appendix B for an overview of the requirements of 40 CFR 191.

The EPA states in 58 FR 66399 that, "Although developed primarily through consideration of mined geologic repositories, 40 CFR 191, including today's amendments, applies to disposal of the subject wastes by any method, with three exceptions." The three exceptions are disposal in the ocean, disposal that occurred before 1985, and disposal within 1/4 mile of an underground source of drinking water (USDW) (which will be the subject of future rulemaking). *40 CFR 191 is the only promulgated or even proposed standard for disposal of HLW.*

A fourth exception is that the current version of 40 CFR 191 is not applicable to sites being characterized under Section 113(a) of the NWPA (see 40 CFR 191.11(b)(3)). After the initial promulgation of 40 CFR 191, the Waste Isolation Pilot Plant Land Withdrawal Act (PL 102-579) exempted all sites being characterized under section 113(a) of the NWPA from the requirements of 40 CFR 191.

Could the EPA's 40 CFR 191 be applied to the unrecoverable Hanford tank residue? The simple answer is yes, but the EPA still needs to write the Groundwater Protection Requirements for disposal systems located within 1/4 mile of a USDW (see 58 FR 66410 for details). The Containment Requirements, Assurance Requirements, and Individual Protection Requirements of the current version of 40 CFR 191 could be applied to Hanford, but the Groundwater Protection Requirements have yet to be promulgated.

A second issue relates to the link between the current version of 40 CFR 191 and the NWPA. The EPA's 40 CFR 191 is not applicable to sites being characterized under the authority of the NWPA, so if the NWPA governs the disposal of the SST residue, the current version of 40 CFR 191 is not applicable. If the NWPA does not govern the disposal of the SST residue, the current version of 40 CFR 191 is applicable (except the Groundwater Protection Requirements are not in place). Possible application of 40 CFR 191 and the NWPA to the SST residue is discussed in Chapter 5 of this report.

NRC Standard for Licensing HLW Repositories

The NRC's 10 CFR 60 sets forth the NRC's *licensing* criteria for "Disposal of High-Level Radioactive Waste in Geologic Repositories." 10 CFR 60 sets rigorous requirements for public involvement, as well as performance objectives, land ownership, siting criteria, design criteria, and license applications. As an example of the NRC's criteria, 10 CFR 60.113(a)(1)(ii)(B) requires that the release rate of any radionuclide from the disposal system following the containment period shall not exceed one part in 100,000 per year. The NRC's 10 CFR 60 is written specifically for the licensing of a geologic repository "... constructed or operated in accordance with the Nuclear Waste Policy Act of 1982...." Therefore, the NRC's licensing criteria for disposal of HLW *only applies to sites authorized by the NWPA.*

DOE Standard for Disposal of HLW

Because the Hanford tank waste is DOE-titled and located on a DOE facility, Chapter I, HIGH-LEVEL WASTE of Order 5820.2A (DOE, 1988a), also governs the disposal of HLW, as follows:

> 2. POLICY. All high-level waste generated by DOE operations shall be safely stored, treated and disposed ... Geologic disposal shall comply with both Nuclear Regulatory Commission regulations and EPA standards. ...
>
> 3d Disposal. New and readily retrievable waste shall be processed and the high-level waste fraction disposed of in a geologic repository according to the requirements of the Nuclear Waste Policy Act of 1982 (Public Law 97-425) as amended. Options for permanent disposal of other wastes, such as single shell tank waste, shall be evaluated and include such methods as in-place stabilization as well as retrieval and processing, as required for new and readily retrievable waste. Analytical predictions of disposal system performance shall be prepared and incorporated in the National Environmental Policy Act process. ...
>
>> (2) Other Wastes. .... Options for permanent disposal of singly contained tank waste shall be evaluated and include such methods as in-place stabilization as well as retrieval and reprocessing, as required for new and readily retrievable waste in paragraph 3d(1).

Like the NWPA, the DOE Order does not set standards for disposal; rather, the Order requires compliance with the existing legal structure. Note that the DOE Order makes a policy statement that defines different disposal options for HLW where (1) new and readily retrievable HLW will be disposed in a deep geologic repository in accordance with the NWPA, and (2) HLW that is not readily retrievable shall be evaluated for in-place stabilization as well as retrieval and reprocessing.

Proposed DOE Standard for Disposal of HLW

As previously discussed, DOE Order 435.1 has been proposed, and, once finalized, Order 435.1 will replace existing DOE Order 5820.2A. Order 435.1 will not apply to facilities licensed by the NRC or to the geologic disposal of HLW.

A detailed comparison between the July 31, 1998 draft of Order 435.1 and existing Order 5820.2A is provided in Appendix C. The Guidance associated with DOE 435.1 (i.e., DOE G 435.1) was not reviewed. The draft order is similar to the current order; however, the new order does not differentiate between "not readily retrievable" and "new and readily retrievable waste." The new order does defines "incidental waste," which is not defined in the current order. Under the draft order, a waste can be categorized as incidental waste by either "citation" or "evaluation." A determination of incidental waste using citation seems to be limited to "fuel reprocessing plant wastes" and could not be applied to SST residue (for example). Closure of tank residue under evaluation is linked to the three Incidental Waste Criteria discussed later in this report. Under the evaluation process, this version of 435.1 M allows a facility to either (1) meet the Class C limits, or (2) meet alternative requirements for waste classification and characteristics, as the NRC may authorize.

For wastes that cannot be readily retrieved, the new order replaces the option of in-place stabilization of HLW with three closure options: (1) close as a LLW disposal site as specified in the LLW Chapter of DOE M 435.1; (2) close as a TRU waste disposal site; or (3) close under CERCLA. These requirement offer regulatory flexibility to close HLW disposal facilities.

3.5 Comparison Between LLW and HLW Standards

The standard for disposal of HLW and the standard for disposal of LLW are both protective of human health. However, the philosophical underpinnings of these standards are different; therefore, these standards take somewhat different approaches to protecting human health.

Appendix B provides an overview of the EPA's general standard for the disposal of HLW and the DOE's standard for disposal of LLW and explores the similarities and differences between these two standards.

For example, the basis of 40 CFR 191 is comparative risk within the general population. In contrast, standards for the disposal of LLW are based on risk to any individual (known as the MOP and the IHI), and the belief that no individual should be exposed to ionizing radiation above a predefined threshold. These philosophical differences are reflected in the disposal standards (most notable in the treatment of the IHI).

3.6 Incidental Waste

Because HLW is defined by origin and not by content, must all the Hanford tank waste be managed as HLW? Not necessarily, because the low-activity waste (LAW) generated incidental to the further treatment of HLW could, possibly, remain in a SST and be disposed as if it were LLW. The NRC states that "incidental wastes generated in further treatment of HLW (e.g., salt residues or miscellaneous trash from waste glass processing) would be outside the ... [legal definition] ... of HLW" (58 FR 12343).

The concept of incidental waste is almost 30 years old. In the June 3, 1969 Federal Register (34 FR 8712), the AEC discusses closure of nuclear fuel reprocessing plants and the legal definition of HLW. In that discussion, the AEC noted that the term HLW should not include "incidental wastes" resulting from SNF reprocessing plant operations. Specifically, the AEC noted in 1969 (34 FR 8712) that radioactive hulls and other contaminated fuel structure hardware may not have to be disposed in the same manner as HLW and that "other solid wastes resulting from operation of commercial fuel reprocessing plants such as ion exchange beds, asphalted sludges, vermiculited sludges and contaminated laboratory items, clothing tools, and equipment" are outside the legal definition of HLW.

Unfortunately, incidental wastes were not specifically excluded from the Appendix F definition of HLW promulgated by the AEC on November 14, 1970 (35 FR 17533). However, the AEC, from that same November 1970 Federal Register forward in time, has applied the concept of incidental waste. In 1970, the AEC states that the reprocessing plant (which would contain residual HLW) would not be managed as HLW and that the requirements for the decontamination and decommissioning (D&D) of the HLW reprocessing plant would be developed later:

> Viewed from the perspective that each generation is trustee of the environment for succeeding generations, the Commission considers that the public interests requires that *a high-degree of decontamination* capabilities be included in such facilities and that any residual radioactive contamination after decommissioning be *sufficiently low as not to present a hazard to the public health* and safety. Specific requirements for decontamination and decommissioning of fuel reprocessing facilities will be developed in consultation with competent groups. (emphasis added, 35 FR 17532)

These same underlying criteria (a high degree of decontamination capabilities and concentrations sufficiently low as not to present a hazard to the public health) continue to be used today as the underlying basis for separating HLW from incidental waste. In 1987, the NRC states in footnote 1 (52 FR 5993) that "incidental wastes generated in further treatment of HLW (e.g., decontaminated salt with residual activities on the order of ... would also be outside the Appendix F definition" of HLW. As discussed in the next section of this report, the NRC relies heavily on the concept of incidental waste to deny a petition for rulemaking in 1993 (58 FR 12342).

Incidental waste is not a "category" of radioactive waste; rather, incidental waste is a concept that the AEC, and subsequently the NRC and DOE, have used for almost 30 years to separate HLW from the LAW fraction generated during the further treatment of HLW. Incidental waste is defined by both origin and characteristics. If the LAW fraction of HLW has the characteristics of LLW, then the LAW fraction may be classify as incidental waste, which is not subject to NRC licensing and which DOE can manage as either DOE-titled LLW or DOE-titled TRU waste.

3.6.1 Separating Incidental Waste from HLW

The boundary between HLW and incidental waste was initially defined by the NRC as a result of concerns raised about the amount of radioactivity that would be disposed at Hanford in near-surface grout vaults. DOE planned to treat liquid HLW waste from the tanks; vitrify the high-level fraction for eventual disposal in a geologic repository; treat the LAW fractions by mixing them with a cement-like grout; and dispose of the incidental waste mixture in near-surface vaults (Report on Defense Plant Wastes, 1990).

A petition sent by Washington State, Oregon State, and the Yakama Indian Nation asked the NRC to change the definition of HLW so that the NRC would regulate the Hanford incidental waste fraction from the treatment facility destined for the grout vaults. The states and tribe petitioned because of their concern that DOE was not doing all it could to separate HLW radionuclides from the LAW or incidental fraction prior to onsite disposal. The petition was specific to the treatment facility and the waste stream proposed for the grout vaults.

In the petition, the NRC was asked to adopt a rule classifying all wastes in the tanks as HLW unless the NRC determines, on a case-by-case basis, that (1) DOE has eliminated as much radioactivity from the material to be grouted as "technically feasible" and (2) the NRC would oversee the pretreatment process and several other requirements.

In response to the petition, the NRC defined a set of three tests to determine if a LAW fraction is incidental waste (58 FR 12345):

> The basis for the Commission's conclusion is that the reprocessing wastes disposed of in the grout facility would be "incidental" wastes because of DOE's assurances that:
>
> - the HLW has been processed (or will be further processed) to remove key radionuclides to the maximum extent that is technically and economically practical;
> - the incidental wastes will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C low-level waste as set out in 10 CFR part 61; and
> - the incidental wastes are to be managed, pursuant to the Atomic Energy Act, so that safety requirements comparable to the performance objectives set out in 10 CFR part 61 are satisfied.

In this report, these three tests are identified as the Incidental Waste Criteria. These same criteria were presented in a letter dated March 2, 1993 from R. Bernero of the NRC to J. Lytle of the DOE, which is discussed later in this report.

The Incidental Waste Criteria were originally developed for evaluating a waste stream from a HLW treatment facility; however, actions at the DOE Savannah River Site (SRS) site and this report suggests that application of these same criteria to the SST residue is a viable closure option. Use of the Incidental Waste Criteria for managing the SST residue will require the development of a petition to the NRC (discussed later).

3.6.2 Previous Use of the Incidental Waste Concept at Hanford

On three occasions, the NRC has provisionally agreed that the LAW fraction from a treatment facility for Hanford tank waste meets the criteria for incidental waste and is not HLW; thus, it is not subject to NRC licensing. With the NRC's agreement that a LAW meets the Incidental Waste Criteria, the LAW is then classified as incidental waste, which can be managed as if it were LLW (for further clarification, see the definition of LAW in the Definitions section of this report).

Shortly after the completion of the DOE EIS for the Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes (DOE, 1987), DOE and NRC staff met to discuss the preferred alternative proposed in the EIS. That preferred alternative was to treat the wastes retrieved from the DSTs and to dispose of the LAW fraction from the treatment facility as grout in near-surface vaults. The NRC provisionally agreed that the LAW fraction from the treatment facility would not be HLW subject to NRC licensing. The NRC further suggested that if DOE could demonstrate that at least 90% (the largest practical amount) of first-cycle solvent extraction wastes had been removed, the NRC would concur that the LAW would not be subject to NRC licensing and could be disposed in the near-surface vaults (November 29, 1988 letter from Michale Bell of the NRC to Ronald Gerton of the DOE/RL; see page A-7 of Westinghouse Hanford Company [WHC] 1996a).

However, stakeholder concerns resulted in a petition sent by Washington, Oregon, and the Yakama Indian Nation to the NRC. The petition requested that the NRC change the definition of HLW so that the NRC would regulate the LAW fraction (the incidental waste) from the Hanford treatment facility. The NRC denied the petition and again concluded that the LAW fraction was incidental waste. The petitional denial includes the three criteria (Section 3.6.1) used by the NRC at Hanford to determine if the LAW fraction is incidental waste.

Subsequently, DOE/RL made three major changes to its strategy for management of tank waste. First, concerns about the stability of grout resulted in the decision to vitrify the LAW fraction (instead of making grout); second, DOE treatment facilities will be privatized; third, retrievable wastes from the SSTs and the DSTs will be treated in the treatment facility to separate the HLW and LAW fractions.

Reflecting these three changes in the strategy, DOE/RL requested NRC agreement that Hanford tank waste planned for disposal onsite as vitrified waste would be incidental waste and therefore not subject to NRC licensing. DOE/RL based their November 7, 1996 request on two reports: "Technical Basis for Classification of Low-Activity Waste Fraction from Hanford Tanks," (WHC, 1996a) and "Hanford Low-Level Tank Waste Interim Performance Assessment" (Mann *et al.*, 1996).

In a letter dated June 9, 1997, the NRC responded to the DOE/RL request of November 7, 1996. A copy of this letter is attached as Appendix D. Although this NRC letter addresses the LAW fraction from the treatment facility, there are five pieces of information that are relevant to closure of the SST residue, specifically:

> ... Low-Activity Waste (LAW) meets the incidental waste classification criteria specified in the March 2, 1993 letter from R. Bernero, NRC to J. Lytle, U.S. Department of Energy. [Letter dated June 9, 1997. See Appendix D]

The criteria in the Lytle letter are identical to the Incidental Waste Criteria presented in 58 FR 12345 and in this report. Therefore, the three criteria presented in 58 FR 12345 continue to be the criteria used to determine if a waste is incidental or high-level.

> ... the staff's preliminary finding is a provisional agreement that the LAW portion of the Hanford tank waste planned for removal from the tanks and disposed onsite is incidental waste and is, therefore, not subject to NRC licensing authority. Staff considers that the information presented is not sufficient to make an absolute determination at this time.

The NRC provisionally agrees with the DOE/RL proposal of November 7, 1996. The acceptance is provisional because much of the information presented to the NRC is draft or generic (e.g., DOE has not selected an onsite disposal configuration for the LAW). Also, the NRC accepts the format of the Technical Basis Report.

> Approximately 8.5 MCi of activity will remain in the LAW fraction, which corresponds to about 2% of the estimated 422 MCi generated at the Hanford site (based on a December 31, 1999 decay date).

Early discussions of the criteria for incidental wastes were based, in part, on percentage removal (e.g., if 90% were removed, the remaining fraction might be incidental waste). Current criteria for incidental waste do not specifically set a limit on the percentage of curies that must be removed; however, as this statement reflects, percentage removal is still a secondary consideration.

> The DOE PA was performed to the requirements of DOE Order 5820.2A, "Radioactive Waste Management," September 26, 1988. This Order is similar to the 10 CFR Part 61 performance objectives.

Importantly, the NRC agrees that the requirements of DOE Order 5820.2A, Chapter III (as interpreted by Mann et al., 1996) are comparable to the requirements set out in 10 CFR 61.

> Please submit future PAs as supplements to the Technical Basis Report so that they can be reviewed to confirm the current analysis and resolve any outstanding issues.

Finally, the NRC plans to take an active role in "reviewing" the DOE LLW PAs for the onsite disposal of incidental waste.

3.6.3 Previous Use of Incidental Waste Concept at Savannah River

The DOE's SRS recently closed two tanks which had been used to store mixed HLW. As part of the closure process, the unretrievable waste in Tanks 17 and 20 was stabilized with grout. The process used by the SRS to solidify the residual tank waste was described in Shyr and Bustard (1997). In a letter dated December 20, 1996, the DOE requested NRC concurrence that the stabilized residue remaining in Tanks 17 and 20 was incidental waste. The details of the December 20, 1996 DOE request have not been reviewed by the authors.

Tanks 17 and 20 are the first HLW tanks to undergo closure using the regulatory concept of incidental waste and the outcome of the NRC review of these closures will have a significant bearing on the closure of the SSTs at Hanford. In a letter dated June 30, 1998, the NRC responded to the DOE request by asking for additional information on the closure of Tanks 17 and 20. A copy of the NRC's June 30, 1998 "Request For Additional Information Regarding Savannah Rivers Site High-Level Waste Tank Closure; Classification of Residual Waste as "Incidental" is included as Appendix E. An initial review of this NRC information request provides a number of observations about the NRC's perspective on the closure of HLW tanks. Each of these observations is followed by a reference to the section of the NRC letter supporting the observation.

- Most importantly, the NRC is using the three Incidental Waste Criteria set forth in the March 1993 letter from R. Bernero/NRC to J. Lytle/DOE to separate HLW from the LAW (incidental waste) fraction (Cover letter, Appendix E).

- The residual tank inventory should be characterized using analytical data (I.A.1., I.A.2., and I.A.3. of Appendix E).

- The NRC is willing to consider site-specific Class C limits (II.B. of Appendix E).

- Assumptions concerning the long-term institutional controls and the life span of barriers must be technically defended (II.B.1., III.B.1, and III.C.1.).

- Assuming that the stabilized waste remaining in Tanks 17 and 20 meets the Class C limits, the NRC questions concerning protection of the IHI (II.B. of Appendix E) seem misplaced, as meeting the Class C limits (along with requirements concerning packaging, depth of burial, and site stability) are, by definition, already protective of the IHI.

- The NRC is interested in possible effects of the grout on the geochemistry of the disposal system (III.H. and III.I.), and the NRC did not question the ability of the grout to bind with the residue waste or question the application of the Class C limits to the waste/grout mixture.

- A detailed and technically defensible PA is required to demonstrate protection of human health so that safety requirements comparable to 10 CFR 61 are satisfied (see all of III.).

- The PA should address consequences for the next 10,000 years (III.A.4.).

- The PA should explicitly address uncertainty, either through a bounding analysis or through quantitative treatment of uncertainty (III.A.6.).

- The PA should address cumulative, interacting source terms (III.D.2.).

These observations are provide insight; however, they should not be the sole basis for altering the Hanford closure program, because the final outcome of the negotiations between the NRC and the DOE are unknown. Despite this uncertainty, the authors are comfortable with three conclusions: the NRC is willing to apply the Incidental Waste Criteria to unretrievable HLW tank residue; they will consider acceptance of site specific Class C limits; and the NRC will be an active participant in determining if a LAW waste stream satisfies the Incidental Waste Criteria.

4.0 CLOSURE OF SST RESIDUE USING THE INCIDENTAL WASTE CONCEPT

4.1 Introduction

The previous chapters presented the history of the SSTs and provided an overview of the regulations that govern radioactive waste. The next two chapters present regulatory options that can be applied to the long-term closure of any residue that may remain in the SSTs after completion of retrieval and closure operations.

Identifying regulatory closure options is made difficult by several factors. First, the end-state of each SST is currently unknown (i.e., the character of the residual waste remaining after retrieval and physical closure operations is unknown). To proceed beyond this uncertainty, different regulatory closure options are offered for different possible end-states. A second difficulty is that some possible end-states are unique; that is, there is no existing regulatory precedent. To proceed past this difficulty, Chapter 5 offers unique closure options to match the unique end-states.

This chapter focuses on the use of the incidental waste concept to close the SST residue, and Chapter 5 provides other regulatory closure options, assuming closure as incidental waste is not desirable or not possible.

The Hanford SSTs contain mixed HLW. Therefore, it would seem that the applicable regulatory option would be to close the SST residue as mixed HLW. Unfortunately, there are many negative issues related to the in-place disposal of HLW at Hanford (these are discussed in Chapter 5). This chapter proposes that any residue remaining in the SSTs should be closed as incidental waste.

The concept of incidental waste was developed to address some of the unique circumstances associated with the D&D of nuclear fuel reprocessing facilities. This chapter presents the application of the incidental waste concept to D&D of unretrievable SST residue. This chapter is divided into two sections: (1) the direct application of the incidental waste concept to the residue and (2) the development of Hanford site-specific Class C limits for use with the incidental waste concept.

4.2 Incidental Waste Criteria

4.2.1 Introduction

Criteria to separate the HLW fraction from the LAW fraction or incidental waste were developed by the AEC/NRC. These "Incidental Waste Criteria" were developed to evaluate waste streams from an HLW treatment facility. In simple terms, the proposed HLW treatment facility would accept an input high-level waste stream on one side and, on the other side of the treatment facility, two output waste streams would emerge: a high-level waste stream for geologic disposal and a LAW or incidental waste stream for onsite disposal. As will be discussed, a SST can be viewed similarly, where the original tank contents represent the input high-level waste stream, with the two output waste streams being the retrieved HLW and the unretrievable residue being the LAW waste stream destined for onsite disposal. The following three sections present the three existing Incidental Waste Criteria written for a HLW treatment facility and describe how these criteria might be interpreted for application to the SST residue.

4.2.2 Technically and Economically Practical

The first criterium for evaluating a proposed waste stream is that

> the HLW has been processed (or will be further processed) to remove key radionuclides to the maximum extent that is technically and economically practical.

Several observations:

(1) this criterium is one of three criteria written to determine if a waste stream can safely remain onsite;
(2) the treatment process(es) must be BOTH technically and economically practical;
(3) this criterium is not quantitative;
(4) "key radionuclides" are not defined; and
(5) this criterium requires a "good faith effort," which is not in itself a standard for protection of human health.

Of the three Incidental Waste Criteria, this first criterium will require little additional scope to complete. Recall the commitment under TPA milestone M-45-00:

> Closure will follow retrieval of as much tank waste *as technically possible*, with tank waste residues not to exceed 360 cubic feet (cu. ft.) in each of the 100 series tanks, 30 cu. ft. in each of the 200 series tanks, *or the limit of waste retrieval technology capability, whichever is less.* If the DOE believes that waste retrieval to these levels is not possible for a tank, then DOE will submit a *detailed explanation* to EPA and Ecology explaining why these levels cannot be achieved, and specifying the quantities of waste that the DOE proposes to leave in the tank. (emphasis added)

Milestone M-45-00 sets a higher standard than the first of the Incidental Waste Criteria. The TPA requires retrieval or separation of as much tank waste as is *technically possible*, whereas the first of the Incidental Waste Criteria requires retrieval of as much waste as is *both technically and economically practical.* Milestone M-45-00 also requires a "detailed explanation" if retrieval operations remove less than 99% of the average volume of the SSTs or the limit of waste retrieval technology capability, whichever is less. Therefore, compliance with the requirements of the TPA should easily satisfy the requirement of the first Incidental Waste Criteria to remove (or retrieve) key radionuclides to the maximum extent that is technically and economically practical. In fact, for some SSTs, compliance with the TPA requirements may exceed technical and economical practicality.

4.2.3 Not To Exceed Class C Limits

The second criterium for evaluating a proposed waste stream is that

> the incidental wastes will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C low-level waste as set out in 10 CFR part 61.

Several observations:

(1) this criterium is one of three criteria written to determine if a waste stream can safely remain onsite;
(2) this criterium is quantitative; and
(3) this criterium sets a standard for protection of an IHI.

Applying this criterium to the SST residue is straightforward: compare the specific activities of radionuclides in the unretrievable residue (the LAW waste stream) to the 10 CFR 61 Class C limits. With NRC agreement, this second test was applied in 1993 to the waste stream proposed for the grout facility (i.e., the test was applied to the LAW fraction combined with grout). The same could also be true for closing an SST; if grout were used to stabilize the residue prior to final closure, the test would be applied to the combination of grout and residue. This approach was recently employed by the SRS for the closure of Tank 20.

4.2.4 Performance Objectives Comparable to 10 CFR 61

The third criterium for evaluating a proposed waste stream is that

> the incidental wastes are to be managed, pursuant to the Atomic Energy Act, so that safety requirements comparable to the performance objectives set out in 10 CFR part 61 are satisfied.

Several observations:

(1) this criterium is one of three criteria written to determine if a waste stream can safely remain onsite;
(2) this criterium is quantitative; and
(3) this criterium sets standards to assure long-term stability of the disposal site and to assure protection of groundwater resources and the MOP.

Applying this criterium to the SST residue requires the assessment of the long-term consequences of the onsite "disposal" of unretrieved residue. 10 CFR 61 is the NRC's standard for disposal of NRC-regulated LLW. 10 CFR 61 is not applicable to disposal of DOE-titled LLW; therefore, the NRC could not ask DOE to follow NRC regulations for disposal of LLW. The NRC asked DOE to provide protection comparable to the NRC's standard for protection of human health from LLW. As noted in Section 3.6.2, the NRC has agreed that the DOE's Order 5820.2A, Chapter III (as interpreted in Mann *et al.*, 1996) is comparable to 10 CFR 61. Therefore, if DOE follows the requirements of DOE Order 5820.2A, Chapter III (as presented by Mann *et al.*, 1996), performance objectives comparable to 10 CFR 61 have been met. The PA analysis required by DOE Order 5820.2A, Chapter III should not be confused with the analysis required for a DOE CA, as discussed in Section 3.3.2.

Two issues that require resolution are identified below. The first issue concerns the time frame of compliance. The previous interpretation of the requirements of DOE Order 5820.2A, Chapter III, is that the time frame of compliance is 10,000 years (Wood *et al.*, 1994, p. 32). This interpretation is in harmony with the NRC requirement for a 10,000-year PA under 10 CFR 61 (NRC, 1997a, p. 3-11). The analysis comparable to 10 CFR 61, which was presented to the NRC in 1996 (Mann *et al.*, 1996), used a 10,000-year time frame. However, recent DOE guidance (DOE, 1996b) sets the time frame of compliance at 1,000 years, as does the current draft of DOE Order 435.1, which is proposed to replace DOE Order 5820.2A. This issue should be discussed with the NRC.

The second issue is related to protection of groundwater resources and the MOP. Recall that demonstrating protection of the IHI is a straightforward comparison of inventory in the SST residue to the NRC's Class C limits. For the Class C limits, the residue in each SST is *evaluated in isolation of other potential sources of contamination.*

Demonstrating protection of the MOP and groundwater resources is not so simple. Multiple sources of contamination could interact to affect groundwater resources and the doses to the future MOP. Two issues should be discussed with the NRC; what is the source term and what is the point of compliance? For example: (1) should the analysis of SST residue only address the radionuclides in the SST residue, assessed at the tank farm boundary (somewhat analogous to a DOE PA under DOE Order 5820.2A); (2) should the analysis include all interacting sources of radiation in a tank farm, assessed at the tank farm boundary; or (3) should the analysis include all interacting sources of radiation from multiple tank farms, assessed at some broader boundary (somewhat analogous to a DOE CA in response to DNFSB 94-2)? These issues touch on a broader topic, which is the need for an integrated approach to regulatory closure of all HLW residue (SST residue, residue in ancillary equipment, and contaminated soil). Developing such an integrated approach to closure is needed, but is beyond the scope of this report.

4.3 Disposal as Incidental Waste

4.3.1 Introduction

The previous section discussed how the Incidental Waste Criteria might be interpreted for application to unretrievable SST residue. This section discusses the mechanics of applying the Incidental Waste Criteria to the SST residue. The format for seeking NRC approval is a "petition." A proposed format for such a petition is presented in the next section. The following section describes some of the analyses which must be complete to support the petition. An example of one required analyses is then presented (i.e, comparing the SST residue to the Class C limits). Finally, a set of potential issues related to direct application of the incidental waste concept is presented in section 4.3.6.

4.3.2 Petition Format

This section presents a proposed format for a petition to the NRC for the SST residue. As noted in Section 3.6.2, the NRC provisionally accepted Hanford's 1996 technical basis for classification of the LAW fraction from the Hanford Site tanks (WHC, 1996a). Therefore, this proposed format is similar to the previously acceptable 1996 format.

Executive Summary

Introduction

Scope
Overview of Report

Background

History of the SSTs
Definition of LLW
Definition of HLW
Discussion of Incidental Waste Concept
Prior Use of Incidental Waste Concept
Interpretation of Incidental Waste Criteria for Application to the SST Residue

Basis for Classifying SST Residue as Incidental Waste

Removal to Extent Technically and Economically Practical
Not To Exceed Class C Limits
Meets Standards Comparable to 10 CFR 61

Conclusion

References

Appendices

This is simply a suggested format; other formats may also be acceptable.

4.3.3 Data Needs

This section identifies data that will be needed to complete a petition to the NRC for a determination that the unretrievable SST residue is incidental waste and not subject to NRC licensing requirements.

Background

History of the SSTs - no new information needed.
Definition of LLW - no new information needed; information exists in this report and in WHC (1996a).
Definition of HLW - no new information needed; information exists in this report and in WHC (1996a).

Discussion of Incidental Waste Concept - no new information needed; information exists in this report.

Prior Use of Incidental Waste Concept - no new information needed; information exists in this report.

Interpretation of Incidental Waste Criteria for Application to SST Residue - information exists in this report; time frame of compliance and interacting source terms should be resolved with the NRC.

Basis for Classifying SST Residue as Incidental Waste

Removal to Extent Technically and Economically Practical - present information generated for TPA MS-45-00; to do this, retrieval operations must be completed or retrieval performance must be assumed.

Not To Exceed Class C Limits - the inventory of radionuclides remaining after retrieval must be determined and compared to the Class C limits; an example of such analysis is presented in the next section.

Meets Standards Comparable to 10 CFR 61 - a LLW PA must be completed, similar to that of Mann *et al*, (1996): (1) retrieval operations must be completed or retrieval performance must be assumed; (2) physical closure operations (e.g., grouting, backfilling, capping) must be completed or assumed; and (3) the time frame of compliance and interacting source-terms issues must be addressed.

4.3.4 Comparison of Tank Contents to Class C Limits

Completion of an incidental waste petition to the NRC will require a number of analyses. One such analysis is to demonstrate that the SST residue does not exceed the NRC's Class C limits. The end-state of wastes remaining after retrieval operations will not be known until retrieval and closure operations are completed. However, the current inventories of wastes in the SSTs can be used as surrogates and compared to the Class C limits. Such a comparison demonstrates how the calculations could be presented to the NRC and also provides insight by comparing the current inventories to the Class C limits. In this section, we present the details of comparing the contents of the four SSTs in the AX Tank Farm to the Class C limits; we then summarize how the current contents of all 149 SSTs compare to the Class C limits.

AX Tank Farm Detailed

The AX Tank Farm consists of four 1,000,000 gallon tanks: AX-101, AX-102, AX-103, and AX-104. Radioactivity (in Ci) for each radionuclide in each tank after 99% retrieval (~360 ft^3 or 10.2 m^3 residual waste) was estimated based on process knowledge, past samples, and model calculations (SGN Eurisys Services Corp., 1997).

Table 2 shows the ratio of the assumed residual sludge concentration to the Class C limits that were listed in Table 1. Also shown in Table 2 are the sums-of-fractions for long-lived and short-lived radionuclides. Because the sum-of-fractions for long-lived radionuclides is greater than one, the residual sludge concentration (before stabilization) exceeds the Class C limits. In the case of Tank 20 at the SRS, which has been grouted for tank closure, a sum of fractions of 174 for long-lived radionuclides in the waste sludge was reported (d'Entremont and Hester, 1997).

Table 2. Ratio of AX Tank Residual Sludge Concentrations to Class C Limits, Assuming 99% Retrieval to Meet Minimum TPA Requirement of 360 ft^3 Residual Waste *

Radionuclide	Tank AX-101	Tank AX-102	Tank AX-103	Tank AX-104
		Long-lived		
C-14	0.0002	0.0013	0.0	0.003
Tc-99	0.0035	0.022	0.0	0.056
I-129	0.00026	0.0016	0.0	0.0041
Alpha emitting transuranic with t1/2 > 5 years				
Np-237	0.0002	0.0014	0.0017	0.002
Pu-238,239, 240**, 242	124	150	73	74
Am-241, 243	19.7	320	0.00056	21
Cm-243 to 247	0.0	2.2	0.04	0.047
Pu-241	1.3	29	0.9	1.1
Cm-242	0.000083	0.0021	0.000083	0.000098
Sum-of-fractions for long-lived nuclide * **	**144**	**497**	**74**	**96**
		Short-lived		
Ni-63	0.02	0.0072	0.0	0.017
Sr-90	9.9	0.84	7.4	7.4
Cs-137	0.3	0.18	0.23	0.23
Sum-of-fractions for short-lived nuclide * **	**10**	**1**	**8**	**8**

* Ratio = (tank residual sludge concentration)/(Class C concentration)
** The higher activity between Pu-239/240 and the sum of Pu-239 and Pu-240 was used.
*** The small differences between the "sum-of-fractions" and the sums of the fraction for each radionuclide in the table were the result of rounding errors.

The current, best-basis inventory in all four SSTs in the AX Tank Farm exceed the Class C limits for long-lived radionuclides. Three of the four tanks also exceed the Class C limits for short-lived radionuclides.

Comparison Between Current Contents of All 149 SSTs and Class C Limits

Table 2 focused on the four SSTs in the AX Tank. Table 3 summarizes a comparison between the Class C limits and the current inventory predicted by the Hanford Derived Waste (HDW) model (Agnew, 1997), assuming 99% retrieval to meet minimum TPA requirements. Details of the analysis are presented in Appendix F.

Table 3. Comparison Between Current Inventory and Class C Limits Assuming 99% Retrieval to Meet Minimum TPA Requirements

Tank Farm	Number of Tanks	% Meeting NRC Class C Limits
A	6	0
AX	4	0
B	16	69
BX	12	67
BY	12	83
C	16	13
S	12	0
SX	15	13
U	16	44
T	16	75
TX	18	83
TY	6	100
Total	**149**	**49%**

Based on the preretrieval inventory, 49% of the SSTs meet the Class C limits. In the next section, we discuss how further treatment of the SST residue by grouting will decrease the number of tanks that exceed the Class C limits.

4.3.5 Use of Best-Basis Inventory

Regulatory requirements for waste characterization at the Hanford Site are described in the TPA. The criteria for chemical and radiological analysis are based on quality assurance requirements, as defined in Article XXXI of the TPA Consent Order:

> *Quality Assurance*: Throughout all sample collection, preservation, transportation, and analyses activities required to implement this Agreement, DOE shall use procedures for quality assurance (QA), and for quality control (QC), in accordance with approved EPA methods, including subsequent amendments to such procedures. The DOE shall use methods and analytical protocols for the parameters of concern in the media of interest with detection and quantification limits in accordance with *both* QA/QC procedures and data quality objectives approved in the work plan, RCRA closure plan *or* RCRA permit. The lead regulatory agency may require that DOE submit detailed information to demonstrate that any of its laboratories are qualified to conduct the work. The DOE shall assure that the lead regulatory agency (including contractor personnel) has access to laboratory personnel, equipment and records related to sample collection, transportation, and analysis.

However, as specified in Sections 6.5 and 7.8 of the TPA Action Plan:

> The level of quality assurance and quality control (QA/QC) for the collection, preservation, transportation, and analysis of each sample which is required for implementation of this Agreement shall be dependent upon the data quality objectives of the sample and shall range from those necessary for non-laboratory field-screening activities to those necessary to support a comprehensive laboratory analysis that will be used in final decision-making.

The data quality objectives (DQOs) are established in specific work plans for various phases of waste tank remediation and closure. One required work plan is the "Closure Work Plan."

The TPA *per se* does not prevent the use of the best-basis waste tank inventory estimates, which are based on a combination of process knowledge and historical records (Agnew, 1997). Analytical requirements for a given activity are to be defined for that activity using the DQO process. In reviewing the closure of SRS's Tanks 17 and 20, the NRC is interested in actual analytical data (see Section IA of Appendix E).

4.3.6 Stabilization Using Grout and the Class C Limits

In-tank grouting is one of the options being considered for stabilizing any residue which may remain after retrieval operations. In the late 1980s, the NRC approved disposal of the LAW fraction from the HLW treatment facility as grout. For grouted waste, the concentration of the combined residue and sludge may be taken into account in estimating the solidified waste concentration (d'Entremont and Hester, 1997; NRC, 1995).

The process used by the SRS to solidify the residual tank waste in Tank 20 was described in Shyr and Bustard (June 1997). In the case of Tank 20 (with a diameter of 85 feet), about 7 inches of grout were required to allow the solidified waste to be lower than the Class C limits (d'Entremont and Hester, 1997). If that same *volume* of grout were used to stabilize a Hanford SST (with a diameter of 75 feet), the depth of the grout would be about 10 inches.

In the NRC guidance document on concentration averaging (NRC, January 1995), the technical bases for waste mixing and averaging, concentration estimation for waste disposal using high-integrity containers, and alternative provisions for waste averaging were discussed. The extent to which grout averaging can be applied to tank closure may soon be determined by the NRC, as the NRC is currently reviewing the closure of Tank 20 using grout as a stabilizing agent.

Appendix F presents a detailed description of the comparison between the NRC's Class C limits and the current inventory in the SSTs: (1) assuming the mixing of the residue with 10 inches of grout and (2) assuming a pregrout residual volume of 360 ft^3 in each of the 100-series tanks and 30 ft^3 in each of the 200-series tanks.

Table 4. Comparison Between Current Inventory and Class C Limits, Assuming 99% Retrieval to Meet Minimum TPA Requirements and 10 Inches of Grout

Tank Farm	Number of Tanks	% Meeting NRC Class C Limits	% Meeting Class C with 10" Grout
A	6	0	33
AX	4	0	0
B	16	69	94
BX	12	67	83
BY	12	83	100
C	16	13	75
S	12	0	92
SX	15	13	100
U	16	44	94
T	16	75	81
TX	18	83	94
TY	6	100	100
Total	**149**	**49%**	**86%**

This table shows that only 15% of the SSTs would require more than 10 inches of grout to meet the Class C limits. It is also evident from Table 4 that the tanks in the AX Tank Farm present the greatest challenge in meeting the Class C limits. A detailed evaluation of the amount of grout necessary to meet the Class C limits for the AX tanks is presented below.

AX Tank Solidified Waste Radionuclide Concentration

Table 5 shows the inches of grout required for the AX tanks so that the averaged solidified waste concentration will be lower than the Class C limits, assuming an average residual volume of 360 ft^3 in the 75 foot in diameter SSTs and 30 ft^3 in the 20 foot in diameter SSTs (i.e., 99% retrieval). This calculation was performed to facilitate the understanding of the AX tank characteristics. The extent of the applicability of such a grout-averaging approach may be determined by the DOE in conjunction with appropriate stakeholders. In the case of Tank 20 (with a diameter of 85 feet) at the SRS, about 7 inches of grout were required to allow the solidified waste to be lower than the Class C limits (this same volume would translate into approximately 10 inches of grout in a Hanford SST with a diameter of 75 feet).

Note that the estimation of "inches of grout required in a tank" depends on the number of inches of the residual waste in a tank and the concentration of the residue. In the case of SRS Tank 20, the residual waste depth was about 1/4 inch (about 1,000 gallons) (d'Entremont and Hester, 1997).

Table 5. Inches of Grout Needed for Solidified Waste to Meet Class C Limits, Assuming 99% Retrieval to Meet Minimum TPA Requirement of 360 ft^3 Residual Waste *

	AX-101	AX-102	AX-103	AX-104
Inches of grout to allow grouted sludge concentration to be lower than Class C	95	305	51.5	67
Long-Lived Radionuclides				
C-14	2.0E-06	4.0E-06	0.0E+00	4.3E-05
Tc-99	3.6E-05	7.0E-05	0.0E+00	8.1E-04
I-1 29	2.6E-06	5.1E-06	0.0E+00	5.9E-05
Alpha emitting transuranic with t1/2 > 5 years				
Np-237	1.4E-06	2.7E-06	2.3E-05	2.1 E-05
Pu-238,239, 240**, 242	8.5E-01	3.0E-01	9.9E-01	7.6E-01
Am-241, 243	1.4E-01	6.4E-01	7.5E-06	2.2E-01
Cm-243 to 247	0.0E+00	4.4E-03	5.4E-04	4.9E-04
Pu-241	9.1E-03	5.8E-02	1.2E-02	1.1E-02
Cm-242	5.7E-07	4.2E-06	1.1E-06	1.0E-06

Table 5. Inches of Grout Needed for Solidified Waste to Meet Class C Limits, Assuming 99% Retrieval to Meet Minimum TPA Requirement of 360 ft^3 Residual Waste *

	AX-101	AX-102	AX-103	AX-104
Pu-241	9.1E-03	5.8E-02	1.2E-02	1.1E-02
Cm-242	5.7E-07	4.2E-06	1.1E-06	1.0E-06
		Short-Lived Radionuclides		
Ni-63	2.0E-04	2.3E-05	0.0E+00	2.4E-04
Sr-90	1.0E-01	2.7E-03	1.4E-01	1.1E-01
Cs-137	3.1E-03	5.6E-04	4.3E-03	3.3E-03
Sum-of-fractions for short-lived ***	**0.10**	**0.00**	**0.14**	**0.11**

* Assuming 360 ft^3 equals 1 inch in the tank bottom
** The higher activity between Pu-239/240 and the sum of Pu-239 and Pu-240 was used.
*** The small differences between the "sum-of-fractions" and the sums of the fraction for each radionuclide in the table were the result of rounding errors.

The preliminary estimates described in Tables 2 through 5 are based on current inventory data projected using process-knowledge-based models and/or very limited past samples. If the current inventory is correct, then waste retrieval (e.g., sluicing) should reduce both the volume of the residue and the concentration of radionuclides remaining in the residue. The concentrations of radionuclides that may be present in the residue after retrieval could be significantly lower and calculations for the petition should be based on the actual inventory at the time of closure.

Based on assumptions presented, 85% of all SSTs will meet the Class C limits with the use of 10 inches of grout. However, a few tanks will require very significant volumes of grout (up to 305 inches or 25 feet) to meet the Class C limits.

4.3.7 Issues

So far in this chapter, we have discussed: (1) how the Incidental Waste Criteria might be interpreted for application to the SST residue; (2) the format and data needs for an incidental waste petition to the NRC; and (3) a comparison of the existing tank contents to the Class C limits, both before and after stabilization with grout. This section summarizes some of the issues related to the closure of the SST residue as incidental waste.

The outcome of the NRC review of the closure of SRS's Tanks 17 and 20 could have a significant bearing on the closure of the SSTs at Hanford, and this issue should be closely monitored.

In 1993, the NRC noted that, "there was no fundamental challenge to the concept of incidental wastes" (58 FR 12343). However, some stakeholders still question the concept of incidental waste because incidental waste is defined by policy and not by rule. This issue should be discussed with the NRC.

Much of this report focuses on the NRC's Class C limits. However, the ability to comply with the third criterum (meeting safety standards comparable to 10 CFR 61) should be assessed simultaneously. Meeting safety standards comparable to 10 CFR 61 is linked to: (1) a 1,000 or 10,000-year, 25 mrem/year dose standard to protect the hypothetical MOP, and (2) a 1,000 or 10,000-year standard to protect groundwater resources. Two known issues should be discussed with the NRC prior to performing the 5820.2A PA: (1) whether or not the PA should address only the contents of an individual tank or all interacting source terms and (2) the time frame of compliance.

Based on 99% retrieval and 10 inches of grout (and other assumptions presented), 86% of all SSTs meet the Class C limits. However, 21 tanks (14%) may fail to meet Class C limits and another closure strategy maybe needed for those 21 tanks.

The NRC regulates the disposal of HLW, and the NRC is the regulator that determines if a particular LAW waste stream is HLW or incidental waste. DOE and the NRC may want to formalize a working agreement to provide the NRC with the resources necessary provide a timely resolution of closure issues. One option for a working agreement would be for the NRC to become a party to the TPA, or, as another option, the DOE and NRC could enter into an MOU. At the SRS, the DOE and NRC work together under the terms of an MOU.

Any SST residue which is not retrievable will be mixed waste. Therefore, closure of the hazardous component and closure of the radioactive component are interrelated. Under the terms of the TPA, Ecology has the lead for closure of the tank farms under Washington's dangerous waste regulations; therefore, the disposition of the unretrievable SST residue requires Ecology's approval. The role that Ecology (and EPA?) will play in closing the radioactive component is unclear. At a minimum, Ecology (and EPA?) should continue to be informed of closure actions for the radioactive component of the SSTs so that they can be satisfied that NRC and DOE actions are protective of human health.

Closure of an entire tank farm, or operable unit (or groups of operable units) will be addressed by a single closure plan. This means that under the TPA, the SSTs, any unretrievable waste in the SSTs, contaminated soil, and ancillary equipment will be addressed simultaneously. Although it is beyond the scope of this report, a single closure strategy is necessary to address the HLW residue remaining in the SSTs, the ancillary equipment, and soil at the time of closure (a preliminary, integrated closure strategy is presented in section 5.4 of Cochran and Shyr, 1998).

Because of the lack of information regarding past tank leaks, retrieval technologies, and closure technologies, previous NEPA activities did not address closure of the SSTs. Prior to selecting a final closure option for the SSTs, DOE must prepare a NEPA analysis of SST closure options. Regulatory closure options cannot be finalized until the safety analyses (e.g., protection of the MOP, IHI, and groundwater resources) are completed and these analyses cannot be completed until the retrieval and closure "end-state" is known or assumed.

Strengths of Closure as Incidental Waste

Demonstrating that the residue is incidental waste and not HLW means that no HLW would be disposed onsite. Onsite disposal of HLW is of concern to many stakeholders.

Closure as incidental waste would not require rule making or amending existing regulations.

The incidental waste concept has been successfully used at Hanford in the recent past to separate HLW from the LAW fraction destined for onsite disposal. Although the criteria were developed for evaluating waste streams from a HLW treatment facility, the criteria could also be applied to the Hanford SST residue.

4.4 Disposal as Incidental Waste, Site-Specific Class C Limits

4.4.1 Introduction

Closure of the SST residue as incidental waste is an excellent closure option for the radioactive component of the unretrievable residue, if the residue meets (or can be further treated to meet) the Incidental Waste Criteria. This path is defined, acceptable, and has been used recently at Hanford.

However, based on the analysis presented in the previous section, some SSTs may require stabilization with large volumes of grout (upto 25 feet) to meet the Class C limits. This section describes closure of the SST residue using the incidental waste concept and Hanford site-specific Class C limits. The NRC, under 10 CFR 61.58, allows an NRC-regulated facility to petition the Commissioners to establish site-specific Class C limits. DOE LLW PAs across the United States have developed site-specific limits that protect the IHI. Deriving site-specific Class C limits for Hanford SST residue would be no different, except that the analysis may have to be presented in the format that the NRC used to develop the existing Class C limits.

As with the previous closure option, the NRC would be the regulator. First, the NRC would determine if the proposed site-specific Class C limits protect the IHI; then the NRC would determine if the residue meets the Incidental Waste Criteria.

4.4.2 Development of Site-Specific Class C Limits

To develop Hanford site-specific Class C limits, we studied the NRC intrusion models and parameters used to derive the 10 CFR 61 Class C limits and then proposed changes in model parameter values based on Hanford-specific characteristics. No changes were made to the conceptual model or the performance objectives (i.e., the dose limits).

Appendix A shows the proposed values and the technical basis for these proposed values for site-specific Class C limits. To aid in selecting appropriate values for Hanford tank-specific applications, we also evaluated the intrusion model and scenarios used in PA for the Hanford

Low-Level Burial Ground (LLBG). Table G-1 in Appendix G shows the comparisons between the LLBG and NRC intrusion models, exposure pathways, and exposure scenarios. The differences and implications of the LLBG model on the tank-specific Class C limits are stated in the table. The tables in Appendix A show some of the differences in parameter values between LLBG and NRC models. Most of the parameters cannot be compared directly because the models were constructed somewhat differently. However, it can be stated that the NRC and LLBG models are not inconsistent.

This comparative study (Appendices A and G) was not intended to be comprehensive, and was to identify relevant information to be considered in developing site-specific parameter values for the NRC Class C intrusion model. Importantly, this proposed, site-specific derivation of the Class C limits was made using the same conceptual model and performance objectives as the NRC used to derive the 10 CFR 61 Class C limits.

As an illustration of the site-specific Class C approach to the Hanford SSTs, we derived Hanford tank-specific Class C limits for Pu-239 and Am-241. The derived Hanford tank-specific Class C limit is about 1700 times higher than the generic limit for Pu-239 and is about 40 times higher than the generic limit for Am-241. The derivation of these values is detailed in Appendix A.

The increase in the Pu-239 limit was due mainly to the change in the values for dispersibility and site-specific environmental parameters (Table A-2 in Appendix A). The same magnitude change was not reflected in the Am-241 limit, because external gamma irradiation has become the dominant exposure pathway for Am-241 (as opposed to the inhalation pathway due to the lowered dispersibility). Table 4 shows Pu-239/240 and Am-241 Class C compliance status for AX tanks when Hanford tank-specific values were used. These ratios demonstrated that when Hanford tank-specific parameter values are considered, problematic radionuclides in AX tanks are likely to meet the Class C performance objectives (i.e., dose limits) for the protection of the IHI.

Table 6. Ratio Of AX Tank Pu-239, Am-241, and Sr-90 Residual Sludge Concentration to Hanford Tank-Specific Limits*

Radionuclide	AX-101	AX-102	AX-103	AX-104
Pu-239/240**	2.0E-01	7.9E-02	4.3E-02	4.3E-02
Am-241	1.3E+00	7.7E+00	0.0E+00	5.2E-01
Sr-90	1.3E-01	3.9E-03	3.4E-02	3.4E-02

*Ratio = (tank residual sludge concentration for 360 ft^3 residual waste)/(Hanford tank-specific Class C limit)

** The use of Pu-239 tank-specific Class C limit for Pu-240 is conservative because of the shorter half-life of Pu-240

4.4.3 Petition to the NRC

The format for a petition to the NRC would follow the format used for incidental waste petition, except for the additions of a new chapter (and probably some appendices). The new chapter would be inserted above the chapter titled "Basis for Classifying SST Residue as Incidental Waste" and might have the following subheadings:

Justification for Site-Specific Class C Limits

Review of the Models and Parameters Used for the 10 CFR 61 Class C Limits
Hanford Site-Specific Parameters, Presentation, and Defense
Hanford Site-Specific Class C Limits

The authors are unaware of NRC accepting a site-specific Class C analysis. Therefore, DOE would have to work with NRC staff to develop a one-of-a-kind petition.

4.4.4 Issues

There are a number of issues related to the use of the Hanford site-specific Class C limits and the incidental waste concept to close the unretrievable SST residue. Many of those issues are the same as those associated with closure using the NRC's standard Class C limits and are not repeated here (see section 4.3.6). This section presents issues unique to the use of site-specific Class C limits.

Under the EPA's definition of TRU waste (40 CFR 191.02(i)), the NRC has the authority to approve disposal of wastes exceeding 100 nCi/g of TRU radionuclides on a case-by-case basis in accordance with 10 CFR 61. The NRC's ability to apply this authority to DOE-titled wastes should be thoroughly analyzed.

Acceptance of a site-specific Class C limit could have ramifications broader than the Hanford Tank Farms. For example, other NRC-licensed facilities might desire to negotiate their own site-specific limits, which could reopen discussion on the basis of the NRC's 10 CFR 61 Class limits.

The authors are not aware of NRC accepting a site-specific Class C analysis. Therefore, DOE would have to work with NRC staff to develop a one-of-a-kind petition. This may or may not be a big disadvantage. Possibly no NRC-licensed facility has petitioned the NRC in the past is because 99% of all commercial LLW is Class C or less (52 FR 5999).

The TPA commitment to "retrieval of as much tank waste *as technically possible*" will require a more detailed defense than would be required if the residue had met the existing Class C limits. The additional defense may be necessary to refute the concern that there would be no need to develop site-specific Class C limits if more wastes had been retrieved originally.

The development of site-specific Class C limits could be viewed by stakeholders as an attempt to leave waste onsite that historically has been unacceptable for shallow land burial based on existing Class C limits (Fioravanti, and Makhijani, 1997).

Strengths of Closure as Incidental Waste

DOE LLW PAs have always developed site-specific disposal limits that protect the IHI. Deriving site-specific Class C limits for Hanford SST residue would be no different, except that the analysis may have to be presented in the format that the NRC used for developing the existing Class C limits.

For all 149 SSTs, the combination of grout stabilization and site-specific Class C limits should allow for the in-place closure of any unretrievable residue.

Demonstrating that the residue is incidental waste and not HLW means that no HLW would be disposed onsite. Onsite disposal of HLW is of concern to many stakeholders.

This closure option would not require rule making, or amending existing regulations.

The incidental waste concept has been successfully used at Hanford in the recent past to separate HLW from the LAW fraction destined for onsite disposal. Although the criteria were developed for evaluating waste streams from a HLW treatment facility, the criteria could also be applied to the Hanford SST residue.

4.5 Summary

This Chapter presented procedures for using the NRC's incidental waste concept to close the radioactive component of any unretrievable SST residue. If the NRC agrees that the SST residue is incidental waste, then the residue can be safely disposed onsite without a license from the NRC.

The Incidental Waste Criteria were written for an HLW treatment facility and the authors interpreted the criteria for application to the SST residue. Application of the Criteria to the residue will be through a petition to the NRC. A proposed format for such a petition was presented, as was a list of the analyses which must be completed to support the petition. A set of potential issues related to direct application of the incidental waste concept was also presented.

An example of one analysis required for a petition was detailed (i.e, comparing the SST residue to the Class C limits). The current concentrations of wastes in the SSTs were used as surrogates for the end-state wastes and compared to the Class C limits. The details of comparing the contents of the four SSTs in the AX Tank Farm to the Class C limits were presented and how the current contents of all 149 SSTs compare to the Class C limits were summarized.

Based on the Class C analysis, some SSTs may require stabilization with large volumes of grout to meet the Class C limits. The NRC, under 10 CFR 61.58, allows an NRC-regulated facility to petition the NRC to establish site-specific Class C limits. The technical details and defense of developing Hanford site-specific Class C limits were then described. A list of potential issues related to the development of site-specific Class C limits was also presented. Some of the potential issues are significant, and if closure using the site-specific Class C limits and the incidental waste concept is not desirable or not possible, the next chapter presents a set of alternative closure options.

5.0 OTHER REGULATORY CLOSURE OPTIONS

5.1 Introduction

In Chapter 4 we provided detailed procedures for closing the SST residue as incidental waste, both under the existing NRC Class C limits and under site-specific Class C limits. We also identified some significant issues related to the use of the incidental waste concept to closure of the SST residue. It is possible that some of the issues will be significant enough to prevent closure using the incidental waste concept. This chapter presents alternative closure options, assuming that closure as incidental waste is not feasible.

Some possible end-states are unique; that is, there are no existing regulatory precedences. For example, there is no regulatory precedent for managing *unretrievable* HLW in a shallow land burial configuration. To proceed past this difficulty, unique closure options are offered. Rather than inventing closure options, these unique closure options are "extensions" of existing regulatory closure options. Four closure options are presented in this section:

- Dispose as GTCC-Equivalent LLW;
- Disposal as HLW, Three Interpretations;
- Decontamination and Decommissioning; and
- Cleanup under CERCLA using "Risk Balancing."

The development of these alternative closure options involves three issues:

- the classification of the residue;
- the standard(s) for long-term closure; and
- the identification of the regulator(s).

Each of the four closure options is discussed in light of these three issues.

<u>Risk Balancing</u>

The term "risk balancing" is used to describe two of these closure options. What is risk balancing and why is this concept potentially important? The mixed HLW stored in the 149 SSTs represents a hazard. To remove, treat, transport, and dispose of these wastes will result in risks to workers engaged in heavy construction activities, with the associated radiation risks, transportation risks, and risks from the redisposed wastes. To leave the wastes in place with no further action will result in long-term risks to the general public and the further degradation of natural resources. Given the existing situation, we cannot proceed without incurring risks.

Risk balancing is the term applied to the process of assessing and managing risk tradeoffs. Risk balancing is not necessary in most situations, because compliance with existing regulations can be accomplished with minimal risk. However, closure of the SST residue may represent a unique closure problem, one that was not envisioned by the authors of existing regulations.

The concept of risk balancing will be important if compliance with existing regulations will result in great risk to onsite workers and great expense to the nation. Risk balancing is easier to describe than implement, and is only viable if all major parties agree that compliance with existing regulations cannot be achieved without great risk to workers and at great expense.

Ultimately, the most important function of this chapter is to stimulate discussion. Through additional discussions, and through the NEPA closure process, the final closure criteria will ultimately be developed.

5.2 Disposal vs. Cleanup

For closure of the SST residue, disposal and cleanup are terms that are linked to different regulations. Disposal regulations are written for waste "emplacement." Cleanup regulations are written for wastes that have already been "released" to the environment (see the Definitions section). For example, emplacement of waste acetone in a disposal facility would require compliance with regulations for disposal. On the other hand, the cleanup of an old paint shop with acetone-contaminated soil would require compliance with cleanup regulations. The actual concentrations of acetone may be very similar in these two situations, but the regulations and regulatory agencies governing them could be very different, because one regulation is written to define current practice and the other regulation is written to correct problems from past practices. As another example, DOE self-regulates disposal of DOE-titled LLW; however, under CERCLA, EPA regulates cleanup of DOE LLW that has been released to the environment.

With respect to the SSTs, the residue in the SSTs is currently in storage and the waste does not appear to be released to the environment. If waste remains after final closure, then final closure may constitute disposal, not cleanup.

However, if the residue in the SSTs is unrecoverable, then the residue has already been released to the environment and thus the current situation only appears to be storage. In reality, the waste has already been released (i.e., it is unrecoverable). This interpretation suggests that cleanup standards rather than disposal standards could be applied to tank closure. Several of the proposed closure options are based on standards written for cleanup (e.g., cleanup under CERCLA).

Each of the four closure options is presented in a standard format, beginning with the use of the Incidental Waste Criteria.

5.3 Disposal as GTCC-Equivalent LLW

Overview

This closure option is offered for end-states that exceed the NRC's Class C limits. This option proposes a closure standard that is unique, i.e., without regulatory precedence. In simple terms, the residue would be managed as if the residue were commercially-generated GTCC LLW. This option acknowledges an end-state with characteristics between those of LLW and HLW.

The NRC would determine if the residue meets the Incidental Waste Criteria. The NRC would use some boundary other than the existing Class C boundary. For example, if the residue did not exceed 100 or 1,000 times the Class C limits, the residue might be suitable for onsite disposal (with the incorporation of additional safety features). Because the waste form would be above the Class C limits (i.e., GTCC LLW), the NRC could serve as the regulator for onsite disposal.

Waste Classification

If the LAW residue meets the Incidental Waste Criteria (using 100 or 1,000 times the current Class C limit, for example), the waste would be managed as LLW.

Standard for Long-Term Closure

The NRC has suggested that 10 CFR 61 could be used to regulate non-repository disposal of commercially-generated GTCC LLW (54 FR 22578); therefore, 10 CFR 61 could be used as the standard for the closure of the SST residue.

Regulator(s)

For this unique closure option, the NRC would license the onsite disposal as if the waste were commercially-generated GTCC LLW.

Discussion

The major strength of this option is the retention of the NRC as an external regulator for the onsite disposal of waste that does not have the characteristics of normal LLW (i.e., it clearly exceeds the Class C limits).

The residue in the bottom of a SST is typically *56.1 feet* below the land surface, which provides isolation of the wastes from most IHI activities (except inadvertently drilling a water well through the wastes and bringing the wastes to the surface in the cuttings.)

This regulatory option is offered for an end-state in which the residue exceeds NRC Class C limits. The residue would be managed on site, recognizing that the residue requires greater isolation than typically required for disposal of LLW. The NRC is responsible for licensing the DOE disposal of commercially-generated GTCC LLWs. This closure option would extend that framework to the closure of the SST residue, with the NRC licensing the closure of the residue as if the wastes were commercially-generated GTCC LLWs.

Selection of this option would clearly require closure of the SST residue using techniques that are more stringent than those normally used for shallow land burial of LLW.

The onsite disposal of GTCC-equivalent LLW should be coordinated with the DOE's program for disposal of commercially-generated GTCC LLW (Mr. Terry Plummer at DOE/HQ/EM-35).

Under the current terms of the TPA, Ecology is the lead agency for closure of the tank farms. The NRC is not a party to the TPA. For the NRC to license the onsite disposal of GTCC-equivalent LLW would probably require renegotiation of the TPA to include the NRC (i.e., the Quad-Party Agreement).

Advantages

A strength of this option is the retention of the NRC as an external regulator for the onsite disposal of waste that does not have the characteristics of normal LLW (i.e., it clearly exceeds the Class C limits). Stakeholders might be more comfortable with onsite disposal of GTCC-equivalent LLW if the NRC serves as an external regulator.

Even if the sum of the TRU radionuclides exceeds 100 nCi/g, the waste may not be classified as TRU wastes because " ... (3) wastes that the NRC has approved for disposal on a case-by-case basis in accordance with 10 CFR 61 ..." may be exempt from the definition of TRU wastes (see the definition of TRU waste in the Definitions section).

Demonstrating that the residue is incidental waste and not HLW means that no HLW would be disposed onsite. Onsite disposal of HLW is of concern to many stakeholders.

Disposal of GTCC wastes in a near-surface facility could be acceptable to the NRC: "There may be some instances where waste with concentrations greater than permitted for Class C would be acceptable for near-surface disposal with special processing or design" (10 CFR 61.7(b)(5)).

Disadvantages

The NRC has licensing authority over disposal of DOE HLW and licensing authority over DOE disposal of commercially-generated GTCC LLW, but the NRC has no licensing authority for disposal of DOE LLW, including defense LLW that might be analogous to GTCC LLW. Therefore, the Energy Reorganization Act would need to amended for the NRC to regulate the onsite disposal of this Hanford waste. Amending the Energy Reorganization Act would be difficult.

For this closure option, the NRC would use some boundary other than the existing Class C limits to determine if the LAW residue meets the Incidental Waste Criteria. This report suggests that the NRC could use 100 or 1,000 times the Class C limits; however, the exact boundary would need to be determined.

Demonstrating that "key radionuclides have been removed to the maximum extent that is technically and economically practical" will require a more detailed defense than would be required if the residue had met the existing Class C limits. The additional defense may be necessary to refute the concern that there would be no need to dispose of GTCC-equivalent LLW on site if more wastes had been retrieved initially. A methodology for evaluating this criterium should be developed and shared with Ecology, the NRC, and other stakeholders.

No facilities have ever been licensed for disposal of GTCC LLW; therefore, this option would require implementation of many one-of-a-kind activities.

The NRC's "default" option for disposal of GTCC LLW is a geologic repository. The NRC's 10 CFR 61 specifically states that GTCC wastes are wastes

> ... for which form and disposal methods must be different, and in general more stringent than those specified for Class C wastes. In the absence of special requirements in this part, such waste must be disposed in a geologic repository as defined in part 60 of this chapter, unless proposals for disposal of such waste in a disposal site licensed pursuant to this part are approved by the Commission.

Onsite disposal of GTCC-equivalent LLW could be viewed by stakeholders as an attempt to leave waste on site that historically has been unacceptable for shallow land burial.

5.4 Disposal as HLW

The following three closure options are proposed for an end-state where the unretrievable residue is clearly HLW and where the HLW cannot be further treated during closure to change the classification. Two of these closure options are presented because it is unclear if the NWPA applies to the disposal of HLW at the Hanford Site. The third closure option is presented to highlight a clause in the EPA's standard for disposal of HLW which could accommodate "risk balancing."

The NWPA establishes the national program for the disposal of SNF and HLW. The NWPA sets a number of administrative requirements for the selection, characterization, and licensing of a repository for SNF and HLW. The NWPA probably would not apply to the disposal HLW at Hanford. Closure options 5.4 (A) and 5.4 (C) discuss closure of tank residue as HLW, assuming the NWPA *does not apply*. Closure option 5.4 (B) discusses closure of tank residue as HLW, assuming the NWPA *does apply*. Table 7 clarifies some of the macro-issues associated with the applicability of the NWPA to disposal of HLW at Hanford.

Under the terms of the TPA, Ecology has the lead for closure of the tank farms. As defined in Chapter 5 of the TPA Action Plan, regulatory authority shall remain with the regulatory agency having legal authority for those decisions, regardless of whether that agency is the lead regulatory agency for the work. The disposition of the SST residue will not occur without Ecology's approval. The role that Ecology (and EPA) play in classifying the SST residue is unclear. At a minimum, Ecology and EPA should continue to be informed of closure actions for the radioactive component of the SSTs so that they can be satisfied that NRC and DOE actions are protective of human health.

Table 7. Macro-Issues Associated with the NWPA

Issue	NWPA applies	NWPA does not apply
EPA standard for disposal	no EPA standard available; must amend 40 CFR 191 or write new standard	existing 40 CFR 191 applies; EPA needs to promulgate groundwater requirement
NRC standard for licensing	existing 10 CFR 60 applies, but not good fit, written for site search, deep repository, containerized waste ...	no NRC standard available; must amend 10 CFR 60 or write new standard
Disposal authorized under 113(a) of NWPA	not authorized; Congress must amend NWPA	not required
Other issues	significant administrative requirements set by NWPA and onsite disposal may not be "deep geologic disposal" as required by NWPA	many believe the NWPA does apply to HLW disposal at Hanford; court action likely

5.4 (A) Disposal as HLW, NWPA Does Not Apply

Overview

This closure option is offered for end-states in which the residue is clearly HLW and the HLW cannot be further treated during closure to change the classification. Under this closure option, the residue would be disposed *in situ* as HLW under regulations written for (or regulations to be written for) the disposal of HLW. This option assumes that the provisions of the NWPA do not apply.

Waste Classification

The waste would be disposed as HLW.

Standard for Long-Term Closure

(1) The EPA's 40 CFR 191 sets disposal requirements (The EPA needs to promulgate groundwater protection requirement for disposal systems within 1/4 mile of a USDW); (2) the NRC's 10 CFR 60 licensing requirements do not apply (the NRC would need to amend 10 CFR 60 or write new licensing requirements); and (3) DOE Order 5820.2A.

Regulator(s)

(1) The regulator that certifies compliance with 40 CFR 191 is not clear; (2) The NRC would license the disposal facility; (3) Ecology's role is unclear (see discussion below).

Discussion

In some ways, this is a straightforward option; if the residue has the characteristics of HLW, then HLW disposal standards apply.

Unfortunately, implementation of this option will not be straightforward. Not only is disposal of HLW at Hanford a sensitive topic, the EPA and NRC regulations must be amended and/or new regulations must be promulgated to accommodate disposal of HLW at Hanford.

Any SST residue which is not retrievable will be mixed HLW, not just HLW. Therefore, closure of the hazardous component and closure of the radioactive component are interrelated. Under the terms of the TPA, Ecology has the lead for closure of the tank farms under Washington's dangerous waste regulations; therefore, the disposition of the unretrievable SST residue requires Ecology's approval. The role that Ecology (and EPA?) will play in closing the radioactive component is unclear.

Under the current terms of the TPA, Ecology is the lead agency for closure of the tank farms. The NRC is not a party to the TPA. For the NRC to license the onsite disposal of HLW would probably require renegotiation of the TPA to include the NRC (i.e., the Quad-Party Agreement).

Advantages

Defining the boundary between HLW and incidental waste will not be necessary.

The EPA's disposal standard (40 CFR 191) is risk-based and does not contain dose-based IHI protection requirements (see discussion of differences between standards for disposal of HLW and LLW in Appendix B).

Disadvantages

This option could trigger court action. Many believe that the NWPA applies to the disposal of all HLW.

Onsite disposal of HLW could be poorly received by Ecology, stakeholders, and others.

The NRC needs to promulgate a 10 CFR 60 equivalent standard for a non-NWPA disposal site. One option would be to amend the "applicability" section of the existing 10 CFR 60 so that the existing version of 10 CFR 60 could be applied to Hanford. However, the assumption that permeates the existing 10 CFR 60 is that HLW will be disposed as glass, in canisters, in a deep geologic repository, and disposal of SST residue may not meet 10 CFR 60 requirements. Writing a site-specific 10 CFR 60-equivalent regulation for Hanford could be controversial and difficult.

This option may place a significant burden on the NRC to develop a 10 CFR 60 equivalent licensing standard for Hanford.

Onsite disposal of HLW at Hanford will be difficult. Although the DOE has maintained for a decade that onsite disposal of HLW at Hanford may be viable, this option runs counter to the philosophies of many laws and stakeholders. If onsite disposal is to be pursued, the DOE should establish a working group that involves NRC, EPA, Ecology, and the DOE's Office of Civilian Radioactive Waste Management to explore the issues associated with onsite disposal of HLW. Once the issues are better defined, others (Congress, the State governor, the State legislature, the public, etc.) should be informed of the issues and involved in the subsequent decision-making process.

Under 40 CFR 191, the EPA needs to promulgate groundwater protection requirements for disposal systems within 1/4 mile of an USDW, and this could be time-consuming and controversial (because the standard would really be a Hanford-specific standard).

5.4 (B) Disposal as HLW, NWPA Applies

Overview

This closure option is offered for end-states in which the residue is clearly HLW and the HLW cannot be further treated during closure to change the classification. Under this closure option, the residue would be disposed *in situ* as HLW under regulations written (or regulations to be written) for the disposal of HLW. This option assumes that the provisions of the NWPA apply.

Waste Classification

The waste would be disposed as HLW.

Standard for Long-Term Closure (1) The EPA will need to promulgate a 40 CFR 191-equivalent standard for Hanford; (2) The NRC's 10 CFR 60 licensing requirements apply; (3) The NWPA would need to be amended to include Hanford as a NWPA 113(a) site; and (4) DOE Order 5820.2A, Chapter 1.

Regulator(s)

(1) Congress will need to amend the NWPA to include Hanford as a 113(a) site; (2) The regulator that certifies compliance with the disposal standard (a 40 CFR 191-equivalent) is not clear; (3) The NRC will license the onsite disposal; and (4) Ecology's role is unclear (see discussion below).

Discussion

In some ways, this is a straightforward option; if the residue has the characteristics of HLW, then the disposal standards for HLW apply.

Unfortunately, implementation of this option will not be straightforward. Not only is disposal of HLW at Hanford a sensitive topic, but Congress must amend the NWPA, and both EPA and NRC regulations must be amended and/or new regulations promulgated to accommodate disposal of HLW at Hanford.

Under the current terms of the TPA, Ecology is the lead agency for closure of the tank farms. The NRC is not a party to the TPA. For the NRC to license the onsite disposal of HLW would probably require renegotiation of the TPA to include the NRC (i.e., the Quad-Party Agreement).

Advantages

Defining the boundary between HLW and incidental waste will not be necessary.

Disadvantages

Congress must amend the NWPA to include Hanford as a NWPA 113(a) site.

The NWPA is written under the assumption that HLW will be disposed in a deep geologic repository, and therefore designation of Hanford as a disposal facility will be counter to many of the siting criteria established by the NWPA.

Onsite disposal of HLW could be poorly received by Ecology, stakeholders, and others.

The NRC's 10 CFR 60 licensing criteria would be applicable. However, the assumption that permeates the existing 10 CFR 60 standard is that HLW will be disposed as glass, in canisters, in a deep geologic repository, and disposal of SST residue may not meet the existing 10 CFR 60 requirements.

Onsite disposal of HLW at Hanford will be difficult. Although the DOE has maintained for a decade that onsite disposal of HLW at Hanford may be viable, this option runs counter to the philosophies of many laws and stakeholders. If onsite disposal is to be pursued, the DOE should establish a working group that involves the NRC, EPA, Ecology, and DOE's Office of Civilian Radioactive Waste Management to explore the issues associated with onsite disposal of HLW. Once the issues are better defined, others (Congress, the State governor, the State legislature, the public, etc.) should be informed of the issues and involved in the subsequent decision-making process.

Congress has specifically stated that the existing 40 CFR 191 does not apply to any site being characterized under the authority of the NWPA. Given this situation, there are three possible paths: (1) Congress could direct the EPA to promulgate a 40 CFR 191-equivalent standard for disposal of HLW at Hanford (just as Congress has directed the EPA to promulgate a site-specific standard for disposal of HLW at the proposed Yucca Mountain site); (2) Congress could direct that the standard being developed for HLW disposal at the Yucca Mountain site (40 CFR 197) be applied to Hanford; or (3) Congress could direct the EPA to apply the current version of 40 CFR 191 to Hanford (the groundwater protection requirement still needs to be promulgated). Of these three possible paths, using the existing 40 CFR 191 and promulgating groundwater protection requirements may be the easiest path forward.

This option may place a significant burden on the EPA.

5.4 (C) Disposal as HLW Using EPA "Risk Balancing" Standard

Overview

This closure option is offered for end-states in which the residue is clearly HLW and the HLW cannot be further treated during closure to change the classification. Under this closure option, the residue would be disposed *in situ* as HLW under regulations written (or regulations to be written) for the disposal of HLW.

This option is identical to 5.4 (A) (Disposal as HLW, NWPA Does Not Apply), with one important change: a Hanford site-specific disposal standard would be developed and applied, as allowed by the EPA in 40 CFR 191.16.

The EPA, in 40 CFR 191.16, offers the option for developing a unique HLW disposal standard based on "... costs, risks, and benefits ..." This unique disposal standard may match the unique situation posed by the unrecoverable residue in the SSTs, where meeting existing disposal standards can only be achieved at risk to onsite workers, at great expense to the country, and where all parties are best served by balancing near-term workers' risks and costs against long-term risks to the public and groundwater resources.

An EPA, 40 CFR 191.16 HLW disposal standard based on "... costs, risks, and benefits ..." would be in harmony with the TPA requirement that, in evaluating closure options, Ecology and the EPA will consider "cost, technical practicability and potential exposure to radiation ..."

Waste Classification

The waste would be disposed as HLW.

Standard for Long-Term Closure

(1) A unique HLW disposal standard would be promulgated by the EPA under the EPA's 40 CFR 191.16; (2) the NRC's 10 CFR 60 licensing requirements do not apply and the NRC will need to amend 10 CFR 60 or write a new licensing standard; and (3) DOE Order 5820.2A.

Regulator(s)

(1) The EPA would promulgate a site-specific disposal standard for Hanford; (2) The regulator that would certify compliance with that new standard is not clear; (3) The NRC will license the disposal; (4) Ecology's role is unclear (see discussion below).

Discussion

The EPA, in writing 40 CFR 191, recognized that unique situations might present themselves, and the EPA's disposal standard for HLW offers the opportunity to develop an alternative standard. The EPA specifically states in 40 CFR 191.16:

> The Administrator, may by rule, substitute for any of the provision of Subpart B, alternative provisions chosen after: (a) The alternative provisions have been proposed for public comment in the FEDERAL REGISTER together with information describing the *costs, risks, and benefits of disposal in accordance with the alternative provisions* and the reasons why compliance with the existing provisions of Subpart B appears inappropriate; (b) A public comment period of at least 90 days has been completed, during which an opportunity for public hearings in affected areas of the country has been provided; and (c) The public comments received have been fully considered in developing the final version of such alternative provisions. (*emphasis added*)

Under the current terms of the TPA, Ecology is the lead agency for closure of the tank farms. The NRC is not a party to the TPA. For the NRC to license the onsite disposal of HLW would probably require renegotiation of the TPA to include the NRC (i.e., the Quad-Party Agreement).

Advantages

This option may be ideal for an SST end-state where meeting existing disposal standards can only be achieved at great risk to onsite workers, at great expense, and all parties are best served by balancing near-term workers' risks and costs against long-term risks to the public and groundwater resources.

This option mirrors the TPA requirement (M-45-00) that, in evaluating closure options, Ecology and the EPA will consider "cost, technical practicability and potential exposure to radiation ..." However, as discussed below, implementation may be difficult.

Promulgation of an alternative disposal standard under 40 CFR 19.16 and promulgation of a new NRC licensing standard (10 CFR 60-equivalent) could be combined.

Disadvantages

The EPA's current 40 CFR 191 took a decade to develop and has been the subject of court and Congressional intervention. Demonstrating that a new standard provides equal protection could be difficult.

The NRC needs to promulgate a 10 CFR 60-equivalent standard for a non-NWPA disposal site. One option would be to amend the "applicability" section of the existing 10 CFR 60 to apply to Hanford. However, the assumption that permeates the existing 10 CFR 60 is that HLW will be disposed as glass, in canisters, in a deep geologic repository, and disposal of SST residue may not meet 10 CFR 60 requirements. Writing a site-specific 10 CFR 60-equivalent regulation for Hanford will be controversial and difficult (i.e., will probably require many years).

This closure option could trigger court action. Many believe that the NWPA applies to the disposal of all HLW.

Onsite disposal of HLW, under any circumstances, may be poorly received by some stakeholders.

This option may place a significant burden on the EPA to promulgate an alternative standard for disposal of HLW that is appropriate and protective.

This option may place a significant burden on the NRC to promulgate a 10 CFR 60-equivalent licensing standard for Hanford.

Onsite disposal of HLW at Hanford will be difficult. Although the DOE has maintained for a decade that onsite disposal of HLW at Hanford may be viable, this option runs counter to the philosophies of many laws and stakeholders. If onsite disposal is to be pursued, the DOE should establish a working group that involves the NRC, EPA, Ecology, and DOE's Office of Civilian Radioactive Waste Management to explore the issues associated with onsite disposal of HLW. Once the issues are better defined, others (Congress, the State governor, the State legislature, the public, etc.) should be informed of the issues and involved in the subsequent decision-making process.

5.5 Decontamination and Decommissioning

Overview

The West Valley Demonstration Project (WVDP) was a commercial nuclear fuel reprocessing facility that generated HLW. Cleanup of the radioactive contamination at this facility will proceed under the NRC's D&D criteria (and other criteria discussed below).

Waste Classification

HLW is stored in tanks at the WVDP. Preliminary research does not indicate if there will be unretrievable residue and how the residue will be closed.

Standard for Long-Term Closure

The NRC's 10 CFR 20. Subpart E sets a 1,000-year dose-based standard for the D&D process (discussed below).

Regulator(s)

The NRC (possibly) and Ecology under the terms of the TPA (details are still uncertain).

Discussion

The WVDP was the only commercial nuclear fuel reprocessing facility to have operated in the U.S. The facility was operational from 1966 to 1972 and generated HLW. The WVDP Act (Public Law 96-368) stipulates that the DOE will D&D the WVDP in accordance with NRC D&D criteria (Sullivan *et al.*, 1995) and in compliance with other applicable regulations.

The WVDP is a unique facility and closure will proceed under a law (Public Law 96-368) written specifically for this facility.

The Implementation Plan for the EIS for closure of the WVDP (DOE, 1995b) does not identify any issues associated with possible in-tank residue. A general description of the regulatory environment for closure (DOE, 1995b) is that:

> The ongoing WVDP operations and the activities proposed herein are subject to DOE regulations, Orders and guidelines. In addition to these requirements and in accordance with the WVDP Act, the project will be subject to NRC-prescribed decontamination criteria to be applied as part of the final cleanup. Other federal and state laws and regulations regarding hazardous materials, hazardous and radioactive waste, air pollution and water pollution , apply to the WVDP. Most notable of this latter class of constraints is the fact that ... the Project has signed a RCRA 3008(h) Administrative Order on Consent with the EPA and the NYSDEC. (New York State Department of Environmental Conservation)

The NRC's criteria to D&D NRC-regulated facilities are set by 10 CFR 20 Subpart E, which was finalized on July 21, 1997 (62 FR 39088).

The NRC's 10 CFR 20 Subpart E criteria set an *all source terms*, all pathways dose limit of 25 mrem per year Total Effective Dose Equivalent (TEDE) for "the average member of the critical group" for the unconditional release of a licensed facility. The time frame of compliance is 1,000 years. A site-specific analysis similar to a PA is performed to determine if an NRC facility undergoing D&D meets these unrestricted release criteria. Protection of groundwater resources is not an independent performance objective. Under the NRC's requirements, the groundwater pathway could contribute up to 25 mrem/year, assuming that no other pathway contributes to the annual dose.

If the unrestricted release criteria of 25 mrem per year TEDE cannot be met, there is a second tier (with higher dose standards) for "restricted releases." Restricted release sites require the use of "institutional controls" (see the Definitions section in the beginning of this report). The dose standard for a restricted release site is based on the consequences of the failure of the institutional controls. If the institutional controls were no longer in effect, there must be reasonable assurance that the TEDE from residual radioactivity to the average member of the critical group is ALARA and would not exceed either:

(1) 100 mrem per year; or
(2) 500 mrem per year provided the licensee
  (i) Demonstrates that further reductions in residual radioactivity necessary to comply

with the 100 mrem/year value are not technically achievable, would be prohibitively expensive, or would result in net public or environmental harm;

(ii) Makes provisions for durable institutional controls;

(iii) Provides sufficient financial assurance to enable a responsible government entity or independent third party, including a governmental custodian of a site, both to carry out periodic rechecks of the site no less frequently than every 5 years to assure that the institutional controls remain in place as necessary.

In many ways, the NRC D&D criteria are similar to the DOE criteria for disposal of LLW (i.e., Chapter III of DOE Order 5820.2A, discussed later). The DOE LLW disposal requirements set a 25 mrem/year dose standard for the MOP, similar to the NRC's 25 mrem/year unrestricted release criteria (the methods of calculating dose are actually different, but the difference is not relevant to this overview). The DOE LLW disposal requirements also set a 100 mrem/year chronic and 500 mrem acute dose standard for protection of an IHI, which is similar to the NRC's 100 or 500 mrem/year chronic dose standard, assuming failure of institutional controls. For the protection of groundwater resources, the DOE LLW disposal criteria are much more restrictive than the NRC's D&D criteria.

Importantly, this closure option does not seem to offer a mechanism for separating HLW from non-HLW.

The Hanford Site is not an NRC-licensed facility; therefore, the NRC's D&D criteria do not legally apply. If Hanford were to seek a license from the NRC for onsite disposal of HLW, then Hanford would be an NRC-licensed facility. However, these D&D criteria apply only to the ancillary surface facilities that support radioactive waste disposal activities; 10 CFR 20.1401(a) and these D&D criteria do not apply to the actual disposal operations.

In summary, the D&D process provides the regulatory framework for closure of NRC-licensed facilities, and the WVDP will undergo D&D under NRC oversight. Under the existing legal structure, the D&D criteria cannot be applied to Hanford.

5.6 Cleanup under CERCLA Using "Risk Balancing"

Overview

This closure option could be applied to any end-state. Under this option, the TPA would be renegotiated and cleanup (i.e., closure) of the tank farms, including any unretrievable SST residue, would proceed under the requirements of CERCLA and the associated NCP.

With CERCLA providing the overarching set of regulations for cleanup, other requirements would be introduced as Applicable or Relevant and Appropriate Requirements (ARARs). The NCP specifies nine criteria that must be considered in evaluating remedies. Consideration of these criteria provides the regulatory mechanism for "risk balancing."

Waste Classification

The residue could be treated as a hazardous substance. However, classification of the residue as HLW or incidental waste may still be required for the identification of ARARs.

Standard for Long-Term Closure

CERCLA and the associated NCP; the remedy selection process is discussed below.

Regulator(s)

The EPA would be the lead agency.

Discussion

Under this option, the TPA would be renegotiated and closure of the tank farms, including any unretrievable SST residue, would proceed under CERCLA. The Hanford Site is an EPA NPL site. Responsibilities for cleanup of the Hanford Site are specified in the TPA. The TPA specifies that the SST and DST tank farms are RCRA hazardous waste management units that will be closed under State Dangerous Waste regulations. The TPA could be amended to designate that the SST and DST Tank Farms will be closed under CERCLA.

This is the approach the EPA uses to address the uncontrolled releases of hazardous substances. This approach allows the EPA to approve remedial actions that leave contaminants in place with institutional controls, and it requires active maintenance and monitoring programs. As compared to the standards for disposal of LLW and HLW, CERCLA minimizes the consideration of long-term hazards.

If this option involves onsite disposal of HLW at Hanford, the DOE should establish a working group that involves the NRC, EPA, Ecology, and DOE's Office of Civilian Radioactive Waste Management to explore the issues associated with onsite disposal of HLW. Once the issues are better defined, others (Congress, the State governor, the State legislature, the public, etc.) should be informed of the issues and involved in the subsequent decision-making process.

CERCLA is a complex act. The next few paragraphs simply highlight a few key features that maybe relevant to closure of the SSTs.

ARARs

The *substantive* requirements of other laws are incorporated into the CERCLA process as ARARs. In simple terms, ARARs are promulgated federal and state requirements that are legally applicable or relevant to a specific situation (see ARARs in the Definitions section). Compliance with ARARs is considered a minimum threshold. In some cases (e.g., multiple exposure pathways), a CERCLA risk assessment is also necessary. There are also circumstances under which compliance with less than ARARs may be allowed. These circumstances are: for interim actions; *when compliance results in increased risk*; when compliance is technically impractical;

when another response action achieves equal performance; and finally, when a state has inconsistently applied a requirement. Many of the laws discussed in this report (e.g., 10 CFR 60, the NWPA, and 40 CFR 191) might be identified as ARARs.

Risk Assessment

Guidance on EPA's use of ARARs and risk assessment was issued as OSWER No. 9200.4-18 (Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination), Memorandum of August 22, 1997 from Stephen Luftig, director of EPA Office of Emergency and Remedial Response and Larry Weinstock, Acting Director of EPA Office of Radiation and Indoor Air:

> ARARs are often the determining factor in establishing cleanup levels at CERCLA sites. However, where ARARs are not available or are not sufficiently protective, EPA generally sets site-specific remediation levels for: 1) carcinogens at a level that represents an excess upper bound life-time cancer risk to an individual of between 10^{-4} and 10^{-6}; ... (40 CFR 300.430(e)(2)(i)(A)(2)). ... The site-specific level of cleanup is determined using the nine criteria specified in Section 300.430(e)(9)(iii) of the NCP. ... *Cancer risk from both radiological and non-radiological contaminants should be summed to provide risk estimates for persons exposed to both types of carcinogenic contaminants.* ... Cleanup should generally achieve a level of risk within the 10^{-4} to 10^{-6} risk range based on the reasonable maximum exposure for an individual. ... If a dose assessment is conducted at the site, then *15 millirem per year* (mrem/yr) effective dose equivalent (EDE) should generally be the maximum dose limit for humans. This equates to approximately 3×10^{-4} increased lifetime risk and is consistent with levels generally considered protective ... The concentration levels for various media that correspond to the acceptable risk level established for cleanup will depend in part on land use at the site. ... *Institutional controls generally should be included as a component of cleanup* alternatives that would require restricted land use in order to ensure the response will be protective over time. ... EPA will conduct reviews at least once every five years to monitor the site for any changes including changes in land use. *(Emphasis added)*

Remedy Selection Process (Risk Balancing)

CERCLA established five principal statutory requirements for the selection of remedies. Remedies must:

- Protect human health and the environment;
- Comply with ARARs unless a waiver is justified;
- Be cost-effective;
- Utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and
- Satisfy a preference for treatment as a principal element, or provide an explanation in the Record of Decision (ROD) why the preference was not met.

In addition to the five principles established in CERCLA, the NCP requires evaluation of nine criteria in selecting a remedy. The nine criteria for analysis of remedial alternatives are (40 CFR 300.430(e)(9)(iii)):

Threshold Criteria:
- Overall Protection of Human Health and the Environment
- Compliance with ARARs

Balancing Criteria:
- Long-term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume Through Treatment
- Short-term Effectiveness
- Implementability
- Cost

Modifying Criteria:
- State Acceptance
- Community Acceptance.

During the remedy selection process, the nine evaluation criteria are considered in distinct groups that play specific roles in working toward the selection of a remedy that satisfies the five principal statutory requirements. The nine evaluation criteria include two "threshold" criteria, five "balancing" criteria (including cost), and two "modifying" criteria.

The first two statutory requirements—protection of human health and the environment and compliance with ARARs (unless a waiver is justified)—are embodied in the two threshold criteria. A remedial alternative must satisfy these two requirements to be eligible for further evaluation against the other seven factors. Advantages and disadvantages of alternatives that satisfy the threshold criteria are balanced using the five balancing criteria and the two modifying criteria.

Advantages

Because this closure option utilizes an existing regulatory framework, implementation could be accomplished without amending existing laws or promulgating new laws.

This option could provide a holistic approach for addressing all sources of contamination at a tank farm.

This option could provide a holistic framework for integrating the multitude of Federal and State laws governing closure of the SST residue. The current regulatory framework is fragmented: the NRC has authority over HLW; DOE and EPA have authority over non-HLW; and the State has the lead for tank farm closure under the terms of the TPA.

This option has the flexibility to balance competing requirements (short-term worker risks and costs balanced against long-term risks to the public and groundwater).

CERCLA and the NCP contain well-defined and robust public participation requirements.

Disadvantages

This option would require renegotiation of the TPA.

As compared to the current TPA, the States' authority might be diminished; the final mix of EPA, DOE, NRC, and State authorities would have to be negotiated.

This option could be viewed as an attempt to circumvent NRC authority. However, the NRC would clearly retain authority over approximately 99% of all the HLW at Hanford; only the small fraction of waste that might remain after retrieval would be closed under CERCLA.

This option may place a significant burden on the EPA.

Defining the boundary between HLW and non-HLW may still be necessary to determine which laws qualify as ARARs.

This option may have to address the issue of onsite disposal of HLW, which could be unpopular with many stakeholders.

Actually balancing the nine criteria will be very difficult (with one of the nine criteria being the multitude of Federal and State laws governing radioactive waste, mixed waste, and hazardous waste).

6.0 SUMMARY

This report reviewed *regulatory requirements* that may be applicable to the long-term closure of the radioactive component of any residue that may remain after retrieval. Requirements for disposal of HLW and LLW were reviewed and compared. Incidental waste, which is radioactive waste produced incidental to the further processing of HLW, was then discussed.

Detailed procedures for using the NRC's incidental waste concept to close the radioactive component of any unretrievable SST residue were presented in this report. If the NRC agrees that the SST residue is incidental waste, then the residue can be safely disposed on site without a license from the NRC.

The Incidental Waste Criteria were written for an HLW treatment facility and the criteria were interpreted for application to the SST residue. Application of the Incidental Waste Criteria to the residue will be through a petition to the NRC. A proposed format for such a petition was presented, as was a list of the analyses that must be completed to support the petition. A set of potential issues related to direct application of the incidental waste concept was also presented.

As an example of one analysis required for a petition, we used the current concentrations of wastes in the SSTs as surrogates for the end-state wastes and compared them to the Class C limits. Based on the Class C analysis, 49% of the 149 SSTs meet the Class C limits and 86% of the SSTs meet the Class C limits if 10 inches of grout is used to stabilize the SST residue (assuming 99% retrieval prior to grouting). In the extreme case, one SST, AX-102, will require stabilization with 25 feet of grout to meet the Class C limits (assuming 99% retrieval prior to grouting).

The NRC, under 10 CFR 61.58, allows a facility to petition the NRC to establish site-specific Class C limits. The technical details and defense of developing Hanford site-specific Class C limits were then described. A list of potential issues related to development of site-specific Class C limits was also presented. Some of the potential issues are significant. This report presented a set of alternative closure options if closure using the site-specific Class C limits and the incidental waste concept is not desirable or not possible:

- Disposal as GTCC-Equivalent LLW;
- Disposal as HLW, Three Interpretations;
- Decontamination and Decommissioning; and
- Cleanup under CERCLA using "Risk Balancing."

Each option was presented in a standard format that included an overview (what character of end-state does the option apply to); waste classification; standard(s) for long-term closure; regulator(s); discussion; advantages; and disadvantages. As detailed in this report, closure under CERCLA offers the best alternative closure option. Implementation of CERCLA does not require amending existing laws, and "risk-balancing" is integrated into the CERCLA criteria for selecting a final remedy.

If the SST residue meets (or can be further treated to meet) the NRC's Incidental Waste Criteria, then closure of the tank residue as incidental waste is the best closure option; this path is defined, acceptable, and has been used recently at Hanford. Based on analysis presented in this report, a combination of grouting, Hanford site-specific Class C limits, and use of the incidental waste concept will be necessary to justify in-place closure of the radioactive component of the SST residues.

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Appendix A
Derivation of the 10 CFR 61 Class C Limits and the Proposed Hanford Tank-Specific Class C Limits

Derivation of the 10 CFR 61 Class C Limits and the Proposed Hanford Tank-Specific Class C Limits

Background on NRC Class C Limits and Assessment Approach

In 10 CFR 61, NRC classified low-level radioactive waste into three categories for near surface disposal. These three categories are Class A, Class B, and Class C, with Class C having the most stringent disposal requirements. Greater than Class C waste (GTCC) are typically inappropriate for near surface burial and need special disposal methods and requires NRC's approval on waste form and disposal configuration. As stated in 10 CFR 61, waste classification is a mechanism to assure that the overall performance objectives for near surface disposal will be met through implementation of the technical requirements and controls established for various waste categories. Technical requirements for various waste classes were established for site characterization, design and operation, waste form and packaging, and institutional control. NRC's classification of waste is based on radionuclide concentration as described in the next section.

Concentration Limits for Class C Waste

Class C waste concentration limits were derived based on calculated doses to inadvertent intruders, assuming intrusion occurred at 500 years after waste disposal. The intruder is assumed to contact the disposed waste while performing typical excavation work such as installing utilities, putting in basements, and so forth. Two scenarios were considered in developing the Class C limits: intruder-construction scenario and intruder-agriculture scenario. For the intruder-construction scenario, the intruder digs a 3-meter deep foundation hole (20x10 m at the bottom, 26x16 m at the top) for a house on top of the waste site. The top 2 meters are cover material, and the bottom 1 meter is waste. The volume of excavated waste is about 232 m^3, which is less than one-third of the total volume of material excavated. During the construction phase, intruders would be exposed to external irradiation and contaminated airborne dust. Following the construction of a house, the excavated mixture of soil and waste is used as backfill around the house and is also used in the gardening bed. Intruders living in the house are exposed to external irradiation, airborne radionuclides, and radionuclides in food grown in the garden. This is considered to be the intruder-agriculture scenario. Class C limits are the waste concentrations that would deliver either 500 mrem radiation dose to the whole body or the bone or 1500 mrem to other organs under the intruder-construction or intruder-agriculture scenario. Table A-1 lists the Class C limits for various radionuclides as defined in 10 CFR 61. The mathematical model and the parameters used in deriving Class C limits are described later in this Appendix.

Table A-1. Class C Concentration Upper Limits

Long-lived Radionuclides	Class C Upper Limits	Short-lived Radionuclides	Class C Upper Limits
C-14	8 Ci/m^3	Ni-63	700 Ci/m^3
C-14 in activated metal	80 Ci/m^3	Ni-63 in activated metal	7000 Ci/m^3
Ni-59 in activated metal	220 Ci/m^3	Sr-90	7000 Ci/m^3
Nb-94 in activated metal	0.2 Ci/m^3	Cs-137	4600 Ci/m^3
Tc-99	3 Ci/m^3		
I-129	0.08 Ci/m^3		
Alpha emitting transuranic with $t_{1/2}$ > 5 years	100 nCi/g		
Pu-241	3500 nCi/g		
Cm-242	20000 nCi/g		

Given the Class C upper limits for individual radionuclides (Table A-1), the NRC regulation, 10 CFR 61, requires using the following scheme to determine waste classification. If radioactive waste does not contain any of the radionuclides listed in Table A-1, it is Class A waste. Otherwise, long-lived radionuclides should be assessed first to classify waste. For multiple radionuclides, the sum-of-fractions for individual radionuclides needs to be used. If the concentration does not exceed 0.1 times the limit in Table A-1, the waste will be Class A. If the concentration exceeds 0.1 times the limit but is less than the limit, the waste is Class C, unless the short-lived radionuclides in the waste exceed the Class C upper limits. On the other hand, if long-lived radionuclides have exceeded Class C upper limits, the waste will be classified as Class C regardless of the concentrations of short-lived radionuclides. If only short-lived radionuclides exist, waste will be Class C if concentrations exceed the upper limits for Class B (did not show) but are less than the Class C limits listed in Table A-1.

Derivation of the Class C Limits and the Proposed Hanford Tank-Specific Class C Limits

In this section the models used to derive the 10 CFR 61 Class C concentration limits for near surface disposal of low-level waste are described along with the parameter values used in model calculations. Tables A-2 and A-3 list parameters values used in the NRC model, proposed Hanford tank-specific parameter values, and corresponding values , if applicable, used in the Hanford LLBG PA intrusion model.

Intrusion Models

Class C waste concentration limits were derived based on inadvertent intruder scenarios that occur at 500 years after waste disposal. Two scenarios were considered: intruder-construction scenario and intruder-agriculture scenario. The scenarios were described earlier in this Appendix.

The exposure pathways considered in the intruder-construction scenario included direct gamma exposure from the wastes during excavation (the digging scenario) and the air pathway, which considers inhalation and external exposure from suspension of contaminated dust and the consumption of food grown nearby upon which the airborne contamination is assumed to settle.

The dose to the intruder can be expressed in a mathematical form as follows (NRC, September 1981).

Dose = Suspension of contaminated dust (inhale + external + food)
+ Direct gamma exposure to the waste during excavation

$$H = \sum_n (f_0\, f_d\, f_w\, f_s)_{air}\, C_w\, PDCF\text{-}2 + \sum_n (f_0\, f_d\, f_w\, f_s)_{DG}\, C_w\, PDCF\text{-}5$$

where

H (mrem) is the 50-year dose commitment summed over all "n" radionuclides.

PDCF-2 (mrem/(Ci/m^3)) is the radionuclide-specific dose conversion factor for the air pathway.

PDCF-5 (mrem/(Ci/m^3)) is the radionuclide-specific dose conversion factor for the external gamma pathway (DG stands for the digging activity).

C_w (Ci/m^3) is the waste concentration.

f_0 is the decay fraction: fraction of waste left at the time of excavation t. f_0=exp(-0.693*t/$T_{1/2}$, where $T_{1/2}$ is the radionuclide half life.

f_d is the site design/operation factor: accounts for the effects of any engineered barriers designed into the waste disposal facility, plus any site operational practices that may reduce transport.

f_w is the waste form and packaging factor: accounts for the physical and chemical characteristics of the waste at the time of the initiation of the release/transport scenario that may inhibit contaminant transfer to the transport agent.

f_s is the site selection factor: includes effects of the natural site environment that contribute to reducing the contaminant concentrations at the biota access location.

The exposure pathways considered in the intruder-agriculture scenario included the air pathway, external gamma pathway, and the food pathway. Specifically, five exposure scenarios were considered: (1) inhalation of contaminated dust suspended due to tilling activities as well as natural suspension, (2) direct gamma exposure from standing in the contaminated cloud, (3) consumption of food (leafy vegetables) dusted by fallout from the contaminated cloud, (4) consumption of food grown in the contaminated soil, and (5) direct gamma exposure from the disposed waste volume. The exposure to the intruder can be expressed mathematically as follows (NRC, September 1981).

Dose = Suspension of contaminated dust due to tilling and natural suspension
(inhale + external + food)
+ Direct gamma exposure to the waste during excavation
+ Food grown in the garden

$$H = \sum_n (f_0\, f_d\, f_w\, f_s)_{air}\, C_w\, PDCF\text{-}3 + \sum_n (f_0\, f_d\, f_w\, f_s)_{food}\, C_w\, PDCF\text{-}4$$

$$+ \sum_n (f_0\, f_d\, f_w\, f_s)_{DG}\, C_w\, PDCF\text{-}5$$

where

H (mrem/yr) is the dose equivalent rate in mrem/yr, received during the 50^{th} year of an exposure period of 50 years (summed over all "n" radionuclides).

PDCF-3 ((mrem/year) per(Ci/m^3)) is the radionuclide-specific dose conversion factor for the air pathway.

PDCF-4 ((mrem/year) per (Ci/m^3)) is the radionuclide-specific dose conversion factor for the food pathway.

PDCF-5 ((mrem/year) per(Ci/m^3)) is the radionuclide-specific dose conversion factor for the external gamma pathway (DG stands for the digging activity).

C_w (Ci/m^3) is the waste concentration.

f_0 is decay fraction: same as above.

f_d is the site design/operation factor as described in the intruder-construction scenario.

f_w is the waste form and packaging factor as described in the intruder-construction scenario.

f_s is the site selection factor as described in the intruder-construction scenario.

Generic and Proposed Hanford Tank-Specific Model Parameter Values

Table A-2 shows the **intruder-construction** model parameter values used to derive 10 CFR 61 Class C limits and the proposed parameter values for Hanford tank waste disposal configuration and site environment, along with the applicable Hanford LLBG PA intrusion model parameter values. The technical bases for these model parameter values are discussed below. Since postexcavation and postdrilling scenarios used in LLBA PA to derive the radionuclide disposal limits are similar to the NRC **intruder-agriculture** scenario, parameter comparison was recorded in the intruder-agriculture table (**Table A-3**).

Table A-2
Comparison of Parameter Values for Various Intrusion Models
(NRC Class C **Intruder-construction** scenario)

Model Parameter	Values Used in Setting 10 CFR 61 Class C Limit	Proposed Hanford Tank - Specific Values	Impact on 10 CFR 61 Class C Limits[1]	Hanford LLBG PA Intrusion Model[2]
Suspension of contaminated dust				
1. (a): f_0_air (decay fraction at 500 years after disposal)	Nuclide-specific	Same		NA
1. (b): f_d _air (site design/operation factor)	0.5*0.1	< 0.5*0.1 (a deeper disposal)	↑	NA
1. (c): f_w _air (waste form/packaging factor)	1.0	0.001	↑ by 1000	NA
1. (d): f_s _air (site selection factor)	2.01E-11	1.10E-11	↑ by 2	NA
1. (e): PDCF_2 (dose conversion factor for air pathway)	Nuclide-specific	Same		NA
Direct gamma from waste				
2. (a): f_0_dg (decay fraction at 500 years after disposal)	Nuclide-specific	Same		NA
2. (b): f_d _dg (site design/operation factor)	0.5*0.1	< 0.5*0.1 (a deeper disposal)	↑	NA
2. (c): f_w _dg (waste form/packaging factor)	1.0	0.8	↑ by 1.25	NA
2. (d): f_s _dg (site selection factor)	0.057	0.057		NA
2. (e): PDCF_5 (dose conversion factor for air pathway)	Nuclide-specific	Same		NA
3. Intruder Dose limit for Class C waste	500 mrem for whole body or bone; 1500 mrem for other organs	Same		100 mrem/yr

[1] Actual impact depends on which pathway is the limiting factor.
[2] Since postexcavation and postdrilling scenarios used in LLBA PA to derive the radionuclide disposal limits are similar to the NRC intruder-agriculture scenario, parameter comparison was recorded in the intruder-agriculture table (Table A-3).

1. Parameters for Suspension of Contaminated Dust as Listed in Table A-2.

(a) *The decay fraction for the air pathway (f_0_air)* at 500 years after disposal depends on radionculide half-life and stays the same for the generic and the Hanford tank-specific Class C calculations.

(b) *The site design/operation factor for the air pathway (f_d_air)* represents the effects of any engineered barriers designed into the waste disposal facility, plus any site operational practices that may reduce transport. For the generic Class C, f_d_air has a value of 0.5*0.1, where 0.5 represents a random disposal practice and 0.1 is for layered disposal to indicate the reduced likelihood of contact with the layered wastes at a greater depth (~ 7 meters) by the intruder. For the Hanford tank-specific case, a smaller value should have been used to represent the reduced likelihood for an even deeper disposal (~ 17 meters), but the same value was used because no quantitative relationship between disposal depth and probability of intruder contacting the waste has been derived. If a lower value were used, the Class C limit would be raised as indicated in the last column of Table A-2.

It has been suggested that the use of engineered barriers, such as a concrete cap and grouting, could reduce intruder risk by a factor of 10 (NRC, September 1981). If such a reduction in risk over the long term (in terms of long-lived radionuclides) can be fully justified, the Class C limits may be further increased by a factor of 10 when such engineering barriers are used.

(c) *The waste form/packaging factor for the air pathway (f_w_air)* accounts for the physical and chemical characteristics of the waste at the time of the initiation of the release/transport scenario that may inhibit contaminant transfer to the transport agent. For the air pathway, f_w is the product of "accessibility" and "dispersibility". For the generic Class C calculation, a value of 1.0 was used to represent full accessibility, and a value of 1.0 was also used for dispersibility to represent a complete dispersion of waste into respirable particle sizes. Essentially, no credit was given to waste form and waste is considered to be the same as soil. For the Hanford tank-specific case, a dispersibility value of 0.001 is proposed while the value of 1.0 for accessibility stays the same. The low dispersibility may cause the increase of Class C limits by a factor of 1000. The technical basis for the 0.001 dispersibility value is discussed below.

The dispersibility of the waste form is dependent on the resistance of the waste form to chemical and biological attack (NRC, November 1981b; Aikens, December 1977; DOE, October 1980), and the compressive strengths of the waste form (NRC, October 1981). Four categories of dispersibility were identified in the technical supporting document (NRC, September 1981) for 10 CFR 61 rule-making. They included (a) dispersibility of 1.0 for full dispersion of all waste forms into respirable fractions, such as unsolidified LWR filter sludges, (2) a value of 0.1 for waste forms which tend to crumble or fracture extensively and those forms that are subject to relatively rapid (within about 100 years) decomposition, such as trash (3) a value of 0.01 for waste forms consisting of a mixture of materials with dispersibility factors of 0.001 and 0.1, such as cement solidified waste with 100 psi, and (4) a value of 0.001 for waste forms that have a low probability of becoming suspended into respirable particles, such as powdered PuO_2 packages in transportation accidents (NRC, January 1977; NRC, 1988) and waste solidified by synthetic polymer with 1700 to 7000 psi. The last category represents waste forms that are likely to resist biological and chemical attack and have compressive strengths (NRC, September 1981). Based on the data compiled in a DOE handbook on airborne release fractions (DOE, December 1994), the bounding airborne fraction for the categories of "aggregated solids" and "powders" under "free fall spill and impaction stress" are 0.001 and 2E-3, respectively. Therefore, it is reasonable to propose a value of 0.001 for dispersibility for grouted tank waste. It should be borne in mind that the dispersibility factor in the intrusion model implicitly represents the product of the airborne fraction and the respirable fraction. Consequently, when a value of 0.001, which was the bounding for airborne fraction, was assumed to be the dispersibility factor, the respirable fraction was implicitly assumed to be 1.0, which is very conservative based on available studies on respirable fractions (DOE, December 1994).

(d) *The site selection factor for the air pathway (f_s_air)* includes effects of the natural site environment that contribute to reducing the contaminant concentrations at the biota access location. For the air pathway, f_s = exposure duration per year * soil/air transfer factor. The exposure duration for a typical house construction was assumed to be 300 working hours, which corresponds to a fraction of 0.057 when compared to the total hours in a year (24x365). The soil/air factor is a function of wind speed, soil silt content, and precipitation/evaporation index and is equal to $2.53e\text{-}10 * (10/v)*(s/30)*(50/PE)^2$, where v is the average wind speed at the site in m/sec, s is the silt content of the site soils in percent, and PE is the Thornthwaite Precipitation-Evaporation index of the site vicinity indicative of the antecedent moisture conditions. For the generic case, the values for the southeast reference disposal facility as described in the Draft EIS for 10 CFR 61 rule-making were used. These values were v=3.61, s=50, and PE=91, and the resulting f_s was 2.01E-11. For the Hanford tank-specific analysis, proposed values for v, s, and PE were 3.5 m/sec, 2%, and 25, respectively. The value of "v" is the mean of the Hanford typical high and low wind speeds (DOE, August 1996), the silt percent of 2% is the best estimate for area around AX tank farms (WHC, October 1995), and the PE value of 25 is documented in NUREG/CF-1759 (NRC, November 1981). The Hanford tank-specific value for f_s may result in an increase of the site-specific Class C limits by a factor of 2.

(e) *The dose conversion factors for the air pathway under the construction scenario (PDCF_2_air)* were radionuclide-specific and were not changed in the Hanford tank-specific calculation.

2. Parameters for Direct Gamma Exposure from Waste as Listed in Table A-2.

(a) *The decay fraction for the DG pathway (f_0_dg)* is the same as item 1. (a).

(b) *The site design/operation factor for the DG pathway (f_d_dg)* is essentially the same as item 1. (b). The minor difference exists in the application of a factor 1/1200 or smaller to denote attenuation of the radiation through layered disposal. The dose term associated with this small multiplier was negligible compared to other terms so that the application of this shielding factor in the model calculation could have hardly any impact on the Class C calculation.

(c) *The waste form/packaging factor for the DG pathway (f_w_dg)* is intended to account for the physical and chemical characteristics of the waste in reducing the external gamma penetration through waste forms and the exposure to the intruders. For the DG pathway, f_w is the product of "accessibility" and "solidification multiplier." For the generic Class C limits, a value of 1.0 for accessibility was used to represent a full accessibility to the radiological sources and a value of 1.0 for the solidification multiplier was assumed for not taking any credit for waste solidification. For the Hanford tank scenario, a solidification multiplier of 0.8 was proposed based on the recommended multiplier for waste solidified with a significant amount of cement (NRC, September 1981).

(d) *The site selection factor for the DG pathway (f_s_dg)* includes only the exposure duration term described in item 1. (d). For both the generic and Hanford tank-specific cases, the value was 0.057 based on a 300-working-hour construction period (0.057=300/(24*365)).

(e) *The dose conversion factors for the DG pathway (PDCF_3_dg)* were radionuclide-specific and were not changed in the Hanford tank-specific calculation.

3. *The intruder dose limits* for the construction scenario were set at 500 mrem for the whole body and the bone and 1500 mrem for other organs and were not changed in performing the Hanford tank-specific calculation.

Table A-2 shows the intruder-construction model parameter values used to derive 10 CFR 61 Class C limits and the proposed parameter values for Hanford tank waste disposal configuration and site environment, along with the applicable Hanford LLBG PA intrusion model parameter values. The technical bases for these model parameter values are discussed below.

Table A-3
Comparison of Parameter Values for Various Intrusion Models
(NRC Class C **Intruder-agriculture** scenario)

Model Parameter	Values Used in Setting 10 CFR 61 Class C Limit	Hanford Tank-Specific Values	Impact on Class C Limits[1] (approx.)	Hanford Low-level Burial Ground PA
Suspension of contaminated dust				
4. (a): f_0_air (decay fraction at 500 years after disposal)	Nuclide-specific	Same		Should be Same
4. (b): f_d_air (site design/operation factor)	0.5*0.1*0.25	0.5*0.1*0.1	↑ by 2.5	No excavation scenario, only well drilling possible for disposal > 5m; soil dilution factor 0.2 for postexcavation; 9.3e-4 for postdrilling
4. (c): f_w_air (waste form/packaging factor)	1.0	0.001	↑ by 1000	1.0 (see discussion)
4. (d): f_s_air (site selection factor)	3.174E-11	3.174E-11*0.55^2	↑ by 2	6.25E-11 (see discussion)
4. (e): PDCF_3 (dose conversion factor for air pathway)	Nuclide-specific	Same		See Table F-2
Direct gamma from waste				
5. (a): f_0_dg (decay fraction at 500 years after disposal)	Nuclide-specific	Same		Should be the same
5. (b): f_d_dg (site	0.5*0.1*0.25	0.5*0.1*0.1	↑ by 2.5	No excavation scenario, only well

design/operation factor)				drilling possible for disposal > 5m; soil dilution factor 0.2 for postexcavation; 9.3e-4 for postdrilling
5. (c): f_w_dg (waste form/packaging factor)	1.0	0.8	↑ by 1.25	1.0 (no credit for waste form)
5. (d): f_s_dg (site selection factor)	0.27	same		NA
5. (e): PDCF_5 (dose conversion factor for air pathway)	Nuclide-specific	Same		See Table F-2
Food grown in the garden				
6. (a): f_0_food (decay fraction at 500 years after disposal)	Nuclide-specific	Same		Should be Same
6. (b): f_d_food (site design/operation factor)	0.5*0.1*0.25	0.5*0.1*0.1	↑ by 2.5	No excavation scenario, only well drilling possible for disposal > 5m; soil dilution factor 0.2 for postexcavation; 9.3e-4 for postdrilling
6. (c): f_w_food (waste form/packaging factor)	nuclide-specific*1*1*1	nuclide-specific*0.00647 *1*1	↑ by 150	soil leaching coefficient was calculated (fraction removed from a soil layer of thickness "d" per year)
6. (d): f_s_food (site selection factor)	0.5	same		0.25 of vegetable and 0.5 of animal diet
6. (e): PDCF_4 (dose conversion factor for air pathway)	Nuclide-specific	Same		See file: ClasC.n1.doc
7. Intruder Dose limit for Class C waste	500 mrem for whole body or bone; 1500 mrem for other organs	Same		100 mrem/yr TEDE is the performance objective

[1] Actual impact depends on which pathway is the limiting factor.
[2] 0.55 = 1.10E-11/2.01E-11 (ratio of f_s for 61 Class C and Hanford Class C)

1. Parameters for Suspension of Contaminated Dust as Listed in Table A-3.

(a) <u>*The decay fraction for air pathway (f_0_air)*</u> is the same as 1. (a).

(b) <u>*The site design/operation factor for the air pathway (f_d_air)*</u> is the same as 1. (b) except a dilution factor was added because of the mixing of excavated waste and the soil when used as backfill and gardening bed. For the generic case, the dilution factor was derived based on a mixing of excavated waste of 232 m^3 (~ 1m deep of waste) with excavated cover soil of 680 m^3 (~ 2 m deep of cover, see Figure 1). For the Hanford tank scenario, if the intruder needs to dig at least 10 meters to get to the waste, the dilution factor could be 0.1 based on the same calculation scheme. This reduction in dilution would raise Class C limits by a factor of 2.5 as indicated in the last column of Table A-3.

As defined in Hanford LLBG PA, soil dilution factor is the ratio of total activity to volume of mixing soil (waste volume/mixing volume). This results in 3cm/15cm=2e-1 for

postexcavation and 1.4e-2cm/15cm=9.3e-4 for postdrilling, which is 270 higher than that used in NRC model.

(c) _*The waste form/packaging factor for the air pathway (f_w_air)*_ is the same as 1. (c)

In the case of Hanford LLBG limits, it appeared that this factor was assumed to be 1.0 because waste was assumed to be just like soil (no credit for waste form) and could be completely dispersed into air. (an approach of using dust loading of 100 μg/m^3 was used, see the discussion in (d).)

(d) _*The site selection factor for the air pathway (f_s_air)*_ is the same as 1. (d) except the soil-to-air transfer factor was averaged to account for natural resuspension of the soils during part of a year, including time spent outdoors, indoors, and during gardening. For the generic case, a value of 3.17E-11 was used. For the Hanford tank scenario, this value was adjusted due to the change in the site selection factor as described in 1. (d). A lower value of f_s_air could result in an increase of the site-specific Class C limits by a factor of 2.

In setting Hanford LLBG limits, dust loading of 100 μg/m^3 was used, which corresponds to a soil/air transfer factor of 6.25E-11 for a soil density of 1.6 g/cm^3 (i.e., 100 μg/m^3 = 6.25E-11*1.6 g/cm^3 *1E6 μg/g * 1E6 cm^3/m^3.) In other words, the amount of soil dispersed into air used in the NRC model is about 50% of that assumed in the Hanford LLBG PA.

(e) _*The dose conversion factors for the air pathway (PDCF_3_air)*_ were radionuclide-specific and were not changed in Hanford tank-specific calculation.

5. Parameters for Direct Gamma Exposure from Waste as Listed in Table A-3.

(a) _*The decay fraction for the DG pathway (f_0_dg)*_ is the same as item 1. (a).

(b) _*The site design/operation factor for the DG pathway (f_d_dg)*_ is the same as 4. (b).

(c) _*The waste form/packaging factor for the DG pathway (f_w_dg)*_ is the same as 2. (c)

(d) _*The site selection factor for the DG pathway (f_s_dg)*_ is the same as 2. (d) except the exposure duration should be multiplied by a correction factor to account for the limited areal extent of the direct gamma source that the intruder is exposed to. For the generic case, a value of 0.27 was used (NRC, September 1981), and the same value was also used for the tank scenario.

(e) _*The dose conversion factors for the DG pathway (PDCF_5_dg)*_ were radionuclide-specific and were not changed in Hanford tank-specific calculation.

6. Parameters for Food Grown in the Garden Pathway as Listed in Table A-3.

(a) _*The decay fraction for the garden food pathway (f_0_food)*_ is the same as item 1. (a).

(b) _*The site design/operation factor for the garden food pathway (f_d_food)*_ is the same as 4. (b).

(c) *The waste form/packaging factor for the garden food pathway (f_w_food)* is intended to account for the physical and chemical characteristics of the waste in reducing leaching and hence the exposure to the intruders. Leaching was calculated as the product of M_0, t_c, Mult, and the accessibility multiplier. M_0 is the radionuclide-specific leach fraction of unsolidified waste forms; t_c is the contact time fraction (the fraction of time in one year that the waste is in contact with irrigation or rainwater); Mult represents the reduction due to solidification and the presence or absence of chelating chemicals and other factors; and the accessibility multiplier is the same as in 1. (c).

For the generic Class C calculation, a contact time fraction (t_c) of 1.0 was assumed for conservatism. For Hanford tank scenario, the fraction was calculated using the formula, $t_c = p/(n*v)$, where p is the precipitation (m/yr) that infiltrates and comes into contact with the waste, n is the waste cell effective porosity, and v is the speed of the percolating water (m/yr). The values used for the northwest reference facility in 10 CFR 61 EIS (NRC, September 1981) were used (p = 0.18 m/yr, n = 0.25, and v = 111.3 m/yr.), and the resulting t_c was 0.00647. These values are still conservative when compared to some preliminary Hanford site data (DOE, August 1996; WHC, October 1993; WHC, September 1996). For both generic and Hanford tank-specific Class C calculations, the Mult was assumed to be 1.0 based on the assumption of the use of cement for waste solidification and the existence of chelating agents.

(d) *The site selection factor for the garden food pathway (f_s_food)* means the fraction of on-site food consumed by the intruder. A value of 0.5 was assumed for the generic case and was also used in the Hanford tank case.

(e) *The dose conversion factors for the garden food pathway (PDCF_4_food)* were radionuclide-specific and were not changed in Hanford tank-specific calculation.

7. *The intruder dose limits* for the agriculture scenario were set at 500 mrem/yr for the whole body or the bone and 1500 mrem/yr for other organs and were not changed in performing the Hanford tank-specific calculation.

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Appendix B
Comparison Between HLW and LLW Disposal Standards

Comparison Between HLW and LLW Disposal Standards

Introduction

This paper provides an overview of the EPA's general standard (40 CFR 191) for the disposal of spent nuclear fuel (SNF), high-level radioactive waste (HLW), and TRansUranic radioactive (TRU) waste. Additionally, this paper makes general comparisons between the requirements in 40 CFR 191 and the DOE requirements for disposal of low-level radioactive wastes (LLW).

The DOE's Order 5820.2A, Chapter III (effective since 1988) sets requirements for DOE facilities for disposal of LLW. The Order has been under revision for the past couple of years, and the future order (DOE Order 435.1) has not been finalized; therefore, this paper presents the existing DOE requirements. Except for the time frame of compliance, the new Order will probably be similar to the existing Order.

Environmental standards can be complicated. Because of the limited scope, this paper is only an overview, fashioned to identify critical issues for demonstrating compliance.

Comparison Between 40 CFR 191 and Order 5820.2A, Chapter III

This section provides a comparison of the key aspects of the standard set by 40 CFR 191 and the standard set by DOE Order 5820.2A, Chapter III. Member of public, general population, and inadvertent human intruder refer to distinct receptor populations and the terms are not interchangeable (discussed later).

Time frame of compliance
- HLW: 10,000 years
- LLW: not defined (10,000 years typically used, revised Order may be 1,000 years)

Time frame of institutional control
- HLW: 100 years
- LLW: 100 years (revised Order may have more flexibility)

Dose standard to protect the member of the public
- HLW: 15 mrem/yr committed effective dose
- LLW: 35 mrem/yr (25 mrem/yr all pathways except air, plus 10 mrem/yr via air)

Point of compliance to protect the member of the public
- HLW: beyond controlled area boundary (i.e., at the land surface and groundwater pumped from a location approximately 5 kilometers (km) laterally from the disposal system.)
- LLW: not defined (typically assessed at 100 meters (m) from burial site)

Dose standard to protect the inadvertent human intruder
- HLW: not protected

LLW: 100 mrem/yr all pathways chronic and 500 mrem acute

Point of compliance for the inadvertent human intruder
HLW: not required
LLW: onsite (probability of intrusion typically assumed to be one)

Exposure scenario for inadvertent human intrusion
HLW: not required
LLW: not defined (well drilling, home construction and subsidence farming are typical)

Protection of the general population
HLW: probabilistic flux-based standards (discussed later)
LLW: not required (however, protection of the member of public may protect general population)

Groundwater protection standards
HLW: follow 40 CFR 141 (Maximum Contaminant Levels (MCLs))
LLW: follow DOE Orders, local, State, and Federal standards (MCLs and others)

Point of compliance for groundwater standards
HLW: 5 km from the disposal site, for disposal systems > 1/4 mile from an aquifer
HLW: not defined for disposal systems < 1/4 mile from aquifer (future rulemaking)
LLW: not defined (typically assumed at 100 m from the disposal site)

Site evolution
HLW: consideration of all significant processes and events for 10,000 years
LLW: not defined (revision may require consideration of reasonably foreseeable processes)

Treatment of uncertainty
HLW: probabilistic containment requirement (no bias, full range)
LLW: typically deterministic (conservative bias, single value inputs and single value output)

Standard of review
HLW: "reasonable expectation" of meeting the standards
LLW: not defined (revision may require "reasonable expectation")

Regulator
HLW: NRC must "license" HLW disposal facilities, other regulators vary
LLW: DOE self-regulates (stakeholders via NEPA, and in the far future, NRC may regulate)

Discussion

The general standard for disposal of HLW and the standard for disposal of LLW are both protective of human health. However, compliance with one of these standards may be more difficult than compliance with the other, depending on the circumstances. Here are a few observations:

1. The LLW standard to protect the inadvertent human intruder may be the most limiting criteria for burial of LLW at arid sites with deep groundwater. The HLW standard does not require protection of the inadvertent human intruder.

2. Protection of groundwater resources may be the second most limiting criteria for the burial of LLW. For LLW sites, the point of compliance is typically 100 m from the disposal system, at the point of highest concentration. The HLW standard for disposal systems more than 1/4 mile from an underground source of drinking water (USDW) sets the point of compliance not more than 5 km from the disposal system.

However, there are no groundwater protection requirements for disposal systems less than 1/4 mile from an USDW; the EPA has reserved this portion of 40 CFR 191 for future rule making. The EPA has deferred this portion of the standard because of an apparent conflict between 40 CFR 191 (which allows contamination of groundwater) and the Safe Drinking Water Act (which seeks to protect all USDW). The EPA has promised to address this issue when they draft a site-specific disposal standard for Nuclear Waste Policy Act (NWPA) sites (i.e., Yucca Mountain) (58 FR 66399). The Hanford Site is less than 1/4 mile from a USDW, therefore, assessment with this portion of 40 CFR 191 is not currently possible (a surrogate requirement is suggested below).

3. The DOE LLW standard is deterministic, setting single-value standards. A very conservative bias is typically added to LLW modeling to compensate for the great uncertainty associated with assessing doses over the next 10,000 years. Furthermore, deterministic calculations do not present the range of possible outputs (e.g., the possible range of doses) to the decision maker. A probabilistic LLW performance assessment (PA) could be performed and compared to the deterministic LLW standards; however, no probabilistic PAs have been presented to the DOE Peer Review Panel.

The Containment Requirement of 40 CFR 191 is probabilistic. Furthermore, Appendix B of 40 CFR 191 recommends conducting the other analysis (groundwater protection and individual protection) probabilistically. The probabilistic, or risk-based, approach taken by 40 CFR 191 presents the decision maker with the full range of possible outcomes, rather than a single, conservative-biased outcome typical of LLW Pas.

Issues

This paper is written to provide information on the possible application of 40 CFR 191 for onsite disposal of the Single-Shell Tank (SST) residue as HLW. As with the other possible regulatory options for onsite disposal of the SST residue, there are issues which will require further research. This section presents issues associated with the use of 40 CFR 191 for onsite disposal of HLW at Hanford.

The NWPA of 1982 establishes the national program for the disposal of spent nuclear fuel and HLW. *The NWPA does not set quantitative standards for disposal of HLW*; rather, the NWPA defines U.S. policies and assigns responsibilities. The NWPA assigns three agencies with responsibility for disposal of HLW: (1) EPA is to set the standards for the disposal; (2) DOE is to develop and operate the mined geologic repository; (3) NRC is to license the repository; and (4) EPA and NRC are to regulate the disposal program (National Research Council, 1995).

The EPA's 40 CFR 191 sets general requirements governing the disposal of SNF, TRU wastes, and HLW. *40 CFR 191 is the only promulgated or even proposed standard for disposal of HLW.* The current version of 40 CFR 191 is applicable to disposal of HLW "... by any method..." (58 FR 66399), with three exceptions. The three exceptions are: ocean disposal; disposal systems located within 1/4 mile of an underground source of drinking water; and wastes disposed before 1985 (58 FR 66399). A fourth exception, related to the NWPA, is discussed below. As the SST residue is less than 1/4 mile from the underlying aquifer, the EPA needs to promulgate the final Groundwater Protection Requirement of 40 CFR 191. The EPA has proposed to publish a draft of this Groundwater Protection Requirement in late FY 1997.

The future Groundwater Protection Requirement probably will not be any more rigorous than the application of 40 CFR 141 MCLs at a tank farm boundary. Application of MCLs at a Tank Farm boundary could serve as a surrogate requirement until the EPA finalizes the Groundwater Protection Requirement of 40 CFR 191.

The Waste Isolation Pilot Plant (WIPP) Land Withdrawal Act (PL 102-579) exempted sites required to be characterized under section 113(a) of the NWPA from the requirements of 40 CFR 191. The only section 113(a) site currently under consideration is the Yucca Mountain site in Nevada. The Energy Policy Act (PL 102-486) directed the EPA is develop a specific standard for the disposal of HLW at Yucca Mountain (but no other NWPA sites; see Section 801 of the Energy Policy Act). If the NWPA governs the disposal of the SSTs residue, then the current version of 40 CFR 191 is not applicable (unless Congress specifically required application of 40 CFR 191 to Hanford). If the NWPA does not govern the onsite disposal of the SSTs residue, the current version of 40 CFR 191 would be applicable.

Facilities for the disposal of HLW must be licensed by NRC. The NRC's 10 CFR 60 sets forth the NRC *licensing* criteria for "Disposal of High-Level Radioactive Waste in Geologic Repositories." The NRC's 10 CFR 60 is written specifically for the licensing of a geologic repository authorized by the NWPA. If the NWPA does not apply to the onsite disposal of HLW, then NRC would need to develop 10 CFR 60-equivalent licensing criteria for Hanford.

DOE has maintained for many years (e.g., DOE Order 5820.2A, Chapter I) that the NWPA only applies to "new and readily recoverable" HLW and that the NWPA may not apply to other HLW; this issue is currently unresolved.

Historically, demonstrating compliance with 40 CFR 191 has required very expensive modeling (e.g., the PA for WIPP), whereas the PAs for LLW disposal sites have been less expensive. However, the software for conducting probabilistic modeling has improved and the number of professionals capable of conducting probabilistic PA modeling has increased.

As a point of reference, two facilities are currently engaged in demonstrating compliance with 40 CFR 191. The disposal of TRU waste at the WIPP is governed by 40 CFR 191 with site-specific requirements set by 40 CFR 194. The WIPP facility is greater than 1/4 mile from an USDW, therefore the current 40 CFR 191 is applicable and fully promulgated. EPA will "certify" whether or not the DOE complies with 40 CFR 191 and 40 CFR 194 and the NRC does not have a role in licensing facilities for disposal of DOE TRU waste.

The past disposal of "orphan" TRU waste in the DOE's Greater Confinement Disposal (GCD) facility at the Nevada Test Site is governed by the 1985 version of 40 CFR 191. The 1985 version is applicable to GCD because the GCD wastes were disposed during the time that the 1985 version was in effect. The 1985 version and the current version of 40 CFR 191 have the same Containment Requirement (i.e., the flux-based, 10,000 year standard), and the Groundwater and Individual Protection Requirements are more stringent in the current version. DOE self-certifies for the GCD facility and the NRC does not have a role in licensing facilities for disposal of DOE TRU wastes.

Unique Aspects of 40 CFR 191

Before discussing the specifics of 40 CFR 191, it is important to understand many of the unique aspects of 40 CFR 191. This standard has several differences that separate it from other environmental standards. The EPA, in drafting 40 CFR 191, recognized that unmined uranium deposits would cause cancer-based deaths in the general population. The EPA then reasoned that the number of deaths in the general population from buried SNF, HLW, and TRU wastes should not exceed the number of deaths that would have occurred if the uranium had not been mined (50 FR 38067).

Specifically, the *basis of 40 CFR 191 is comparative risk within the general population.* Implementation of 40 CFR 191 may result in some premature deaths from cancer, and these deaths *in the general population* are acceptable, so long as the number of deaths does not exceed the number of deaths that would have occurred if the uranium had not been mined. In contrast, *standards for the disposal of LLW are based on risk to any individual* (known as the member of public and the inadvertent human intruder), and the belief that no individual should be exposed to ionizing radiation above a predefined threshold. The philosophical basis behind the Containment Requirement in 40 CFR 191 and the dose standards for disposal of LLW are different, and these philosophical differences are reflected in the disposal standards (most notably in treatment of the inadvertent human intruder).

In drafting 40 CFR 191, the EPA also reasoned that it would be acceptable to contaminate a small area surrounding the buried waste, so long as the risks to the general population were acceptable (47 FR 58199). The adjacent geologic formations which serve as part of the containment system are defined as the "controlled area." The controlled area includes the subsurface and *groundwater for a 5 km radius* around the disposal system.

Protection of the general population is provided by the Containment Requirement defined at 40 CFR 191.13. The Containment Requirement does not set a dose-based limit; rather, the Containment Requirement sets *probabilistic limits on the fluxes* of certain radionuclides through the controlled area boundary. Demonstrating compliance with the flux limits provides protection of the general population. The Containment Requirement sets a low flux limit for likely releases and a higher flux limit for unlikely releases.

The allowable flux limits through the controlled area boundary are calculated using the "EPA Sum." The EPA sum is the ratio of the calculated releases (the calculated curies that move through the controlled area boundary) divided by the number of curies set by the release limit. The release limit is taken from a table in the back of 40 CFR 191. For example, if a disposal system contained the HLW from 1,000 metric tons of heavy metal reactor fuel, the Technetium-99 release limit would be 10,000 curies, and if a disposal system contained ten times as much HLW, the Technetium-99 release limit would be ten times higher or 100,000 curies; *the more you bury, the more you are allowed to release.* As a point of reference, Yucca Mountain is authorized to receive wastes from up to 70,000 tons of heavy metal. The Individual Protection Requirements and the Groundwater Protection Requirements of 40 CFR 191 are rigid and do not change with the disposal inventory.

The Containment Requirement also requires the assessment of "all significant processes and events that may affect the disposal system" for 10,000 years. No other environmental standard requires such an explicit consideration of future events and processes.

The EPA's 40 CFR 191 does not protect the inadvertent human intruder (see 58 FR 66402). There are three quantitative sets of requirements in 40 CFR 191. Both the Groundwater Protection Requirements and the Individual Protection Requirements are, *by regulation, to be assessed under the assumption that the disposal system has not been disturbed by human intrusion.* The third quantitative requirement, the Containment Requirement, does require consideration of inadvertent human intrusion, but the standard is not dose-based; therefore, doses to the hypothetical intruder are not relevant in demonstrating compliance with 40 CFR 191.

These unique aspects are deliberate; the EPA's 40 CFR 191 is probably the most reviewed, and the most deliberated, environmental standard in U.S. history. At the request of President Ford, the EPA began work on 40 CFR 191 in 1976. After a series of public meetings, technical studies, and a Draft Environmental Impact Statement, the EPA proposed 40 CFR 191 in 1982 (47 FR 58196). The EPA then solicited additional written comments and held more public hearings. Additionally, the Agency's Science Advisory Board held nine public meetings reviewing the draft rule. The final rule was published in 1985 (50 FR 38066). Then, in 1987, the U.S. Court of Appeals remanded the disposal standard. After additional deliberation, and Congressional intervention, the EPA published the current version of 40 CFR 191 in 1993 (58 FR 66398). Every aspect of this short standard has been thoroughly reviewed.

Summary of 40 CFR 191

Subpart B of 40 CFR 191 contains three quantitative sets of requirements: containment; individual protection; and groundwater protection. The fourth set of requirements (assurance) are to help provide assurance that the three quantitative requirements are met. Each of these four requirements are reviewed below. The bolded text highlights important features of the standard. A few of the legal definitions used in 40 CFR 191 are presented at the end of this section.

Containment Requirement (40 CFR 191.13) Disposal systems shall be designed to provide the reasonable expectation, based on PA, that the cumulative releases of radionuclides **to the accessible environment** for 10,000 years after disposal from **all significant processes and events** shall:

(a) have a likelihood of less than one chance in 10 of having an EPA Sum greater than one, and
(b) have a likelihood of less than one in 1,000 of exceeding an EPA Sum of 10.

The EPA sum is the ratio of the calculated releases (the calculated curies that move through the controlled area boundary) divided by the number of curies set by the release limit. The release limit is taken from a table in the back of 40 CFR 191.

Assurance Requirement (40 CFR 191.14) To provide confidence and defense in depth that the Containment Requirement will be met, disposal shall be conducted such that: (a) active institutional controls are maintained as long as practical; however, the PA shall assume controls fail after 100 years; (b) disposal systems shall be monitored; (c) disposal systems shall be designated by permanent markers, records, and other passive controls; (d) disposal systems shall use both engineered and natural barriers; (e) places that have been mined for resources or where there is the reasonable expectation of scarce or easily accessible resources should be avoided; and (f) removal of most of the wastes shall not be precluded for a reasonable time after disposal. At NRC licensed facilities, the NRC sets "equivalent" Assurance Requirements, which supersede the EPA's Assurance Requirements.

Individual Protection Requirement (40 CFR 191.15) - Disposal systems shall be designed to provide the reasonable expectation that, for 10,000 years after disposal, **undisturbed performance** of the disposal system shall not cause the annual committed effective dose to any member of the public **in the accessible environment** to exceed 15 millirems.

Groundwater Protection Requirement (40 CFR 191.16) Disposal systems shall be designed to provide the reasonable expectation that, for 10,000 years after disposal, **undisturbed performance** of the disposal system shall not cause the levels of radioactivity in any underground source of drinking water **in the accessible environment** to exceed the limits specified in 40 CFR 141 as they existed on January 19, 1994. Regulation of disposal systems above or within a formation which are within 1/4 of a USDW are reserved; the subject of future rulemaking.

Some Definitions

"Accessible environment" is defined as:

(1) The atmosphere; (2) lands surface; (3) surface waters; (4) oceans; and (5) all of the lithosphere **that is beyond the controlled area.**

"Controlled area" is defined as:

(1) A surface location, to be identified by passive institutional controls, that encompasses no more than 100 square kilometers and extends horizontally no more than five kilometers in any direction from the outer boundary of the original location of the radioactive wastes in a disposal system; and (2) the subsurface underlying such a surface location.

"Undisturbed performance" is defined as:

the predicted behavior of a disposal system, including consideration of the uncertainties in the predicted behavior, **if the disposal system is not disrupted by human intrusion** or the occurrence of unlikely natural events.

Protection of the Inadvertent Human Intruder

The Containment Requirement requires consideration of inadvertent human intrusion, but the standard is not dose-based; therefore, doses to the hypothetical intruder are not calculated for the Containment Standard. The EPA recommends in Appendix B of 40 CFR 191 for calculating fluxes (not doses), that inadvertent human intrusion can be assumed to be no more severe than 30 random, exploratory boreholes per square kilometer per 10,000 years. The Groundwater Protection Requirement and the Individual Protection Requirement are, by regulation, to be assessed under the assumption that the disposal system has not been disturbed by human intrusion. By regulation there can be no dose to the intruder.

Summary of DOE Order 5820.2A, Chapter III

The previous section summarized the EPA requirements for disposal of HLW. This section reviews the DOE requirements for disposal of LLW. Disposal of LLW at DOE sites is covered by Chapter III of DOE Order 5820.2A. Paragraph 3(a) of Chapter III states that DOE LLW shall be disposed in a manner that meets four criteria.

" 1. Protect public health and safety in accordance with standards specified in applicable EH Orders and other DOE Orders.

2. Assure that external exposure to the waste and concentrations of radioactive material which may be released into surface water, groundwater, soil, plants, and

animals results in an effective dose equivalent that does not exceed 25 mrem/yr to any member of the public. Releases to the atmosphere shall meet the requirements of 40 CFR 61. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.

3. Assure that the committed effective dose equivalents received by individuals who inadvertently may intrude into the facility after the loss of active institutional control (100 years) will not exceed 100 mrem/yr for continuous exposure or 500 mrem for a single acute exposure.

4. Protect groundwater resources, consistent with Federal, State, and local requirements."

Paragraph 3(b) of Chapter III of DOE Order 5820.2A states that a PA shall be prepared and maintained for the purposes of demonstrating compliance with the four criteria of paragraph 3(a). Therefore, demonstrating compliance with paragraph 3(a) will require an approved PA. Many of the requirements in DOE Order 5820.2A, Chapter III are not well defined. In those instances, the recommendations of the DOE-funded Performance Assessment Task Team (Wood *et al.*, 1994) are typically cited in the earlier section titled "Comparison Between 40 CFR 191 and Order 5820.2A, Chapter III." Finally, Order 5820.2A has been under revision for the past couple of years, and the final requirements are not finalized; therefore, this paper presents the existing DOE requirements.

Conclusions

This paper provides an overview of the EPA's only standard for disposal of HLW (40 CFR 191) and compares that standard to the DOE's standard for disposal of LLW. A number of issues must be resolved prior to application of 40 CFR 191 to the onsite disposal of HLW at Hanford..

- It is not known if the NWPA applies to HLW that is not "new and readily retrievable." If the NWPA applies: (1) NRC's licensing criteria at 10 CFR 60 would apply; (2) an amendment to the NWPA would be needed for disposal of HLW at the Hanford Site (currently Yucca Mountain is the only site authorized for characterization under the NWPA); and (3) 40 CFR 191 would not apply (unless Congress required compliance with 40 CFR 191).

- If 40 CFR 191 does apply to Hanford, the EPA needs to promulgate the final Groundwater Protection Requirement of 40 CFR 191 for disposal systems within 1/4 mile of an aquifer.

However, the application of 40 CFR 191 may offer the following advantages over application of the DOE's Order 5820.2A, Chapter III:

- The HLW standard does not require protection of the inadvertent human intruder.
- The HLW standard is risk-based.

Appendix C
Comparison Between DOE O 5820.2A and DOE Draft O 435.1

Comparison Between DOE O 5820.2A and DOE draft O 435.1

Introduction

DOE Order 5820.2A, *Radioactive Waste Management*, dated 9-26-88, is compared with draft DOE Order (O) 435.1 and draft DOE Manual (M) 435.1, *Radioactive Waste Management*, dated 7-31-98 to identify differences and to determine the impact of the differences on closure of any residue which may remain in the SST's after retrieval. Draft O 435.1 (3.d.(2)) excludes

> Requirements ... that overlap or duplicate requirements of the NRC related to radiation protection, ... and security of nuclear material, ... [and] the design, construction, operation, and decommissioning of Office of Civilian Radioactive Waste Management facilities and activities licensed by the NRC or an Agreement State.

The Guidance associated with DOE 435.1 (i.e., DOE G 435.1) was not reviewed.

High-Level Waste.

DOE M 435.1 (II.A) defines HLW as: High-level waste is the highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and other highly radioactive material that the Nuclear Regulatory Commission, consistent with existing law, determined by rule requires permanent isolation.

DOE 5820.2A (Attachment 2, page 2, paragraph 18) defines HLW as: The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic waste and fission products in concentrations requiring permanent isolation.

Discussion: The TRU components identified in liquid waste, or solid waste derived from the liquid, were omitted in the definition of HLW in DOE M 435.1. This change is consistent with the EPA's legal definition of TRU wastes in 40 CFR 191 and has no impact.

Incidental Waste.

DOE M 435.1 (I.B): Waste resulting from reprocessing spent nuclear fuel that is determined to be incidental to reprocessing is not HLW, and shall be managed in accordance with the requirements for TRU waste or LLW, as appropriate. When determining whether spent nuclear fuel reprocessing plant waste shall be managed as another waste type or as HLW, either the citation or evaluation processes, as described in II.B(1) and II.B(2) of DOE M 435.1, shall be used.

(1) <u>Citation</u>. Waste incidental to reprocessing by citation includes spent nuclear fuel reprocessing plant wastes that meet the "incidental waste" description included in the promulgation of Appendix F, 10 CFR 50. These radioactive wastes are the result of reprocessing plant operations, such as, but not limited to: contaminated job wastes including laboratory items such as clothing, tools, and equipment; and other irradiated and contaminated fuel structural hardware.

(2) <u>Evaluation</u>. Determinations that any waste is incidental to reprocessing by the evaluation process shall be developed under good record-keeping practices, with an adequate quality assurance process, and shall be documented to support the determinations. Such wastes may include, but are not limited to, spent nuclear fuel reprocessing plant wastes that: (1) have been processed, or will be processed, to remove key radionuclides to the maximum extent that is technically and economically practical; and (2) will be managed to meet safety requirements comparable to the performance objectives set out in 10 CFR Part 61, Subpart C, *"Performance Objectives,"* and the following:

(a) Are to be managed, pursuant to DOE's authority under the *Atomic Energy Act*, as amended, and in accordance with the provisions of Chapter IV of this Manual, provided the waste will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C low-level waste as set out in 10 CFR Part 61.55, *"Waste Classification;"* or

(b) Will meet alternative requirements for waste classification and characteristics, as the Nuclear Regulatory Commission may authorize. Such waste shall be managed pursuant to DOE's authority under the *Atomic Energy Act*, as amended, in accordance with the provisions of:
   1. Chapter IV of 435.1 M; or
   2. Chapter III of 435.1 M, if the waste contains radionuclides that meet the definition of transuranic waste contained in Chapter III.

Authority for determining if a waste is incidental is defined in draft 435.1 M (I.E.2.(17)) which states that the DOE Field Element Manager is responsible for

> Ensuring that waste incidental to reprocessing determinations are made by either the "citation" or "evaluation" .... Obtaining the concurrence of the Office of Environmental Management in such determinations, including the basis for concluding that the Nuclear Regulatory Commission does not have regulatory interest in waste determined to be incidental to reprocessing through the "evaluation" process."

DOE 5820.2A does not define or discuss 'Incidental Waste.'

Discussion: DOE O and M 435.1 acknowledges "incidental wastes" and this acknowledgment adds a closure option for DOE facilities responsible for closing HLW facilities. The two options for making a determination of incidental waste are citation and evaluation. A determination of incidental waste using citation seems to be limited to "fuel reprocessing plant wastes" and could not be applied to SST residue (for example). Closure of tank residue under evaluation is linked to the three Incidental Waste Criteria discussed earlier in this main body of this report. Under the evaluation process, this version of 435.1 M allows a facility to either (1) meet the Class C limits or (2) meet alternative requirements for waste classification and characteristics, as the NRC may authorize. This version of draft 435.1 M provide a quantitative boundary between HLW and incidental wastes and allows a facility such as Hanford flexibility in closing their HLW facilities.

Requirements for Closure.

DOE O 435.1 M (II.U): Facilities that can be cleaned to meet the requirements for decommissioning shall be placed in a condition that meets DOE decommissioning and decommissioning requirements. Facilities that cannot meet the decommissioning requirements shall be closed under the requirements of: 1) Partial Closure; or 2) Final Closure. Final closure shall meet the requirements of a LLW disposal site as specified in Chapter IV of 435.1, a TRU waste disposal site as specified in Chapter III of this 435.1, or shall be completed in accordance with the CERCLA process.

DOE 5820.2A (II.3d) " Disposal. New and readily retrievable waste shall be processed and the high-level waste fraction disposed of in a geologic repository according to the requirements of the Nuclear Waste Policy Act of 1982 (Public Law 97-425) as amended. Options for permanent disposal of other wastes, such as single shell tank waste, shall be evaluated and include such methods as in-place stabilization as well as retrieval and processing, as required for new and readily retrievable waste. Analytical predictions of disposal system performance shall be prepared and incorporated in the National Environmental Policy Act process. ... (2) Other Wastes. .... Options for permanent disposal of singly contained tank waste shall be evaluated and include such methods as in-place stabilization as well as retrieval and reprocessing, as required for new and readily retrievable waste in paragraph 3d(1). "

Discussion: For wastes that can not be readily retrieved, the new order replaces the option of in-place stabilization of HLW with three closure options: (1) close as a LLW disposal site as specified in the LLW Chapter of DOE M 435.1; *or* (2) close as a TRU waste disposal site; or (3) close under CERCLA. These requirement offer DOE regulatory flexibility to close HLW disposal facilities.

Mixed Waste.

DOE O 435.1 (II.C): All TRU and HLW shall be considered mixed waste unless demonstrated otherwise and is thus subject to the requirements of both the Atomic Energy Act, as amended, and RCRA, as amended. HLW generated during the reprocessing of spent nuclear fuel exhibiting the characteristics of corrosivity (EPA Hazardous Waste Number D002) and toxicity for metals (EPA Hazardous Waste Numbers D004--D011) shall be treated using vitrification in accordance with the Land Disposal Restriction (LDR) treatment standards specified in 40 CFR 268.40, *Applicability of Treatment Standards*; and 40 CFR 268.42, *Land Disposal Restriction.*

DOE 5820.2A (Attachment 2, page 3, paragraph 22): Waste containing both radioactive and hazardous components as defined by the Atomic Energy Act of 1954 and RCRA, respectively.

Discussion: DOE M 435.1 provides an expanded discussion of possible RCRA requirements, whereas DOE 5820.2A simply requires compliance with RCRA. No impact, 435.1 just acknowledges some of the specific requirements of RCRA.

Transuranic Waste.

DOE O 435.1 (III.A): The term transuranic waste means waste containing more than 100 nCi (3700 Bq) of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater that 20 years, except for: (1)high-level radioactive waste; (2) waste that the Secretary of Energy has determined, with the concurrence of the Administrator of the Environmental Protection Agency, does not need the degree of isolation required by the disposal regulations; or (3) waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with Part 61 of Title 10, Code of Federal Regulations

DOE 5820.2A (Attachment 2, page 4, paragraph 39): Without regard to source or form, waste that is contaminated with alpha-emitting transuranic isotopes with half-lives greater than 20 years and concentrations greater than 100 nCi/g at the time of assay is classified as transuranic waste. Heads of Field Elements can determine that other alpha-contaminated wastes, peculiar to a specific site, must be managed as transuranic waste.

Discussion: The DOE Order 5820.2A definition for TRU waste could include HLW if the waste met the requirements of both waste types. Draft DOE M 435.1 corrects the problem by specifically excluding HLW in the definition of TRU waste. In other words, if a waste meets the definition of both HLW and TRU waste, the waste is managed as HLW and is not managed as both HLW and TRU waste. This change is consistent with the EPA's legal definition of TRU wastes in 40 CFR 191 and has no impact.

Waste Characterization.

DOE M 435.1 (II.L): Waste shall be characterized at generation, during storage, and after subsequent pretreatment or treatment processes in sufficient detail to ensure safe storage and subsequent treatability to meet requirements in the DOE/EM-0093, *Waste Acceptance Product Specifications for Vitrified High-Level Waste Forms*, applicable revision, or to meet the requirements for disposal as LLW or mixed LLW.

(1) **Data Quality Objectives.** The data quality objectives process shall be used for identifying characterization parameters and acceptable uncertainty in characterization data.

(2) **Minimum Waste Characterization Requirements.** Characterization data shall, at a minimum, include the following:
- (A) Physical and chemical characteristics;
- (B) Volume including any solidification media; and
- (C) Radionuclides or source information sufficient to describe the approximate radionuclide content of the waste.

(3) **Hazardous Characteristics.** Waste characterization processes shall yield sufficient chemical and physical data to clearly identify any hazardous characteristics that may degrade the ability of structures, systems and components to perform their radioactive waste management functions.

DOE 5820.2A (I.3.b(1)): Doubly contained tank systems. Liquid and solidified high-level waste shall be characterized consistent with radiation protection requirements to determine its hazardous components, per 40 CFR 261 and 40 CFR 264. Characterization shall satisfy requirements of paragraph 3b(1)(b) and may reflect knowledge of waste generating processes, laboratory testing results, and/or the results of periodic sampling and analysis. Examples of required information are chemical composition, physical properties, radionuclide concentrations, and pH.

DOE 5820.2A (I.3.c(1)): Singly contained tank systems. The contents of singly contained tank systems shall be characterized consistent with radiation protection requirement and the needs associated with safe storage to determine its hazardous components consistent with 40 CFR 261, 40 CFR 264, and State requirements. Characterization may reflect knowledge of waste generating processes, laboratory testing results, and/or the results of periodic sampling and analysis.

Discussion: Waste characterization may be satisfied via a number of options. The draft Order/Manual requires use of the data quality objectives process and that radionuclides must be sufficiently characterized to describe the approximate radionuclide content of the waste. Draft 4325.1 M stops short of requiring laboratory analysis of HLW. DOE 5820.2A requires that singly contained tank systems shall be characterized according to applicable Federal *and* State requirements.

Appendix D
U.S. Nuclear Regulatory Commission Letter of June 9, 1997

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

June 9, 1997

Mr. Jackson Kinzer, Assistant Manager
Office of Tank Waste Remediation System
U.S. Department of Energy
Richland Operations Office
P.O. Box 550
Richland, WA 99352

SUBJECT: CLASSIFICATION OF HANFORD LOW-ACTIVITY TANK WASTE FRACTION

Dear Mr. Kinzer:

The U.S. Nuclear Regulatory Commission has received your letter dated November 7, 1996, requesting NRC agreement that the Hanford tank waste planned for removal from the tanks and disposal on-site is incidental waste [i.e., not high-level waste (HLW)] and, therefore, would not be subject to NRC licensing authority. In response to your request, NRC and contractor staff [Center for Nuclear Waste Regulatory Analyses (CNWRA)] have reviewed the "Technical Basis for Classification of Low-Activity Waste Fraction from Hanford Site Tanks" (Technical Basis report) and supporting documents, including the "Hanford Low-Level Tank Waste Interim Performance Assessment" [Interim Performance Assessment (PA)], to determine whether there is reasonable assurance that the tank waste slated for disposal as low-activity waste (LAW) meets the incidental waste classification criteria specified in the March 2, 1993, letter from R. Bernero, NRC, to J. Lytle, U.S. Department of Energy (DOE).

Criterion One from the March 1993 letter specifies that "...wastes have been processed (or will be further processed) to remove key radionuclides to the maximum extent that is technically and economically practical." To comply with this criterion, available separation technologies were identified for each of the main radionuclides of interest and individually evaluated to determine the status of the technology and the radionuclide removal efficiency. Three separation technologies were deemed both technically and economically practical. Currently, it is expected that all three will be used. The three technologies include a simple solids-liquids separation, removal of transuranics wastes from selected tanks, and single-cycle ion exchange removal of cesium-137 from certain wastes. Approximately 3.1 x 10^{17} Bq (8.5 MCi) of activity will remain in the LAW, which corresponds to about 2 percent of the estimated 15.6 x 10^{18} Bq (422 MCi) generated at the Hanford site (based on a December 31, 1999, decay date).

NRC staff concludes that available separation processes have been extensively examined to determine those that are both technically and economically practical, and that the residual 2 percent of the activity generated at the Hanford site represents the maximum amount of separation currently technically and economically practical for this case. It is considered that Criterion One for classifying the Hanford site LAW fraction as incidental waste will be met if the waste management plan presented in the Technical Basis report is followed. Note that if actual radionuclide inventories, either in the tanks or following separation, are significantly higher than or different in character from those projected, compliance with this criterion will require re-evaluation by NRC.

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Compliance with Criterion Two. "...wastes will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C [low-level waste] as set out in 10 CFR Part 61," was determined using the estimated total vitrified waste volume (158,000 m^3)(42,000,000 gallons) in conjunction with projected radionuclide activities. From these calculations, which NRC staff verified, the vitrified waste form is expected to meet the limits for Class C or less, as specified. Note that molten metal processing is also being considered for the LAW form. This method would considerably decrease the total waste form volume such that the waste classification could be affected. If the radionuclide inventories in the LAW are significantly higher than those projected in the Technical Basis report, or if the waste form type or total volume are altered, re-evaluation of conformance with this criterion will be necessary.

To evaluate Criterion Three, "...wastes are to be managed, pursuant to the Atomic Energy Act, so that safety requirements comparable to the performance objectives set out in 10 CFR Part 61, Subpart C are satisfied," an Interim PA was prepared. The DOE PA was performed to the requirements of DOE Order 5820.2A, "Radioactive Waste Management," September 26, 1988. This order is similar to the 10 CFR Part 61 performance objectives.

The Interim PA is the first of three PAs planned and is somewhat preliminary: it was conducted before selection of a disposal facility site and design, specific treatment alternatives, LAW form, or a complete and verified radiological and chemical characterization of the contents of the Hanford tanks. Our review identified a number of specific issues and concerns associated with the Interim PA, documented in the February 6, 1997, Request for Additional Information (RAI) from M. Bell, NRC, to D. Wodrich, DOE, and discussed in the enclosed CNWRA report. DOE's responses to the RAI constitute Appendix B to the CNWRA report. Many of the RAI comments cannot be fully resolved until the site, facility design, and solidification process are selected. It is expected that uncertainties and concerns identified with respect to the Interim PA can be satisfactorily addressed in the subsequent PAs.

Although the Interim PA is preliminary, it indicates that the performance objectives of Part 61 will be met. Consistent with the preliminary nature of this Interim PA, the staff's preliminary finding is that Criterion Three appears to be satisfied. As the disposal facility site is chosen, the disposal facility design is completed, treatment alternatives are selected, the LAW form is determined, and proper characterization of the contents of the tanks is confirmed, the various assumptions and input parameters are likely to be further refined. Please submit future PAs as supplements to the Technical Basis report so that they can be reviewed to confirm the current analysis and resolve any outstanding issues.

Based on the preliminary information provided in the DOE Technical Basis report and the Interim PA, the staff's preliminary finding is a provisional agreement that the LAW portion of the Hanford tank waste planned for removal from the tanks and disposal on-site is incidental waste and is, therefore, not subject to NRC licensing authority. Staff considers that the information presented is not sufficient to make an absolute determination at this time. Note that if the Hanford tank waste is not managed using a program comparable to that set forth in the Technical Basis report, or the current characterization of tank contents is not confirmed, the incidental waste classification must be revisited by DOE, and the NRC consulted. As a fundamental element of the incidental waste classification, DOE must ensure the contractors that perform LAW separation and disposal do so in accordance with the criteria set forth in the March 1993 letter and the approved Technical Basis report.

Successive PAs should be submitted as supplements to the Technical Basis report so that they can be reviewed to confirm the current analysis and resolve any outstanding issues. Other specific changes that would necessitate DOE re-evaluation and further consultation with NRC include, but are not limited to, the following:

1) Continuing characterization of tank waste results in a determination that the radionuclide inventory in the HLW tanks is higher than or different from that used to develop the Technical Basis report and the Interim PA. This would affect the resolution of all three criteria.

2) The LAW fraction of the Hanford tank waste is not vitrified, or the final volume of the waste form is significantly different from that projected in the Technical Basis report. The waste form is a determining factor in classification of waste as Class A, B, or C (Criterion Two), and would also impact PA (Criterion Three).

3) Final selection of the LAW disposal site, or changes to site characterization parameters will affect the resolution of Criterion Three.

If you have any questions about the details of this letter, please contact Michael Bell of my staff at (301) 415-7286.

Sincerely,

Carl J. Paperiello, Director
Office of Nuclear Material
Safety and Safeguards

Enclosure: As stated

cc: D. Wodrich, DOE
D. Pepson, DOE
D. Bartus, EPA
R. Stanley, WA State
S. Dahl, WA State
B. Nichols, WA State
J. Erickson, WA State
M. Blazek, OR State
D. Stewart-Smith, OR State
R. Paris, OR State
R. Sockzehigh, YTC
R. Jim, YIN

Appendix E
NRC Letter of June 30, 1998 to Savannah River Site

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

June 30, 1998

Mr. Roy J. Schepens
Acting Assistant Manager for High-Level Waste
U.S. Department of Energy
Savannah River Operations Office
P.O. Box A
Aiken, South Carolina 29802

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION REGARDING SAVANNAH RIVER SITE HIGH-LEVEL WASTE TANK CLOSURE; CLASSIFICATION OF RESIDUAL WASTE AS "INCIDENTAL"

Dear Mr. Schepens:

U.S. Nuclear Regulatory Commission (NRC) staff along with our contractor, the Center for Nuclear Waste Regulatory Analyses, have reviewed the "Regulatory Basis for Incidental Waste Classification at the Savannah River Site High-Level Waste Tank Farms." Rev. 1, as requested in the December 20, 1996, letter from Lee Watkins/ U.S. Department of Energy (DOE), to Carl Paperiello/NRC. In addition to reviewing the Regulatory Basis, we have examined several supporting references and have identified issues that need to be resolved before NRC staff can fully evaluate your request for agreement that the Savannah River high-level waste tanks planned for stabilization on-site can be classified as "incidental waste" that would not be subject to NRC licensing authority. We recognize that Tank 17 and Tank 20 have already been stabilized in place using this methodology.

In general, the concerns address the effects of certain assumptions, models, or parameters on dose calculations with respect to meeting the incidental waste classification criteria set forth in the March 1993 letter from R. Bernero/NRC, to J. Lytle/DOE. Specific questions and comments are listed in the enclosure. Key issues identified in the review include duration of institutional controls, engineered barrier lifetimes, concentration averaging to meet Class C limits, and selection of intruder scenarios.

We would like to resolve these issues in a meeting with you and your staff and contractors, either in-person, or through a telecon or videocon. Written responses to these comments and concerns should also be provided. Please contact Jennifer Davis at (301) 415-5874, or Richard Weller at (301) 415-7287 to discuss your preferred path toward resolution.

Sincerely,

King Stablein

N. King Stablein, Acting Chief
Engineering and Geosciences Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated

cc: E. Regnier, DOE-EH 412
M. Vickers, SCDHEC
J. Rhoderick, DOE-EM35

COMMENTS AND QUESTIONS REGARDING REVIEW OF THE "REGULATORY BASIS FOR INCIDENTAL WASTE CLASSIFICATION AT THE SAVANNAH RIVER SITE HIGH-LEVEL WASTE TANK FARMS," REVISION 1

I. SPECIFIC COMMENTS REGARDING REGULATORY BASIS FOR MEETING CRITERION ONE

"...the waste has been processed (or will be further processed) to remove key radionuclides to the maximum extent that is technically and economically practical ... "

A. Waste Characterization Issues

1. Sample analysis results from Tanks 17 and 20 led to a recognition of elevated contents (as compared to predicted values) of three important radionuclides: Tc-99, Pu-238, and Np-237. No discussion was provided concerning other radionuclides for which analyses were not done during the process knowledge acquisition effort. There may be related radionuclides that could be expected--on the basis of revised process knowledge--to accompany Tc-99, Pu-238, and Np-237 at elevated levels. The U.S. Department of Energy (DOE) should address how it plans to consider this issue.

2. Inconsistencies in tank inventories, which are natural consequences of the ongoing characterization effort, are reflected in the various documents. Some differences are causes for particular concern. For example, the Tc-99 inventory in the Tank 20 Characterization Report (d'Entremont and Hester, 1997) is 0.85 Ci based on sample data; this value is 15 times the value assumed for the fate and transport modeling (FTM) in the Tank 20 Closure Module (U.S. DOE, 1997a). However, d'Entremont and Hester (1997) suggest that the higher value was used in the Tank 20 performance assessment (PA). Considering the importance of Tc-99 to groundwater dose, this discrepancy should be resolved so that there is assurance that use of the lower value in modeling has not underestimated the dose. An order-of-magnitude difference is also observed for the Se-79 inventory for Tank 17 when comparing the Characterization Report (d'Entremont et al., 1997) with the Tank 17 Closure Module (U.S. DOE, 1997b). The identified inconsistencies need to be resolved as new inventories are applied in performance evaluations. In addition, the effects of the outdated inventories on FTM and the tank specific Pas should be addressed.

3. The characterization reports for Tanks 17 and 20 utilized analytical data from only two sludge samples each for comparison with process knowledge estimates. In the case of Tank 17, sampling for analysis was performed in January 1997 (d'Entremont et al., 1997) before slurry washing and sludge redistribution operations were conducted. Furthermore, Tank 17 samples were obtained from only the top layer of the sludge. These observations raise concern that the samples may not be sufficiently representative of the tank sludges. Both characterization reports note some variety in the appearance of solids suggesting the possible effects of in-tank chemical processes on the distribution of constituents. More extensive sampling should be undertaken in the tanks, so that greater confidence may be gained that a representative range of sludge radionuclide concentrations has been measured.

B. Technical Practicality Evaluation

The report did not provide information on radionuclide removal efficiencies for any of the waste removal options. For example, it was reported (U.S. DOE, 1996) that oxalic acid washing has been attempted in a few tanks. However, there is no information on the effectiveness of this process on radionuclide removal. In addition, sample analyses of Tanks 17 and 20 do not provide sufficient information to derive radionuclide removal efficiencies of water washing, although the values of radionuclide concentrations after water spray washing are provided in Tank 17 Closure Module (U.S. DOE, 1997b). It is difficult to assess, based on the information provided, whether wastes will be processed to remove radionuclides to the maximum extent technically feasible. Measured or estimated radionuclide removal efficiencies for bulk waste removal, water washing, and oxalic acid washing should be provided.

II. SPECIFIC COMMENTS REGARDING REGULATORY BASIS FOR MEETING CRITERION TWO

"...the waste will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C LLW, as established in 10 CFR 61.55 ..."

A. Application of the Branch Technical Position (BTP) on Concentration Averaging

No analysis has been provided supporting the application of the NRC "Branch Technical Position on Concentration Averaging and Encapsulation." It is unclear which 14 tanks "do not exceed the Class C low-level waste (LLW) limits for radionuclides listed in 10 CFR Part 61... us[ing] concentration averaging based on NRC guidelines in the BTP issued January 17, 1995" (U.S. DOE, 1997c). Similarly, it is unclear which are "the remaining 37 tank systems" which cannot meet the Class C LLW limits even with application of the BTP.

DOE should provide a discussion regarding this application of the BTP, including how it was applied (i.e., discussion of chosen sections, example calculations, safety factors if any, governing assumptions, etc.). This discussion should also address how the "14 tanks" differ from the "37 tanks," including a listing of which tanks fall into each category and list the source references for concentrations used in the analysis.

B. Alternative Provisions for Waste Classification

§61.58 *"The Commission may, upon request or on its own initiative, authorize other provisions for the classification and characteristics of waste on a specific basis, if, after evaluation, of the specific characteristics of the waste, disposal site, and method of disposal, it finds reasonable assurance of compliance with the performance objectives [P.O.] in Subpart C of this part."*

1. Intruder Scenario Basis for Exemption

As discussed in the Regulatory Basis (U.S. DOE, 1997c), the waste classification system in 10 CFR Part 61 is generally based on intruder protection. Other measures for intruder protection include engineered barriers and active and passive institutional controls. These measures are not assumed to be effective more than 500 years after closure. See further discussion in Section III of this Request for Additional Information (RAI).

"A maximum concentration of radionuclides is specified for all wastes so at the end of the 500 year period, remaining radioactivity will be at a level that does not pose an unacceptable hazard to an intruder or public health and safety [10 CFR 61.7(a)(5)]."

To support the basis provided for the alternative waste classification, intruder doses following the 500-year period should be shown to be no greater than 500 mrem/yr, assuming breakdown of engineered barriers and no institutional controls. Any deviation from these assumptions should be technically justified.

2. Additional Comments Related to Intruder Analysis Provided

   a. No rationale is provided regarding which tanks were chosen for the analysis (Cook, 1997). Note also, that the chosen tanks are Type III tanks that appear to be the most robust. If credit is taken for tank structure in the intruder analysis, choosing only Type III tanks could be nonconservative. A rationale for selecting tanks 25-28, 33-34, and 44-47 should be provided.

   b. Only four radionuclides were included in the intruder analysis; Sr-90, Tc-99, Cs-137, and Pu-239. I-129, and the actinides, U, Np-237, Pu (including Pu-238), Am-241, and Cm should be included in the intruder analysis (Cook, 1997), since the long-term hazard is expected to be dominated by actinides, and several of the radionuclides listed above occur in high concentrations, relative to the Class C limits, in Tanks 17 and 20. These radionuclides, along with Tc-99, should be included in the waste inventory at concentration levels commensurate with those detected in actual waste sampling.

   c. To support the alternative provisions for waste classification, the analysis should assume no oxalic acid cleaning of waste tanks, because the request is designed to show that adequate intruder protection can be provided without oxalic acid cleaning. It is not clear whether the current analysis assumes radionuclide inventories after oxalic acid cleaning or not. This should be addressed.

   d. DOE did not provide justification for not considering the groundwater pathway for intruder dose through the drilled borehole. Groundwater ingestion may be an important pathway for an intruder agriculture scenario, even if agricultural practices are not expected to disturb the wastes buried deep under the site. The groundwater pathway should be considered, or justification for its omission should be provided.

3. Remaining Performance Objectives

In addition to the intruder protection performance objective (P.O.), §61.58 requires reasonable assurance that the other P.O.s of Subpart C can be met. Reasonable assurance that these remaining P.O.s (protection of the general population, protection of worker, and site stability) can be met, should be shown assuming there has been no oxalic acid washing of waste tanks. Other assumptions should be consistent with those used in the PA for Criterion Three.

III. SPECIFIC COMMENTS REGARDING REGULATORY BASIS FOR MEETING CRITERION THREE

"...the wastes are to be managed, pursuant to the Atomic Energy Act, so that safety requirements comparable to the performance objectives set out in 10 CFR Part 61, Subpart C are satisfied."

A. General Comments on PA

1. U.S. DOE has performed *a priori* fate and transport modeling for all of the HLW tank systems in F-AREA, however, similar fate and transport modeling does not appear to have been done for the high-level waste (HLW) tanks in H-area. Similar modeling should be done for the H-area, or the rationale for not performing such modeling should be provided.

2. The FTM (Morrison, 1997) states that modeling for radiological dose was performed using only the major contributors to dose (beta-gamma emitters: Se-79, Tc-99, C-14, I-129, and the alpha emitting isotopes of U, Np, Pu, Am, Cm and their decay products).

   a. According to Table 2 of the FTM (Morrison, 1997), Pu-238, an alpha-emitter (and an appreciable contributor to the inventory in both Tank 17 and Tank 20), is not included in the modeling for radiological dose. Further, Np, U, and Pu-238 do not appear to be included in the modeling for the Tank 17 and 20 Closure Modules (U.S. DOE, 1997b and U.S. DOE, 1997a). These omissions should be justified or rectified.

   b. As shown in Table 2 of the FTM (Morrison, 1997), Sr-90 dominates the radionuclide inventory, but apparently contributes negligibly to dose due to retardation or decay, because it is not reported as a major contributor to dose in Table 10 of the same document. The report does not explicitly show why it is a negligible dose contributor. The FTM should list distribution coefficients for all modeled constituents, and make clear why a key radionuclide, such as Sr-90, is not important to dose.

3. It is unclear what degree of tank cleaning was assumed in the PA. Were tank waste concentrations assumed based on spray-washing only, or with additional oxalic acid cleaning? This should be clarified.

4. Effects of long-term (10,000 yr) natural phenomena (e.g., climate changes) were not considered in the PA, although such consideration was recommended by the Draft Staff Branch Technical Position on a Performance Assessment Methodology for Low-Level Radioactive Waste Disposal Facilities (Draft Staff LLW PA BTP (U.S. NRC, 1997)). Effects of long-term natural phenomena should be included in the PA.

5. An explanation should be provided for the conclusion that the estimated peak dose from Tc-99 occurs earlier (315 yrs) at 100 m than at 1 m (385 yrs) in the Water Table Aquifer in the FTM (Morrison, 1997). A similar apparent inconsistency is present in the peak doses for the Congaree Aquifer (Morrison, 1997).

6. The Draft Staff LLW PA BTP (U.S. NRC, 1997) recognizes two different approaches for representing system performance in the context of the post-closure performance objective. One approach provides a single bounding estimate of system performance. supported by data and assumptions that clearly demonstrate the conservative nature of the analysis. The other approach provides a quantitative evaluation of uncertainty with regard to system performance represented by a distribution of potential outcomes. The analyses supporting the Regulatory Basis appear to be a mix of these two approaches. A consistent approach would make it much simpler to evaluate conformance with Criterion Three.

B. Engineered Barriers

1. In the FTM (Morrison, 1997), the assumption is made that the tank top, grout and basemat will fail at 1000 yr. Part 61 states that the effective life of these barriers should be no longer than 500 years. Any period of time claimed for the performance of engineered barriers, including periods exceeding 500 years, should be supported by suitable information and justification (U.S. NRC, 1997). No supporting data and analyses are provided for stabilized HLW tank performance other than a reference to estimated E-Area vault lifetime, which is not clearly analogous to stabilized HLW tank lifetime. The engineered barriers of the stabilized HLW tank system should be assumed in the PA to last no longer than 500 years, unless engineered barrier lifetimes greater than 500 years can be technically justified.

2. The hydraulic conductivity of the concrete basemat (Morrison, 1997) is assumed to be 9.6×10^{-9} cm/sec until the concrete basemat and the grout fail. This parameter then has a step-change to 6.6×10^{-3} cm/sec. Prior to total failure of the basemat and/or grout, there may be a period during which cracks and microfractures have significantly affected the hydraulic conductivity of the materials. The potential for time-dependent degradation and the consequent effects on hydraulic conductivity should be considered.

3. The FTM (Morrison, 1997) assumes that all tanks remain above the water table. Some of the HLW tanks are currently partially below the water table (U.S. DOE, 1996). The

effect of the water table proximity to the tanks on the performance of the engineered barrier does not appear to be factored into the PA, and the effect of a fluctuating water table does not appear to be factored into the PA either. If the water table is above the tank bottom, then the assumption of rain water infiltration from the tank roof through the reducing grout becomes tenuous. In such a case, the effectiveness of reducing grout in controlling the source term may be questionable, due to water infiltration from the sides and from below, and because of discrete areas of non-homogeneity. In addition, the increased water flux at the radionuclide source will significantly affect transport away from the source. More realistic (and more conservative) water table heights should be assumed in the PA.

C. Institutional Control Issues

1. The DOE proposal for institutional control of the area near the tank farms and extending to Fourmile Creek should be clarified before a PA that supports conformance with Criterion Three can be accepted. The DOE approach to institutional control does not appear consistent among the reviewed documents. The various reports describe planned institutional controls for the site/portions of the site as: (1) active institutional controls for 100 years with area under federal control in perpetuity thereafter [Regulatory Basis (DOE 1997c)]; (2) zoning as an industrial use area for 10,000 years [FTM (Morrison, 1997)]; (3) active institutional controls for 100 years followed by zoning for industrial use for an indefinite period with deed restrictions on the use of groundwater [Closure Plan (DOE, 1996)]; and (4) "DOE . . . control of the site in perpetuity" (Watkins, 1996).

   Institutional control discussions are not consistent throughout the reviewed documents, nor are they generally consistent with NRC regulations and guidance that do not permit reliance on active institutional controls for more than 100 years [§ 61.59(b)]. Because the safe management of waste under Part 61, consistent with current NRC policy, generally includes the assumption that institutional controls may not be relied on for more than 100 years. DOE's demonstration should incorporate that assumption, unless DOE can provide an appropriate justification for not incorporating the assumption.

2. Without active institutional controls for 10,000 yrs, other onsite exposure scenarios should be considered. For example, if the controlled area is to remain open to industrial use, then the aquifer characteristics should be considered with respect to potential use. The aquifer is currently capable of producing drinking water. The possibility of industrial drilling anywhere in the controlled area, not just through the tank system, should be a scenario in the PA.

D. Groundwater Transport Modeling

1. Model uncertainty may not be adequately addressed by the Multimedia Environmental Pollutant Assessment System (MEPAS) in the framework of the groundwater transport segment (GTS) construct. Benchmarking the MEPAS results for the GTS construct against results from a more detailed, physically based model will provide validation of the MEPAS/GTS abstraction and will support its continued use for the remaining tank

closures. For example, a computer code that models the three aquifers and the intervening confining layers in an integrated manner will provide a better estimate of the doses. The FTM (Morrison, 1997) states that an independent sensitivity and uncertainty analysis by Sandia National Laboratory indicated that uncertainty has been properly addressed (Cook, 1996). It is not clear from the FTM (Morrison, 1997) if Cook (1996) addressed model uncertainty. The specific issues concerning model uncertainty are:

a. the vertical transport of contaminants is not adequately addressed in the GTS construct. At distances horizontally removed from the tanks, the GTS construct does not allow for interaction of the aquifers. The lack of interaction is counter to the conceptual model from which the percentages of contaminants in each aquifer appear to have been calculated; and

b. apportioning the release of contaminants in each aquifer immediately below the source area through the use of pseudo-unsaturated layers in MEPAS is neither a conservative nor a realistic choice. This methodology incorporates dilution that is not likely to be present in the physical system. Furthermore, the percentage of downward flux from the Water Table Aquifer to the Barnwell-McBean Aquifer suggests a predominantly vertical flow system. The vertical flow conceptual model is counter to the layered sedimentary system with partially confining clay layers as described in U.S. DOE (1996).

The methodology used to calculate the percentages, as well as the evidence for no further hydraulic communication between the aquifers down gradient from the tanks, should be provided. This information is discussed in U.S. DOE (1994), the first in the list of additional documents requested in Section IV of this RAI.

2. Streamlines in the Barnwell-McBean Aquifer from the H-Area tank farm potentially intersect those from the F-Area tank farm (Flach, 1993). Accordingly, the GTS framework for the F-Area should incorporate the H-Area tank releases. So, the detailed model used as a benchmark for MEPAS and GTS construct would also include the H-Area tank farm.

E. Parameter Selection

1. There is no adequate description of how the value of pore velocity is estimated for input to the MEPAS code. A description should be provided.

2. Effective porosities in Table 6 of U.S. DOE (1997b) are smaller than field capacities. This does not seem conservative and should be corrected.

3. The potential presence of high conductivity zones such as the one controlling a tritium plume near the H-Area basins (Flach, 1993) has not been incorporated into the estimates of hydraulic conductivity for the F-Area modeling. The existence of the hydraulic conductivity zone was not known until the tritium migration was monitored. The high-conductivity zones should be considered in the FTM.

F. Source Term Issues

The transport model makes no allowance for the possible increase in radionuclide source terms due to decay chain ingrowth. Ingrowth needs to be considered in the model.

G. Protection of Individuals from Inadvertent Intrusion

1. The intruder scenario for PA is different from that used to support application of concentration averaging for Criterion Two. For the former, a worker or teenage intruder exposed at the shoreline of Four-Mile Creek was considered. For the latter, an intruder-agriculture scenario was used. Intruder scenario(s) should be consistent for all aspects of the Regulatory Basis.

2. Given the uncertainty of maintaining active institutional control for 10,000 years, the intruder approach used for PA may be inadequate for evaluating conformance with Criterion Three. For the type of aquifer under the control area, other on-site scenarios, such as those involving wells, are possibilities that should be considered for an industrial zoned area. Intruder scenario(s) should be carefully selected and fully justified. See additional discussion in Section III.C.2 of this RAI.

H. Distribution Coefficients for Radionuclide Transport

The sensitivity analysis done as part of the FTM (Morrison, 1997) shows that radionuclide distribution coefficients (K_ds) are one of the more sensitive parameters. Considering the sensitivity of these parameters, the following should be considered.

a. The K_ds used for some radionuclides do not appear to be conservative. For example, C-14, I-129, and Tc-99, which are generally assumed to have $K_d = 0$, have been assigned non-zero values. Although nonconservative K_ds will not change the peak dose for any radionuclide, the time to peak dose will change. Part of the DOE demonstration of conformance depends upon spreading the arrival times for the peak doses for the radionuclides at the seepline. This should be corrected, or justified.

b. For K_ds in the source waste layer, the FTM (Morrison, 1997) uses values determined or estimated for cementitious materials in a reducing environment. An important potential problem with this assumption arises from consideration of the possible inefficiency of grout-sludge mixing. The sorption behavior of elements in the presence of the sludge may differ significantly from that in the presence of reducing cementitious materials, because aqueous chemistry may change markedly as water percolates from grout into a sludge pocket or layer. Another possibility is that local radiolysis of water by radionuclides present in the sludge may create oxidizing free radicals or hydrogen peroxide that will increase the solubility of some radionuclides. These effects should be considered and discussed as part of the FTM.

c. Similarly, no mention is made of the possible effect of cement degradation on the sorbent properties of Zones II and III (the concrete basemat and the vadose zone). As discussed by Bradbury and Sarott (1995), progressive degradation of cementitious materials affects not only the solid phase characteristics of the material, but also the aqueous chemistry. For example, a significant level of cement-water interaction under reducing conditions can lead to degradation that may lower the K_d for Tc by a factor of 10, or of the actinides by a factor of 5. Such degradation would also affect the hydraulic properties of the grout and basemat. The very high K_ds used in Zone III (the vadose zone) may be nonconservative if the concrete basemat is not composed of strongly reducing concrete. These effects should be considered in the PA.

I. Radionuclide Solubilities

Sensitivity analysis should also be performed with particular attention to Pu and U solubilities.

a. Long-term degradation of cementitious materials can affect aqueous chemistry, and solid phases could affect radionuclide solubilities. These effects do not appear to have been considered.

b. The addition of a solution of calcium hydroxide, sodium thiosulfate, and calcium sulfide as a pretreatment before grout pouring (U.S. DOE, 1997a) could affect U and Pu solubility, and should be considered in the DOE analyses.

IV. ADDITIONAL DOCUMENTS REQUESTED

Please forward two copies each of the following documents:

1. U.S. DOE, 1994. WSRC E-7 Procedure Document Q-CLC-H-00005, Revision 0, August 3. 1997.

2. Hester, J.R., 1996. "High-Level Waste Characterization System," WSRC-TR-96-0264, Aiken. S.C, Westinghouse Savannah Company.

3. Cook. J., 1996. Interoffice Memorandum (May 17) to B.T. Butcher. "Evaluation of Computer Modeling for High Level Waste Tank Closure," Aiken. SC; Westinghouse Savannah River Company.

REFERENCES

1. Bradbury, M.H., and F. Sarott, 1995. "Sorption Databases for the Cementitious Near-Field of a L/ILW Repository for Performance Assessment." PSI Bericht Nr. 95-06, Switzerland: Paul Scherrer Institute.

2. Cook, J.R., 1996. Interoffice Memorandum (May 17) to B.T. Butcher, "Evaluation of Computer Modeling for High-Level Tank Closure," Aiken, SC; Westinghouse Savannah River Company.

3. Cook, J.R., 1997. Interoffice Memorandum (April 24) to B.T. Butcher, "Evaluation of High-Level Tank Residuals versus NRC Class C Criteria," SRT-WED-97-0176. Aiken, SC; Westinghouse Savannah River Company.

4. d'Entremont, P.D. and J.R. Hester, 1997. "Characterization of Tank 20 Residual Waste," WSRC-TR-96-0267, Aiken, SC: Westinghouse Savannah River Company.

5. d'Entremont. P.D., J.R. Hester, and T.B. Caldwell, 1997. "Characterization of Tank 17 Residual Waste," WSRC-TR-97-0066, Aiken, SC: Westinghouse Savannah River Company.

6. Flach, G.P., 1993. "Groundwater Model Calibration and Review of Remedial Alternatives at the F & H Area Seepage Basins (U)," WSRC-TR-93-384. Aiken, SC: Westinghouse Savannah River Company.

7. Morrison, A.S., 1997. "Environmental Radiological Analysis: Fate and Transport Modeling of Residual Contaminants and Human Health Impacts from the F-Area High-Level Waste Tank Farm, Savannah River Site," Aiken, SC: Halliburton NUS Corporation.

8. U.S. Department of Energy, 1996. "Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems, Savannah River Site," Construction Permit Numbers 14,338, 14,520, and 17,424-IW, Rev. 1, July 10, 1996; Aiken, SC: Savannah River Operations Office.

9. U.S. Department of Energy, 1997a. "Industrial Wastewater Closure Module for the High-Level Waste Tank 20 System, Savannah River Site," Construction Permit Number 17,424-IW, Rev. 1, January 8, 1997; Washington, DC: U.S. Department of Energy.

10. U.S. Department of Energy, 1997b. "Industrial Wastewater Closure Module for the High-Level Waste Tank 17 System, Savannah River Site," Construction Permit Number 17,424-IW, Rev. 2, August 26, 1997; Washington, DC: U.S. Department of Energy.

11. U.S. Department of Energy, 1997c. "Regulatory Basis for Incidental Waste Classification at the Savannah River Site High-Level Waste Tank Farms," Rev. 1, April 30, 1997.

12. U.S. Nuclear Regulatory Commission, 1995. "Issuance of Final Branch Technical Position on Concentration Averaging and Encapsulation." January 17, 1995. Washington. DC: U.S. Nuclear Regulatory Commission

13. U.S. Nuclear Regulatory Commission, 1997. "Branch Technical Position on a Performance Assessment Methodology for Low-Level Radioactive Waste Disposal Facilities: Draft for Public Comment." NUREG-1573, May, 1997; Washington, DC: U.S. Nuclear Regulatory Commission.

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Appendix F
Comparison of Contents of 149 Single-Shell Tanks to NRC Class C Limits

Appendix F

Comparison of Contents of 149 Single-Shell Tanks to NRC Class C Limits

We were tasked to evaluate whether the residual waste concentrations in SSTs after 99% retrieval would meet NRC Class C criteria. After a review of several source documents recommended by Hanford personnel who are familiar with the status of Hanford tank inventory estimates, it was determined that tank-specific sludge concentrations and volume predicted by the Hanford Defined Wastes (HDW) model (Agnew et al., 1997) would serve the needs for a preliminary assessment. We also obtained inputs from Steve Agnew regarding the appropriate use of HDW data. Table F-1 showed the results of our assessment of all the 149 SSTs. About 50% of the tanks would meet the NRC Class C limits based on the HDW tank concentration data. If a grout-averaging approach, such as the one used by SRS Tank 20, were used, another 35% of the tanks would meet NRC Class C limits with 10 inches grout pour to a 75ft-diameter tank (about the same grout volume for SRS Tank 20 Class C compliance.) It was also evident from Table F-1 that AX Tank Farm would present the biggest challenge in meeting NRC Class C limits.

NRC Class C analysis requires the evaluation of both long-lived and short-lived radionuclides and makes determination of waste classification based on the "sum-of-fraction" of long-lived radionuclides unless the short-lived radionuclide would requires a more restrict waste classification (See Appendix A for details). The plot of the cumulative probability of the sum-of-fraction (SF) for long-lived radionuclides (Figure 1.a) shows that the percentage of tanks (e.g., ~ 50%) that have SF less than a specific value (e.g., 1.0). This type of plot allows an assessment of the spreading of SSTs in NRC Class C compliance. Figure 1.b, the same type of plot for short-lived radionuclides, shows that only 10 % of the tanks would have SF larger than 1.0.

Even for those tanks, the much larger long-lived radionuclides SF dictate the waste classification. Figure 1.c plots the inches of grout required for the SF of long-lived radionculides equal to 1.0. This plot shows that only 15% of the tanks would requires more than 10 inches of grout for a 75 ft-diameter-equivalent tank. Figure 1.d shows that only 1 tank (B-107) has SF-short-lived greater than 1.0. (Since SF-long-lived for B-107 is less than 1.0, a grout pour of 10 inches would reduce the SF-short-lived to be less than 1.0.) Figures 2.a-d shows the SF plots by tank farm and they give an overview about the spreading within and among tank farms in addition to the values shown in Table F-1.

Table F-1. Waste Classification of Hanford Single Shell Tanks, Assuming 99% Retrieval

Tank Farm	Number of Tanks	% Meet NRC Class C limits	% meet Class C with 10 in Grout
A	6	0%	33%
AX	4	0%	0%
B	16	69%	94%
BX	12	67%	83%
BY	12	83%	100%
C	16	13%	75%
S	12	0%	92%
SX	15	13%	100%
U	16	44%	94%
T	16	75%	81%
TX	18	83%	94%
TY	6	100%	100%
Total	149	49%	86%

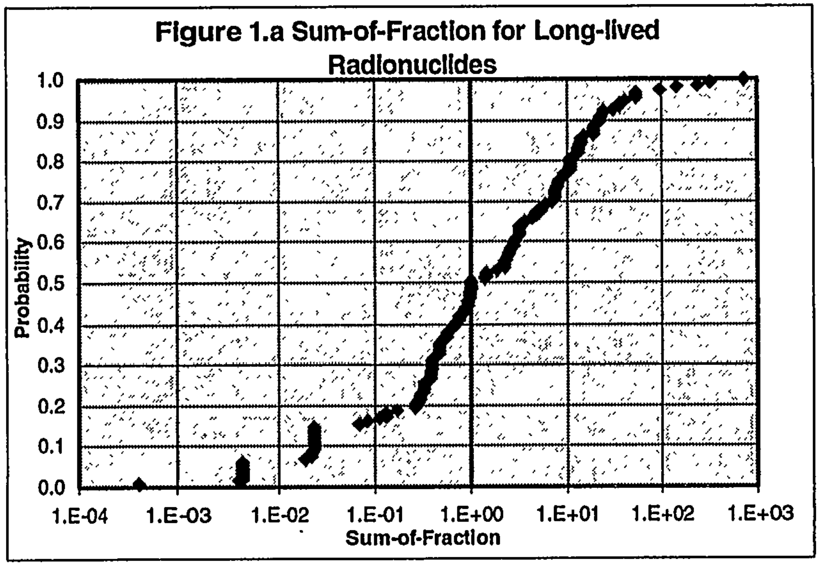


Figure 1.a Sum-of-Fraction for Long-lived Radionuclides
Probability
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1.E-04
1.E-03
1.E-02
1.E-01
1.E+00
1.E+01
1.E+02
1.E+03
Sum-of-Fraction

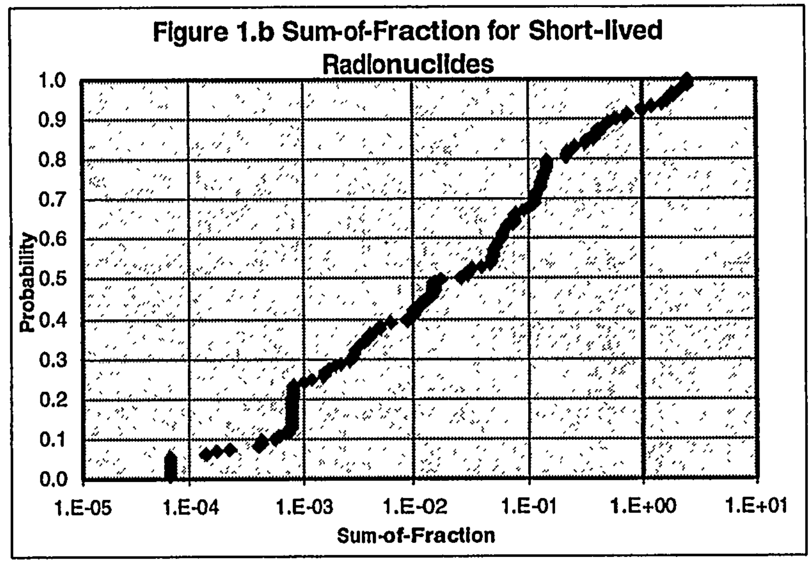


Figure 1.b Sum-of-Fraction for Short-lived Radionuclides
Probability
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1.E-05
1.E-04
1.E-03
1.E-02
1.E-01
1.E+00
1.E+01
Sum-of-Fraction

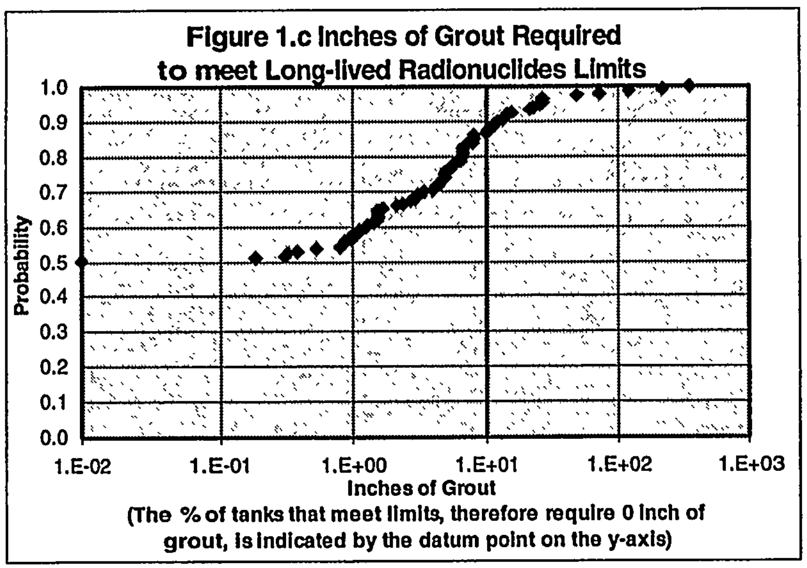


Figure 1.c Inches of Grout Required to meet Long-lived Radionuclides Limits
Probability
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1.E-02
1.E-01
1.E+00
1.E+01
1.E+02
1.E+03
Inches of Grout
(The % of tanks that meet limits, therefore require 0 inch of grout, is indicated by the datum point on the y-axis)

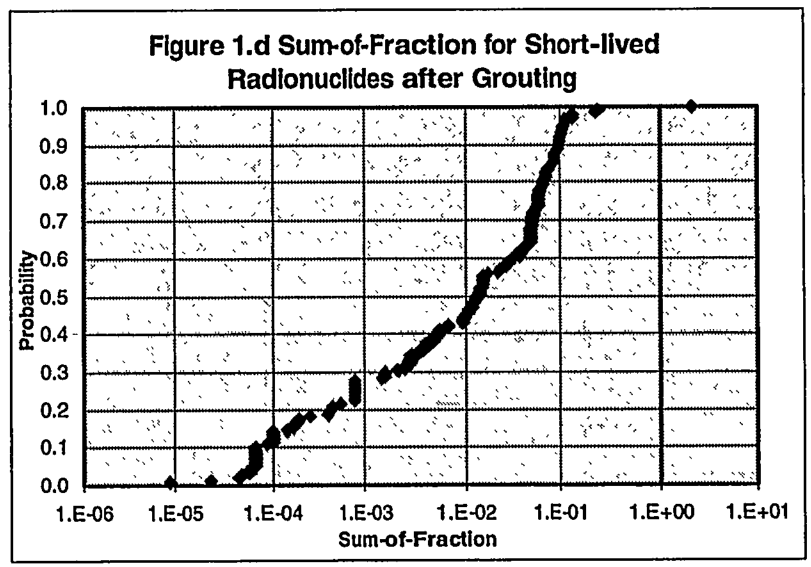


Figure 1.d Sum-of-Fraction for Short-lived Radionuclides after Grouting
Probability
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1.E-06
1.E-05
1.E-04
1.E-03
1.E-02
1.E-01
1.E+00
1.E+01
Sum-of-Fraction

Figure 2.a Sum-of-Fraction for Long-lived Radionuclides by Tank Farm

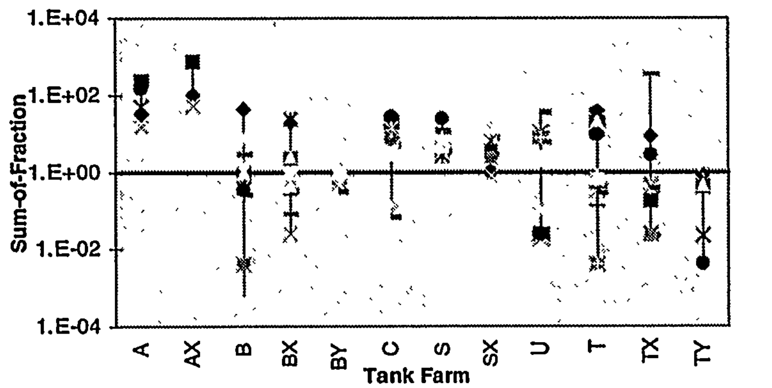


Figure 2.b Sum-of-Fraction for Short-lived Radionuclides by Tank Farm

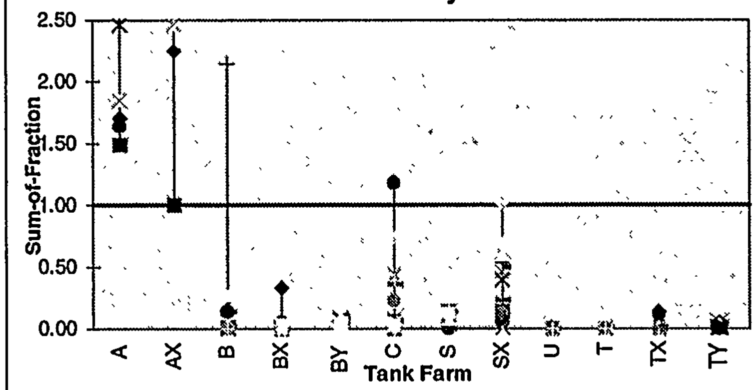
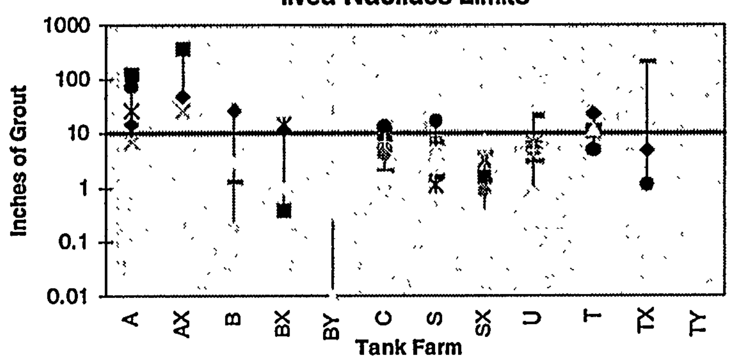
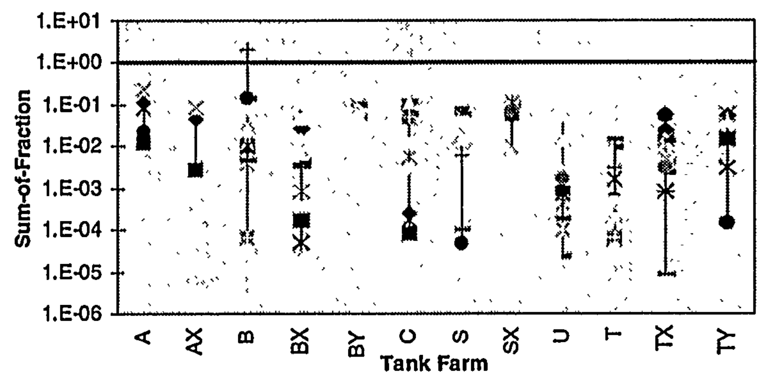


Figure 2.c Inches of Grout Required to Meet Long-lived Nuclides Limits



(About ?% tanks that require 0 inch of grout can not be plotted with log scale)

Figure 2.d Sum-of-Fraction for short-lived Radionuclides after Grouting



Appendix G
Comparison Between NRC Intrusion Model and Hanford LLBG Intrusion Model

Comparision Between NRC Intrusion Model and Hanford LLBG Intrusion Model

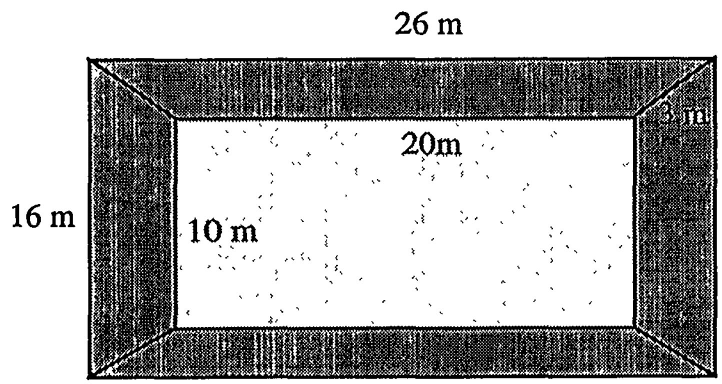
The current regulatory framework under 10 CFR 61.58 also allows a case-by-case consideration for meeting Class C limits (10 CFR 61, NRC, September 1981, NRC, January 1995). Given the contrast between the generic Class C scenario setting and the tank configuration (Figure 1), site-specific and disposal-configuration-specific Class C limits may be justified for this application.

To develop Hanford tank-specific Class C limits, we studied the NRC intrusion model and the scenarios used to derive the 10 CFR 61 Class C limits and proposed changes in model parameter values based on Hanford tank-specific configuration, proposed waste form and solidification method, and site-specific environmental/geological characteristics. No changes were made to the conceptual model and the performance objectives (i.e., the dose limits). Appendix B showed the proposed values and the technical basis for these proposed values. To aid in selecting appropriate values for Hanford tank-specific applications, we also evaluated the intrusion model and scenarios used in Performance Assessment of Hanford Low-level Burial Ground (LLBG).

Table G-1 shows the comparisons between the LLBG and NRC Intrusion models, exposure pathways, and exposure scenarios. The differences and implications of the LLBG model on the tank-specific Class C scenarios were stated in the Table G-2. Table G-2 and tables in Appendix A show some of the differences in parameter values between LLBG and NRC models. It is recognized that most of the parameters can not be compared directly because the models were constructed somewhat differently. For those that can be compared, the major difference is the dose limit of 500 mrem for the NRC model and 100 mrem for the LLBG model. It should be pointed out that this comparative study was not intended to be comprehensive, and was to identify relevant information to be considered in developing tank-specific parameter values for the NRC Class C intrusion model. At this stage, no intention was made to change the conceptual model and performance objectives used by the NRC for the derivation of 10 CFR 61 Class C limits.

Figure 1. Class C Model vs. Tank Configuration

- Topview of intruder-construction scenario configuration
  - intruder digs a 3-meter deep foundation hole (as shown below) for the house
  - top 2 meters is cover material; the bottom 1 meter is waste (additional 5 m intruder protection through layered disposal may be considered)
  - Tank AX-104 - 33 meters in dia.; 15 m in height, 2 m below ground surface



- Implication: Factors such as depth of barrier, waste averaging, waste form, and packaging, etc., could be considered in deriving tank-specific Class C limits.

Table G-1. Comparison between NRC Class C Intrusion Model and Hanford Intrusion Model.

Attributes for Comparison	NRC Class C Intrusion Model	Hanford LLW Burial Grounds PA Intrusion Model
Objective:	Develop criteria for waste governed by 10 CFR 61 (applicable to HLW tank Incidental Waste Classification)	Develop limits as Waste Acceptance Criteria for Hanford Low-level Waste Burial Ground (LLBG)
Documentation:	NUREG-0782	Hanford LLW WAC and PA (WMH-EP-0063; WHC-EP-0645)
Model Assumptions and parameter values:		
Intrusion type (scenario)	I. Intruder-construction scenario: an intruder build a house on the top of disposal site. Intruder digs a 3-meter deep foundation hole (20x10 m at the bottom, 26x16 m at the top) for the house. Top 2 meters is cover material and the bottom 1 meter is waste. The volumes of excavated waste and soil are 232 m^3 and 680 m^3, respectively. Intruder-agriculture scenario: an intruder lives in the house and consume vegetables from a small garden located in the waste/soil mixture. After building the house, 312 m^3 of 812 m^3 excavated vol. would be backfilled outside and around the cellar walls The rest of 600 m^3, with 150 m^3 of the original waste, was assumed to lie within a radius of 25 m from the center of the house. The intruder lives in this distributed waste/soil mixture, work at a regular job during the day,	I. Excavating a basement for dwelling 75 m^3 of waste and 25 m^3 of clean soil are exhumed during construction of a house with a basement. waste from the basement excavation is mixed with soil for which vegetables are grown and consumed. Soil is also consumed. Drilling a well for water to be used in irrigation a 30-cm-diameter well is driven through the waste waste from the well hole is mixed with soil from which vegetables are grown and consumed. Soil is also consumed Crop roots penetrating into waste material crop roots or other natural plant roots penetrate the waste zone, thereby contaminating crops that are consumed. **(The major difference at this level is the inclusion of "well drilling" scenario for Hanford LLBG limits)** **For category 1 facilities**, waste is buried at a minimal depth (about 3 m) and all three types of intrusions could occur. However, **only I (b) above was used to derive the limits** because it generally produces the maximum dose according to a Hanford study.

Attributes for Comparison	NRC Class C Intrusion Model	Hanford LLW Burial Grounds PA Intrusion Model
	and spend some time working in a garden growing vegetables for his own use.	**For category 3 facilities**, waste is buried at a depth of 5 m or more to eliminate excavation and rout penetration as a feasible means of exhuming waste. Among the two well-drilling scenarios under II above, **only II (b) was used to derive the limits** because postdrilling scenario consistently produces max. dose according to a Hanford study. **(One could say that according to this Hanford logic, NRC Class C scenarios, which only include excavation scenarios, would not occur for residual waste disposed of at the bottom of the tank about 17 m from the surface of ground.)** **(Postexcavation and postdrilling scenarios, which are similar to the NRC's agriculture scenario, were determined in a Hanford study to be the limiting scenario for setting the limits; however, in setting the NRC Class C, the construction scenario, similar to *Hanford's excavation and drilling scenarios*, was the limiting scenario for most of alpha-emitting radionuclides.)**
Exposure Pathway	Intruder-construction scenario 1. direct gamma exposure from the waste during excavation 2. inhalation of contaminated dust suspended during construction activities 3. external exposure from suspension of contaminated dust 4. consumption of food nearby upon which the airborne contamination is assumed to settle.	For both Category 1 and 3 facilities: 1. ingestion of vegetables grown in the contaminated soil 2. ingestion of soil 3. inhalation of radionuclides on dust suspended in the air by gardening activities and wind 4. external exposure to contaminated soil while working in the garden or residing in the house built on top of the waste site **(Ingestion of soil was not explicitly considered in NRC Class C scenario. The 4th item on the left column, consumption of food**

Attributes for Comparison	NRC Class C Intrusion Model	Hanford LLW Burial Grounds PA Intrusion Model
	Intruder-agriculture scenario: 1. direct gamma exposure from disposed waste volume 2. inhalation of contaminated dust suspended due to tilling activities as well as natural suspension 3. external exposure from suspension of contaminated dust 4. consumption of food nearby upon which the airborne contamination is assumed to settle 5. consumption of food grown in the contaminated soil **(The major difference between these two scenario is the additional "garden food consumption" pathway for the agriculture scenario.)**	**grown nearby, doesn't seem to be part of Hanford LLBG PA pathway. Other than the above two, other pathways seem to be the same.)**

Table G-2
Comparison of Parameter Values for NRC, Hanford PA, and Proposed Hanford Tank-specific Intrusion Models

Model Parameter	Values Used in Setting 10 CFR 61 Class C Limit	Proposed Hanford Tank - Specific Values	Impact on Derived Radionuclide Limits[1] (approx.)	Hanford LLBG PA Intrusion Model (Only postexcavation and postdrilling scenarios)	Impact on Derived Radionuclide Disposal Limits[1] (approx.)
Source Terms					
1. (a): garden size	1963 m^3	Same	-	2500 m^3	
1. (b): waste and soil volume spread over the garden in excavation	Total of 600 m^3 with 150 m^3 of waste	Same	-	Total of 100 m^3 with 75 m^3 of waste (corresponds to 3 cm of waste is added to the garden)	
1. (c): waste and soil volume spread over the garden in well-drilling	NA	Same	-	Total of 0.35 m^3 with all of them being waste (correspond to 0.14 mm of waste is added to the garden)	
1. (d): garden mixing depth	See soil dilution factor below	Same	-	15 cm (GENII)	
1. (e): soil dilution factor	0.25	0.1 (see Appendix B)	↑ by 2.5	0.2 for postexcavation; 9.3e-4 for postdrilling[2]	↑ by 1.25 for postexcavation↑ by 270 for postdrilling
Exposure Duration					

Model Parameter	Values Used in Setting 10 CFR 61 Class C Limit	Proposed Hanford Tank - Specific Values	Impact on Derived Radionuclide Limits[1] (approx.)	Hanford LLBG PA Intrusion Model (Only postexcavation and postdrilling scenarios)	Impact on Derived Radionuclide Disposal Limits[1] (approx.)
2. (a): exposure time	100 hr/yr gardening; 1700 hr outdoors; 4380 hr inside; 2580 hr elsewhere	Same	-	Same	-
2. (b): average time exposed at the unshielded dose rate	TBD hr/yr	Same	-	3260 hr/yr[3]	
2. (c): does conversion factor		Same	-	GENII Version 1.485 at 1 m above a 15 cm thick layer of contaminated soil	
Inhalation pathway					
3. (a): Inhalation exposure duration			-	2190 hr active; 2190 hr asleep; 1700 hr outdoor; 100 hr gardening	↑ by 1.25
3. (b): Breathing rate			-	1.2 m3/h; 0.45; 1.2; 1.2 corresponding to the hours above	
3. (c): Soil inhaled		Same	-	131.4 mg/yr; 49.3; 204; 60 corresponding to the hours above with a total 445 mg/yr	
3. (d): does conversion factor	DACRIN (Houston et al., 1974)	Same	-	DOE/EH-0071 (1988)	
3. (e): dust loading	565 - 50 $\mu g/m^3$			100 $\mu g/m^3$ (i.e., 100 μg soil/m^3 air)[4]	-
Ingestion pathway					
4. (a): Assumed intake	95 kg/yr for garden plants (50% of total consumed), 47.5 kg/yr for animals (50%		-	4.1 kg/yr for leafy; 13.9 for other; 9.6 for fruit; 18.5 for cereal (grain); 21 for meat; 51.7 for milk (meat and milk are sources in the all-	TBD

Model Parameter	Values Used in Setting 10 CFR 61 Class C Limit	Proposed Hanford Tank - Specific Values	Impact on Derived Radionuclide Limits[1] (approx.)	Hanford LLBG PA Intrusion Model (Only postexcavation and postdrilling scenarios)	Impact on Derived Radionuclide Disposal Limits[1] (approx.)
	of total consumed), 0.3 l/day			pathways irrigation scenarios)	
4. (b): Soil ingested	TBD	Same	-	100 mg/d unintentionally	TBD
4. (c): Transfer factors (soil-plant-human-animal)	NRC Guide 1.109 (1976); EPA 520/1-79-009; Ng et al. And others	Same	-	NUREG/CR-5512 (1990) & ORNL-5785 (1984)	TBD

[1] Actual impact depends on which pathway is the limiting factor and the impact is based on comparison to NRC Class C limits.

[2] Soil dilution factor: ratio of total activity to volume of mixing soil (waste volume/mixing volume). 3cm/15cm=2e-1 for postexcavation and 1.4e-2cm/15cm=9.3e-4 for postdrilling.

[3] Average time exposed at the unshielded dose rate = (1800 h/yr)*1 + (4380 h/yr)*(1/3) = 3260 hr/yr, where the factor, 1/3, is the reduced dose rate by the house structure.

[4] Dust loading: 565 $\mu g/m^3$ was calculated by multiplying the soil/air transfer factor, 3.53E-10, used in the NRC model and an assumed soil concentration of 1.6g/cm^3. 565 $\mu g/m^3$ for 100 hrs spent for gardening; 100 $\mu g/m^3$ for 1700 hrs spent outdoors; and 50 $\mu g/m^3$ for 4380 hrs spent indoors.

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