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Draft Basis for Section 3116 Determination for Closure of H-Tank Farm at the Savannah River Site

February 6, 2013

REVISION SUMMARY

REV. #	DESCRIPTION	DATE OF ISSUE
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ACRONYMS / ABREVIATIONS

ALARA	As Low As Reasonably Achievable
ARP	Actinide Removal Process
CA	Composite Analysis
CFR	Code of Federal Regulations
Ci	curie(s)
CLM	Central Climatology
cm	centimeter(s)
CSRA	Central Savannah River Area
CSSX	Caustic Side Solvent Extraction
CTS	Concentrate Transfer System
DDA	Deliquification, Dissolution and Adjustment
DOE	United States Department of Energy
DOE-SR	United States Department of Energy-Savannah River Operations Office
DSA	Documented Safety Analysis
DWPF	Defense Waste Processing Facility
Eh	Measure of reduction (or oxidation) potential
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
ETF	Effluent Treatment Facility
^{o}F	degree Fahrenheit
FEPs	Features, Events and Processes
FFA	Federal Facility Agreement
ft	foot
FTF	F-Tank Farm
g	gram(s)
GCL	Geosynthetic Clay Liner
GCP	General Closure Plan
GSA	General Separations Area
GSAD	General Separations Area Database
GWSB	Glass Waste Storage Building
HA	Hazard Analysis
HAW	High Activity Waste
HDPE	High Density Polyethylene
HELP	Hydrologic Evaluation of Landfill Performance
HM	H-Modified
HEPA	High Efficiency Particulate Air
hr	hour(s)
HRR	Highly Radioactive Radionuclide
HTF	H-Tank Farm
ISWLF	Industrial Solid Waste Landfill Facility
ITP	In-Tank Precipitation
K_d	Distribution Coefficient
kV	kilovolt
L	liter(s)
LAW	Low Activity Waste
m	meter(s)
MCi	million curie(s)

MCU	Modular Caustic Side Solvent Extraction Unit
MEP	Maximum Extent Practical
mg	milligram(s)
Mgal	million gallon(s)
mrem	millirem(s)
MSL	Mean Sea Level
mSv	milliSievert(s)
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
nCi	nanocurie(s)
NCRP	National Council on Radiation Protection and Measurements
NDAA	Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NRC	United States Nuclear Regulatory Commission
NRMP	Natural Resources Management Plan
OD	Outside Diameter
OSHA	Occupational Safety and Health Administration
PA	Performance Assessment
PC	Performance Category
pCi	picocurie(s)
PEL	Permissible Exposure Limit
pH	Measure of acidity or alkalinity of a solution
ppb	parts per billion
psi	pounds per square inch
PUREX	Plutonium Uranium Extraction
RBA	Radiological Buffer Area
RBOF	Receiving Basin for Offsite Fuels
ROD	Record of Decision
ROI	Region of Influence
RPP	Radiation Protection Program
RRF	Resin Regeneration Facility
SCDHEC	South Carolina Department of Health and Environmental Control
SDF	Saltstone Disposal Facility
SMP	Submersible Mixer Pump
SPF	Saltstone Production Facility
S/RID	Standards/Requirement Identification Document
SREL	Savannah River Ecology Laboratory
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
STP	Submersible Transfer Pump
SWPF	Salt Waste Processing Facility
TED	Total Effective Dose
TEDE	Total Effective Dose Equivalent
TER	Technical Evaluation Report
U.S.	United States
UTR	Upper Three Runs
UTRA	Upper Three Runs Aquifer
UTRA-LZ	Upper Three Runs Aquifer-Lower Zone
UTRA-UZ	Upper Three Runs Aquifer-Upper Zone

WAC	Waste Acceptance Criteria
WCS	Waste Characterization System
WMC	Waste Mixing Chamber
yr	year(s)

1.0 INTRODUCTION AND PURPOSE

Section Purpose

This section provides the purpose and scope of this document, titled *Draft Basis for Section 3116 Determination for Closure of H-Tank Farm at the Savannah River Site* (hereinafter referred to as: Draft HTF 3116 Basis Document).

Section Contents

This section contains a brief introduction to the Savannah River Site (SRS) and H-Tank Farm (HTF) and describes the purpose and scope of this Draft HTF 3116 Basis Document.

Key Points

- The United States Department of Energy (DOE) is issuing this Draft HTF 3116 Basis Document to provide a basis for a determination by the Secretary of Energy, in consultation with the United States Nuclear Regulatory Commission (NRC), pursuant to Section 3116 of the Ronald W. Reagan National Defense Authorization Act (NDAA) for Fiscal Year 2005 (hereinafter referred to as: NDAA Section 3116). [NDAA_3116]
- This Draft HTF 3116 Basis Document concerns stabilized residuals in waste tanks[1] and ancillary structures, those waste tanks, and the ancillary structures (including integral equipment) at the SRS HTF at the time of closure.
- The HTF is a 45-acre site consisting of underground radioactive waste storage tanks and supporting ancillary structures.
- The HTF tank waste storage and removal operations are performed in accordance with a State-issued industrial wastewater construction permit. Removal from service and stabilization of the HTF waste tanks and ancillary structures will be carried out pursuant to a State-approved closure plan and will be consistent with the SRS Federal Facility Agreement (FFA). [WSRC-OS-94-42]
- After completion of waste removal activities, the HTF waste tanks will be stabilized by filling the waste tanks with grout. Ancillary structures will be filled, as necessary, to prevent subsidence.
- Stabilization of individual HTF waste tanks and ancillary structures is anticipated to take place after individual component cleaning is complete.
- The final HTF 3116 Basis Document will be issued by DOE following consultation with the NRC and consideration of public comments.

1.1 Introduction

In accordance with NDAA Section 3116, certain waste from reprocessing of spent nuclear fuel is not high-level waste if the Secretary of Energy, in consultation with the NRC, determines that the criteria in NDAA Section 3116(a) are met. This Draft HTF 3116 Basis Document shows that those criteria are satisfied, to support a potential determination that the Secretary may make pursuant to NDAA Section 3116. This Draft HTF 3116 Basis Document concerns the stabilized residuals in waste tanks and ancillary structures, those waste tanks, and the ancillary structures (including integral equipment) at the SRS HTF at the time of closure.

The HTF is a 45-acre site containing 29 underground radioactive waste storage tanks[2] and supporting ancillary structures, such as evaporators, pump pits, pump tanks, transfer valve boxes and piping. Most of the waste in these waste tanks and ancillary structures originated in the SRS H-Canyon Separations Facility, which, in the past, primarily reprocessed used uranium fuel for the recovery of uranium but also recovered other nuclear materials produced in the site's nuclear production reactors. H Canyon

[1] The HTF has 29 waste tanks and cleaning and waste removal efforts are well underway for several of the waste tanks. All 29 waste tanks in HTF (and their residuals) are addressed by this Draft HTF 3116 Basis Document, and, unless otherwise specified, references in this document to "the waste tanks" or "HTF waste tanks" refers to all 29 of the HTF waste tanks.

[2] The HTF waste tanks have capacities ranging from 750,000 gallons to 1,300,000 gallons, depending on the waste tank, as discussed further in Section 2.0 of this Draft HTF 3116 Basis Document.

continues to generate radioactive liquid waste when performing stabilization missions, such as recovering and blending highly enriched uranium for non-defense related use. DOE carefully controls waste transferred to the HTF waste tanks and ancillary structures through a waste compliance program and waste acceptance criteria which establish the physical, chemical and radionuclide limits for all waste entering the waste tanks and ancillary structures.[3]

The DOE is in the process of closing HTF, and is engaged in an expansive campaign to clean, stabilize and close all HTF underground, radioactive waste storage tanks, as well as supporting ancillary structures (evaporators, pump pits, pump tanks, diversion boxes, transfer valve boxes and piping), used to store, treat and transfer waste generated, in part, by prior reprocessing of spent nuclear fuel. The waste tanks and ancillary structures are several decades old, and several of the aging HTF waste tanks are approaching 60 years of service life – well beyond their design life.[4] Given the risks inherent in exhuming the aging waste tanks, DOE is instead pursuing a campaign to clean, stabilize and close the HTF waste tanks and ancillary structures in place, to reduce the risks to the workers, the public and the environment associated with the aging waste tanks and ancillary structures at HTF.

To date, DOE has over two decades of experience in successfully cleaning waste tanks of different types at SRS, using a variety of mechanical and chemical technologies. The DOE's experience has encompassed some of the largest and most challenging waste tanks at SRS, including waste tanks that contain the most complex internal structures (cooling coil arrays) and the most challenging zeolite-laden wastes.[5] The cleaning campaigns have spanned a number of years and involved multiple phases, and have included some of the most difficult waste tanks at SRS.[6] Following cleaning, waste "residuals", that cannot be practically removed, remain on the floors and internal surfaces of the waste tanks and ancillary structures. After cleaning, the waste tanks and applicable ancillary structures, along with their residuals, are stabilized in place with a grout matrix to prevent subsidence. At HTF, waste removal and cleaning efforts are well underway for several waste tanks. These waste removal efforts will continue for the waste tanks and ancillary structures for which cleaning has not been completed, to be followed by grouting. Based on extensive experience in cleaning the SRS waste tanks, DOE is confident that, although additional waste removal efforts remain to be completed, DOE can appropriately demonstrate at this time that the criteria in NDAA Section 3116(a) will be met at closure for the HTF waste tanks, ancillary structures and residuals.[7]

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[3] All generating facilities, including H Canyon, are required to develop and maintain a Waste Compliance Plan which describes the controls or procedures imposed within the facility to ensure that the HTF waste acceptance criteria are met for any material transferred to the HTF waste tanks and ancillary structures. [X-SD-G-00001]

[4] Some of these waste tanks do not have a secondary containment structure (called an annulus) and some have developed leaks in the primary tanks, which have leaked into the secondary containment annuli. To date, waste has escaped to the surrounding soils due to a leak site in one primary tank. This event occurred in 1960 and was associated with Tank 16 in HTF. [DPSOX-5954]

[5] Zeolite was used in the past to capture cesium and is present from spent zeolite resin in some of the HTF waste tanks. The presence of zeolite poses significant challenges to removal of waste from those waste tanks, due to chemical changes to the zeolite resin over time, the relatively large particle size and high density of zeolite that results in quick settling, and the negative effect of cleaning acids on the zeolite, which causes conglomerates that cannot be readily removed from the waste tank and may retain radionuclides.

[6] In HTF, the DOE has conducted heel removal and annulus cleaning activities for Tank 16 primary tank and annulus and has completed bulk waste removal efforts on Tanks 11 and 12. In addition, bulk waste removal efforts are currently underway in Tank 13 and preparation for bulk waste removal efforts in Tank 10 are in-progress. DOE also has successfully removed sludge and saltcake from several other HTF waste tanks; although available space in those tanks has been re-filled and the tanks are or will be cleaned further for closure, this previous experience illustrates DOE's expertise in removing waste from HTF tanks. DOE also has extensive waste removal experience for F-Tank Farm (FTF) waste tanks, which provides additional indicia of DOE's experience and expertise with waste removal at SRS, although the FTF waste tanks are not within the scope of this Draft HTF 3116 Basis Document. In FTF, DOE has cleaned six waste tanks (Tanks 17, 20, 18, 19, 5 and 6) and completed bulk waste removal efforts on Tanks 4, 7 and 8. DOE's experience to date has encompassed several designs or types of waste tanks. In this regard, the HTF contains four basic designs of waste tanks, called Type I, Type II, Type IV, and Type III/IIIA tanks, whereas FTF has Types I, IV and III/IIIA tanks. In total, DOE has completed cleaning of four Type IV tanks, two Type I tanks and one Type II tank, and has completed bulk waste removal efforts on an additional five Type I tanks. Waste removal is primarily influenced by tank type and waste type (e.g., liquid and solid salt waste versus sludge), and the factors are not primarily tank farm dependent.

[7] Moreover, the Secretary of Energy, in consultation with the NRC, previously determined that similar stabilized residuals, waste tanks and ancillary structures at closure in FTF at SRS are not high-level radioactive waste and may be disposed of in place at SRS. [DOE-WD-2012-001] Considering the high level of interdependency between the HTF and FTF and the importance of continuing to move forward with reducing the risk associated with the aging waste tanks and ancillary structures in both tank farms, DOE believes it is imperative at this time for the Secretary of Energy, in consultation with the NRC, to determine whether the criteria in Section 3116(a) are met for HTF at closure, so as to make progress as expeditiously as possible toward the closure of HTF, in a manner which is protective of human health and safety as well as the environment.

The DOE is predicating this Draft HTF 3116 Basis Document on extensive analyses and scientific rationale, including the *Performance Assessment for the H-Area Tank Farm at the Savannah River Site,* SRR-CWDA-2010-00128 (hereinafter referred to as: HTF PA).[8] These analyses and rationale, including the HTF PA, demonstrate that there is reasonable assurance[9] that the maximum all-pathways dose to any member of the public from closure of HTF will be well below the 25 mrem/yr performance objective referenced in NDAA Section 3116. For example, as explained further and graphically displayed in Section 7.0 of this Draft HTF 3116 Basis Document, the HTF PA projects a maximum all-pathways dose to a member of the public of approximately 0.3 mrem/yr within 1,000 years after tank farm closure and 4.0 mrem/yr within 10,000 years after tank farm closure, using the models and assumptions of the HTF PA Base Case.[10] In addition, the HTF PA projects the peak inadvertent intruder (i.e., individual within the HTF boundary) doses to be less than 500 mrem/yr, thus demonstrating the performance objective referenced in NDAA Section 3116 regarding the inadvertent intruder will also be met. Consistent with the above, DOE is confident that the dose limits to the public and the inadvertent intruder, applicable under Section 3116(a), would not be exceeded. Under these circumstances and given DOE's extensive waste removal experience noted above, DOE believes it is appropriate to proceed at this time with this Draft HTF 3116 Basis Document, which, along with its supporting references, demonstrates that the criteria in NDAA Section 3116(a) are met for the waste tanks, ancillary structures and residuals at HTF at closure.

The DOE is issuing this Draft HTF 3116 Basis Document for NRC consultative review, as part of DOE's consultation with NRC. Although not required by NDAA Section 3116, DOE also is issuing this Draft HTF 3116 Basis Document for public review and comment. This Draft HTF 3116 Basis Document will be finalized after DOE consults with the NRC and considers public comments.

1.2 Purpose and Scope

The purpose of this Draft HTF 3116 Basis Document is to demonstrate and document that, after final stabilization activities are complete, the stabilized residuals in the HTF waste tanks and ancillary structures, the waste tanks, and the ancillary structures (including integral equipment) at the time of closure meet the NDAA Section 3116(a) criteria and, therefore are not high-level waste.

The scope of this Draft HTF 3116 Basis Document specifically addresses the stabilized residuals in the HTF waste tanks and ancillary structures, the waste tanks, and the ancillary structures (including integral equipment) at the time of HTF closure.[11] This Draft HTF 3116 Basis Document does not include other SRS facilities or systems, or waste removed from the waste tanks and ancillary structures.

This Draft HTF 3116 Basis Document is premised on the facts, assumptions and analyses contained or referenced herein. Accordingly, a NDAA Section 3116(a) Secretarial determination made in reliance on the HTF 3116 Basis Document, when finalized, would only cover situations consistent with those facts, assumptions and analyses in the final HTF 3116 Basis Document.

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[8] A performance assessment is a multi-disciplined assessment, (e.g., geochemistry, hydrogeology, materials science, health physics) which uses a variety of computational modeling codes to evaluate groundwater concentrations and doses at various points of assessment. In doing this evaluation, DOE assesses the impact of natural features (e.g., hydrogeology, soil properties, groundwater infiltration) and engineered barriers (e.g., closure cap, fill grout, waste tank design) on the release of radionuclides, to estimate the potential dose to a hypothetical member of the public and a hypothetical inadvertent intruder.

[9] Section 3116 cross-references the NRC performance objectives in 10 CFR Part 61, Subpart C. The first performance objective at 10 CFR 61.40 sets forth a general requirement that "reasonable assurance" exists that exposures to humans are within the limits of the performance objectives in 10 CFR 61.41 through 61.44. The HTF PA was conducted and will be maintained in accordance with DOE Manual 435.1-1 and DOE guidance, pursuant to DOE's authority and responsibilities to protect human health and safety under the Atomic Energy Act of 1954, as amended. DOE Manual 435.1-1 uses the phrase "reasonable expectation", which is analogous to "reasonable assurance". For convenience, this Draft HTF 3116 Basis Document uses the phrase "reasonable assurance".

[10] See Section 7.0 of this Draft HTF 3116 Basis Document for additional discussion. The results of the HTF PA, as reported here, should not be considered limits or thresholds. As required by DOE Manual 435.1-1, maintenance of the HTF PA will include future performance assessment revisions or special analyses to incorporate new information, update model codes and reflect analysis of actual residual inventories.

[11] For the purpose of this Draft HTF 3116 Basis Document, the residual waste remaining in a waste tank or ancillary structure – following successful completion of waste removal activities and removal of the highly radioactive radionuclides to the maximum extent practical – is referred to as "residuals." Stabilization of these residuals within the HTF waste tanks will be carried out by filling the waste tanks with grout after completion of waste removal activities. Ancillary structures will be filled, as necessary, to prevent subsidence of the structure or final closure cap. The DOE does not plan to add fill material to the HTF transfer lines.

1.3 Schedule and Plans for Closing Waste Tanks

The HTF waste tanks[12] are closed in accordance with the SRS FFA, a formal agreement between DOE, Region 4 of the United States Environmental Protection Agency (EPA) and the South Carolina Department of Health and Environmental Control (SCDHEC). The FFA establishes that, among other things, the SRS waste tanks that do not meet secondary containment standards (older style tanks, specifically the Type I, Type II and Type IV tanks in HTF) must be removed from service according to the FFA schedule. The current FFA calls for staggered operational closure of the twelve HTF and ten F-Tank Farm (FTF) older style waste tanks (tank numbers not specified in the SRS FFA) by September 2022.[13] In this regard, the current FFA requires the operational closure of four additional waste tanks by September 2015, which likely will be split between HTF and FTF. DOE anticipates the need to operationally close waste tanks in HTF, as well as FTF, to meet the FFA commitments. [WSRC-OS-94-42] DOE addresses the closure of the remaining HTF waste tanks (Type III/IIIA tanks) and ancillary structures in the SRS *Liquid Waste System Plan.*[14] [SRR-LWP-2009-00001]

The DOE will, pursuant to its authority, including that under the Atomic Energy Act of 1954, as amended, and applicable DOE Orders, manuals and policies, pursue closure of the HTF and monitor its activities to ensure compliance with all requirements. Furthermore, DOE uses a documented process to review and resolve any disposal questions and develop any mitigation measures, as appropriate.

Tank waste storage and removal operations are governed by a SCDHEC industrial wastewater construction permit. [DHEC_01-25-1993] Removal from service and stabilization of the HTF waste tanks and ancillary structures will be carried out pursuant to a State-approved closure plan, the HTF General Closure Plan (GCP), which contains the overall plan for removing from service and stabilizing the HTF waste tanks and ancillary structures. [SRR-CWDA-2011-00022] A specific Closure Module for each waste tank or ancillary structure or groupings of waste tanks and ancillary structures will be developed and submitted to the State of South Carolina for approval. Final waste tank stabilization activities will not proceed until the State of South Carolina grants approval. Stabilization of individual HTF waste tanks and ancillary structures is anticipated to take place after individual component cleaning is complete.

In the *Savannah River Site High-Level Waste Tank Closure Environmental Impact Statement Record of Decision*, DOE selected the alternative to fill the waste tanks with reducing grout to stabilize the residual material. This method was the most preferred environmental alternative. [DOE/EIS-0303 ROD] The stabilized grout form will provide a chemical environment to reduce migration of contaminants into the environment, prevent inadvertent intrusion and minimize void spaces in the waste tanks.

Since the publication of the Environmental Impact Statement (EIS) and issuance of the Record of Decision (ROD), DOE developed new waste removal and cleaning technologies and developed the HTF Performance Assessment (PA). [SRR-CWDA-2010-00128] In light of these changes, DOE will prepare a Supplement Analysis or other appropriate review pursuant to the National Environmental Policy Act (NEPA) prior to proceeding with closure activities in HTF.[15]

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[12] The HTF contains four basic designs (types) of tanks, called Type I, Type II, Type IV, and Type III/IIIA tanks. The HTF waste tanks are also numbered, although not sequentially. The tank types are discussed in further detail in Section 2.0 of this Draft HTF 3116 Basis Document.

[13] The FFA includes procedures for revision of the FFA schedule.

[14] The *Liquid Waste System Plan* is updated periodically as appropriate.
According to the *Performance Assessment for the H-Area Tank Farm at the Savannah River Site* (SRR-CWDA-2010-00128), DOE's planned sequence for closure of HTF is as follows:

- Closure of Types I, II and IV tanks and finally the Type III and IIIA tanks. The ancillary structures (such as transfer lines) are planned to be closed as appropriate with a goal of closing HTF in stages.
- Following closure of a geographic section (such as Type IV tanks and evaporator area), the section may be left in an interim closure state in preparation for final closure.
- Following closure of all HTF waste tanks and ancillary structures, HTF will undergo final closure in accordance with the FFA.

[15] Similarly, DOE prepared the *High-Level Waste Tank Closure Final Environmental Impact Statement for the Savannah River Site Supplement Analysis* for FTF, to determine whether (1) a supplemental EIS was needed, (2) a new EIS was needed or (3) no further NEPA documentation was required. The Supplement Analysis determined that the new information did not present significant new information relevant to environmental concerns, and that no further NEPA documentation was required to proceed with closure activities in the FTF. [DOE/EIS-0303-SA-01]

1.4 Outline of Draft HTF 3116 Basis Document

To support closure of the HTF at the SRS, this Draft HTF 3116 Basis Document demonstrates that the stabilized residuals within the HTF waste tanks and ancillary structures, those waste tanks, and the ancillary structures (including integral equipment) at the time of closure resulting from, in part, prior reprocessing of spent nuclear fuel meet the criteria in NDAA Section 3116(a) and thus are not high-level waste.

Section 2.0 of this Draft HTF 3116 Basis Document provides an overview of SRS and the HTF. In addition, extensive descriptions of the HTF and waste processing facilities are provided in the HTF PA. [SRR-CWDA-2010-00128] Section 3.0 of this Draft HTF 3116 Basis Document provides the specific language and criteria of NDAA Section 3116(a). Subsequently, Section 4.0 through Section 8.0 provides the basis to support a determination that the Secretary of Energy, in consultation with the NRC, may make pursuant to NDAA Section 3116(a).

1.5 NDAA Section 3116(a) Summary

To provide the statutory context for the ensuing discussion, NDAA Section 3116(a) provides that certain waste from the reprocessing of spent nuclear fuel is not high-level waste if the Secretary of Energy, in consultation with the NRC, determines that the waste meets the criteria specified in NDAA Section 3116(a). Those criteria are, in relevant part:

1) the waste does not require permanent isolation in a deep geologic repository for spent fuel or high-level waste;

2) the waste has had highly radioactive radionuclides (HRRs) removed to the maximum extent practical (MEP); and

3) (A) the waste does not exceed concentration limits for Class C low-level waste as set out in 10 Code of Federal Regulations (CFR) 61.55, and will be disposed of (i) in compliance with the performance objectives set out in 10 CFR 61, Subpart C; and (ii) pursuant to a State-approved closure plan or State-issued permit; or

   (B) the waste exceeds concentration limits for Class C low-level waste as set out in 10 CFR 61.55, but will be disposed of (i) in compliance with the performance objectives set out in 10 CFR 61, Subpart C; (ii) pursuant to a State-approved closure plan or State-issued permit; and (iii) pursuant to plans developed by the Secretary in consultation with NRC.

NDAA Section 3116(a) is set forth in its entirety in Section 3.0 of this Draft HTF 3116 Basis Document.

As discussed in Section 4.0 of this document, the stabilized residuals within the waste tanks and ancillary structures, the waste tanks, and the ancillary structures (including integral equipment) do not raise any unique considerations that, notwithstanding the demonstration that all other NDAA Section 3116(a) criteria have been met, require permanent isolation in a deep geologic repository. Accordingly, the HTF residual waste, waste tanks and ancillary structures at closure satisfy the criterion in NDAA Section 3116(a)(1).

The information provided in Section 5.0 and Appendix B demonstrates that the HTF waste tanks, ancillary structures and their associated stabilized residuals will have had HRRs removed to the MEP at the time of closure. Removal of HRRs to the MEP in HTF waste tanks and ancillary structures occurs through a systematic progression of waste removal and cleaning activities using proven technologies to a point where further removal of HRRs is not sensible or useful in light of the overall benefit to human health, safety and the environment.

The stabilized HTF wastes at closure are anticipated to meet concentration limits for Class C low-level waste as set out in 10 CFR 61.55. Nevertheless, DOE is also consulting with the NRC on DOE's disposal plans for HTF pursuant to the consultation process in NDAA Section 3116(a)(3)(B)(iii) to take full advantage of the consultation process established by NDAA Section 3116. In this regard, DOE is specifically requesting in this Draft HTF 3116 Basis Document that NRC identify what changes, if any, NRC would recommend to DOE's disposal plans as described in the Draft HTF 3116 Basis Document, and DOE intends to consider the NRC recommendations, as appropriate, in the development of DOE's plans.

This document demonstrates that the stabilized residuals within the waste tanks and ancillary structures, the waste tanks, and the ancillary structures (including integral equipment) located at HTF at the time of closure will meet the 10 CFR 61, Subpart C performance objectives so as to provide for the protection of the public health and the environment. These performance objectives address protection of the general population from radioactivity releases, individuals from inadvertent intrusion on the disposal site, protection of workers and the public during disposal facility operations, and the stability of the disposal site after closure.

As discussed in Sections 7.1 and 7.2, through use of the performance assessment process, DOE has analyzed the possible methods by which a future member of the public or inadvertent intruder could be exposed to the HTF residuals and has demonstrated that there is reasonable assurance that the performance objectives at 10 CFR 61.41 and 10 CFR 61.42 are met. The results of the HTF PA show that there is reasonable assurance the annual peak doses for a future hypothetical member of the public and a hypothetical inadvertent intruder will be below 25 mrem and 500 mrem, respectively. The DOE has programs in place to ensure protection of workers and the public during facility operations. As demonstrated in Section 7.3 of this Draft HTF 3116 Basis Document, the DOE requirements for occupational radiological protection and those for radiological protection of the public and the environment are equivalent to the requirements contained in the performance objective at 10 CFR 61.43.

Section 7.4 demonstrates that the HTF at closure meets the performance objective at 10 CFR 61.44, concerning long-term site stability. DOE reviewed the site characteristics, including demography, geography, meteorology, climatology, ecology, geology, seismology and hydrogeology. As demonstrated in Section 7.4 of this Draft HTF 3116 Basis Document, the site conditions do not present hazards that threaten long-term HTF stability. In addition, the HTF closure methods will result in a facility closure that does not require ongoing maintenance.

As described in Section 8.0, the HTF waste tanks and ancillary structures will be removed from service (operationally closed) and stabilized pursuant to State-approved Closure Modules, consistent with the HTF GCP that has been approved by SCDHEC. Per the SRS FFA, the waste tanks will be cleaned until the United States Department of Energy-Savannah River Operations Office (DOE-SR), SCDHEC and EPA agree that waste removal may cease.

As summarized above and as discussed more fully in the following sections, this Draft HTF 3116 Basis Document demonstrates that the HTF waste tanks, ancillary structures and residuals at closure meet the criteria in NDAA Section 3116(a). Moreover, DOE will consult with the NRC, as discussed previously. This Draft HTF 3116 Basis Document will be finalized after DOE consults with NRC and, although not required by NDAA Section 3116, after public review and comment. DOE will fully consider any consultative recommendations that may be made by NRC during the consultation process, as well as public comments provided on the Draft HTF 3116 Basis Document. Accordingly, the Final HTF 3116 Basis Document will provide the basis for the Secretary of Energy, in consultation with the NRC, to determine that the NDAA Section 3116(a) criteria are met and, thus, the HTF waste is not high-level waste.

2.0 BACKGROUND

Section Purpose

The purpose of this section is to provide background information to support discussions in later sections which demonstrate that the provisions in NDAA Section 3116(a) are met.

Section Contents

Section 2.1 provides an overview of HTF with descriptions of the different waste tank designs and ancillary structures. Section 2.2 identifies the sources of the waste managed in HTF and summarizes the history of each of the waste tanks. Section 2.3 describes waste tank closure activities and status. Section 2.4 describes the residual characterization process. Section 2.5 discusses stabilization of the waste tanks. Section 2.6 describes the HTF Closure Cap.

Key Points

- The HTF occupies 45 acres in the General Separations Area (GSA) near the center of the SRS.
- The HTF contains 29 carbon steel waste tanks of four different basic designs, four with a nominal capacity of 750,000 gallons per tank, four with a nominal capacity of 1,030,000 and 21 with a nominal capacity of 1,300,000 gallons per tank.
- Most of the waste in these waste tanks originated in the SRS H-Canyon Separations Facility, which primarily reprocessed used uranium fuel for the recovery of uranium but also recovered other nuclear materials produced in the site's nuclear production reactors.
- In addition to the waste tanks, HTF contains ancillary structures with a residual radiological inventory that is accounted for as part of HTF closure.
- Estimated radionuclide concentrations for residual material in HTF at closure were determined by sample analyses, process knowledge data maintained in the Waste Characterization System (WCS), and special analyses; the associated risks were assessed in the HTF PA.
- After waste removal, HTF waste tanks will be filled with grout to provide long-term stability and minimize the mobility and migration of radionuclides.

2.1 Savannah River Site and H-Tank Farm Facility Overview

This section provides brief descriptions of the site and the HTF.[16]

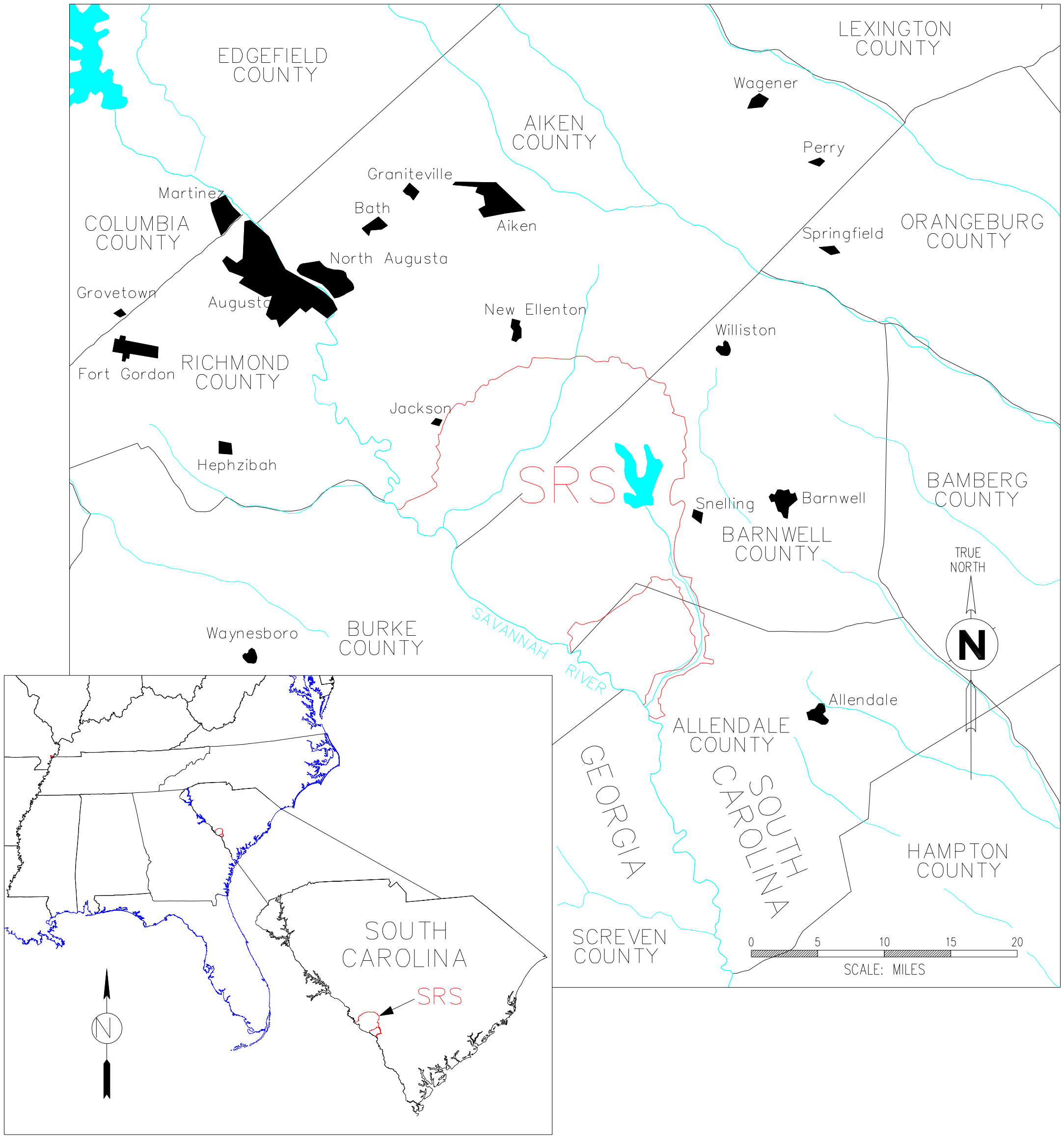
2.1.1 Geography and Demography

2.1.1.1 SRS Site Description

Construction of SRS (one of the facilities in the DOE complex) started in the early 1950s to produce nuclear materials (such as Pu-239 and tritium). The site covers approximately 310 square miles in South Carolina and borders the Savannah River. The SRS encompasses approximately 198,000 acres in Aiken, Allendale and Barnwell counties of South Carolina. The site is approximately 12 miles south of Aiken, South Carolina, and 15 miles southeast of Augusta, Georgia, as shown in Figure 2.1-1. [SRNS-STI-2011-00059]

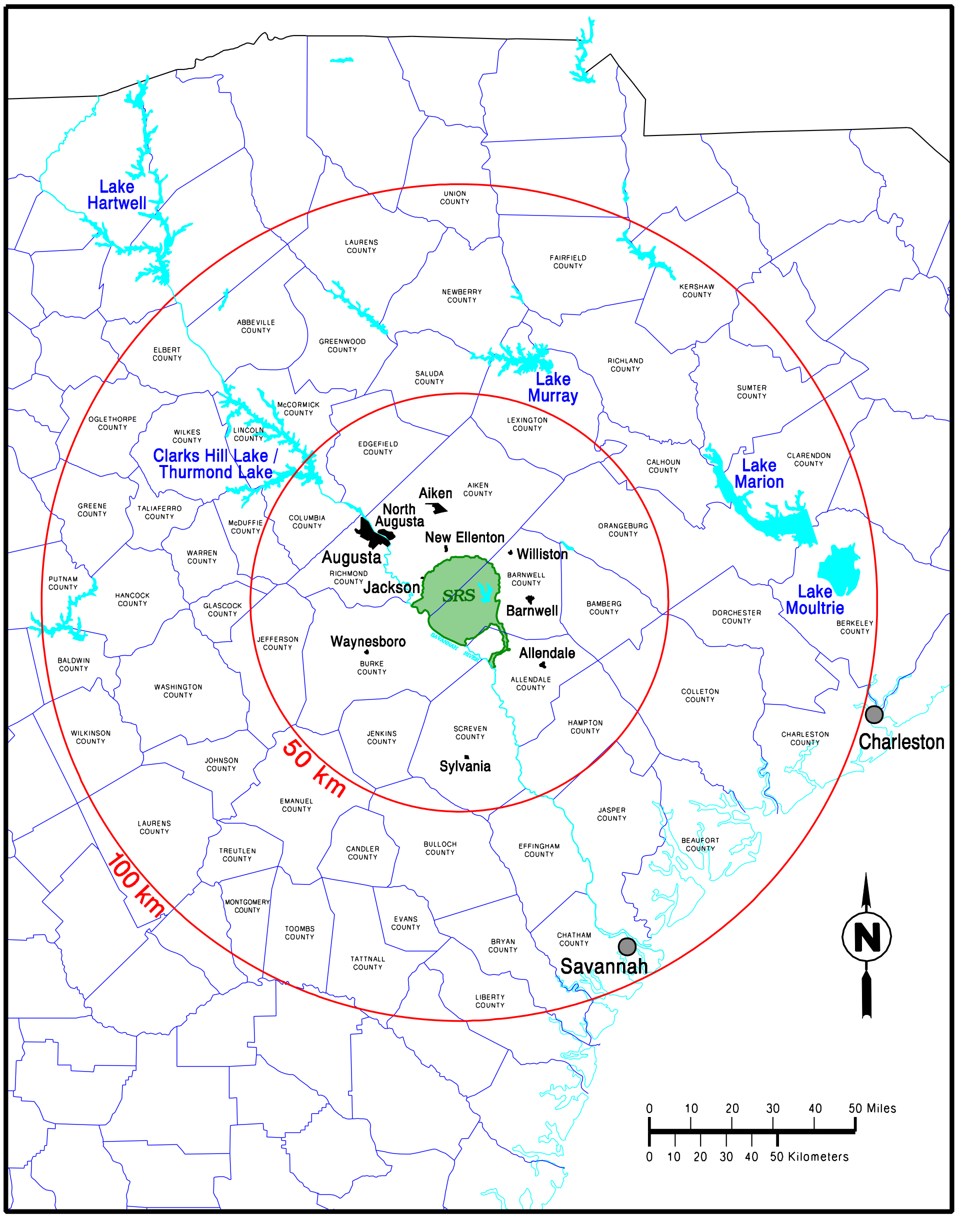
[16] Sections 1.0 and 2.0, as well as Appendix A, of this Draft HTF 3116 Basis Document, contain information to further inform the reader. DOE views such information, to the extent it is not otherwise relied upon in this Draft HTF 3116 Basis Document, as outside the scope of this Draft HTF 3116 Basis Document and not included as NDAA Section 3116 requirements or criteria.

Figure 2.1-1: Physical Location of SRS



Prominent geographic features within 30 miles of SRS include the Savannah River and Clarks Hill Lake (also known as Thurmond Lake), shown in Figure 2.1-2. The Savannah River forms the southwest boundary of SRS. Clarks Hill Lake is the largest nearby public recreational area. This reservoir lies on the Savannah River approximately 40 miles upstream of the center of SRS.

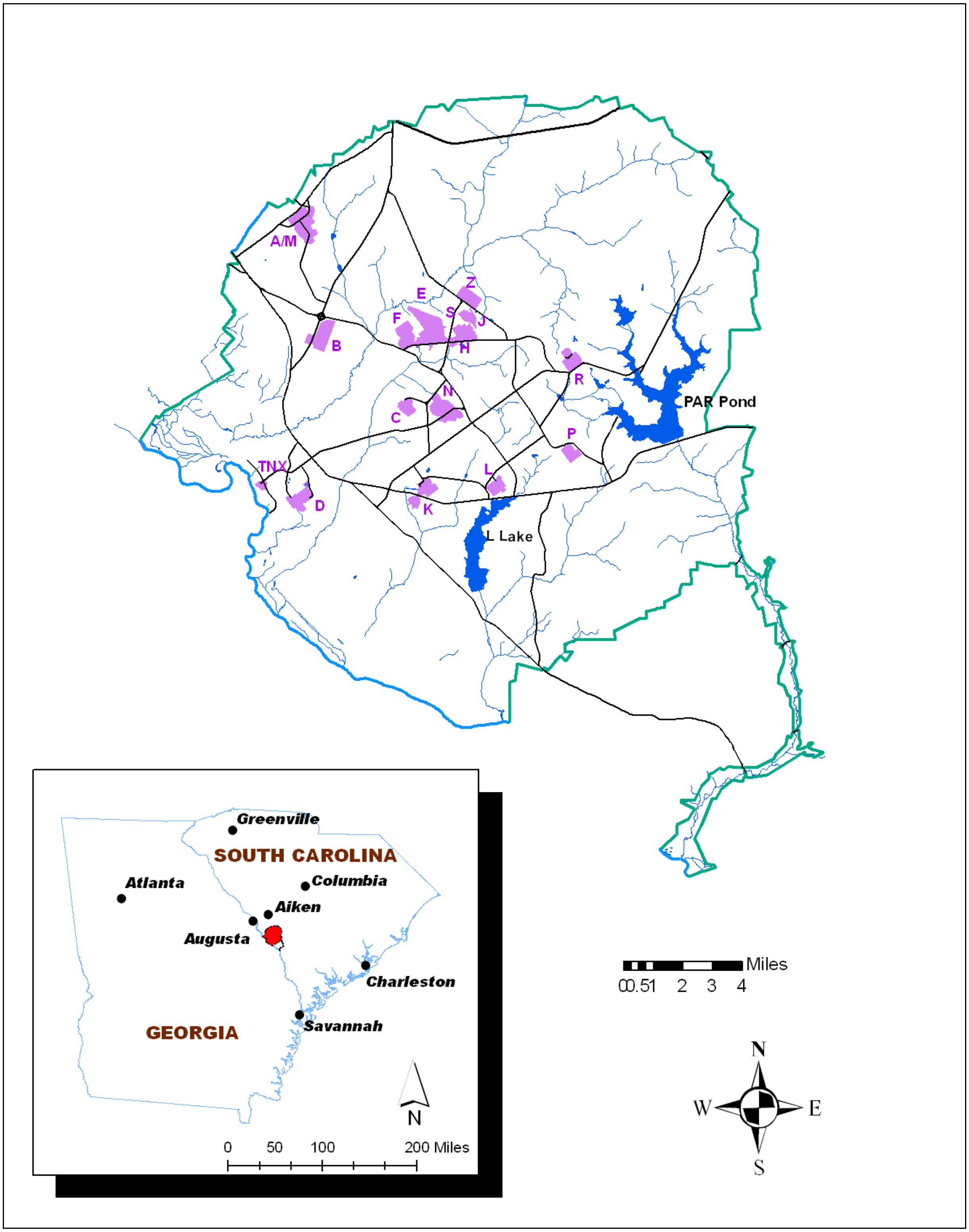
Figure 2.1-2: Location of SRS and Adjacent Areas



Within the SRS boundary, prominent water features include PAR Pond and L Lake, shown in Figure 2.1-3. PAR Pond, a former reactor cooling water impoundment, covers approximately 2,700 acres and lies in the eastern sector of SRS. L Lake, another former reactor cooling water impoundment, covers approximately 1,000 acres and lies in the southern sector of SRS. [WSRC-IM-2004-00008]

Figure 2.1-3 also shows the major operational areas at SRS. Prominent operational areas, both past and present, include, Separations (F and H Areas), Waste Management Operations (E Area), Liquid Waste (F, H, J, S and Z Areas) and the Reactor Areas (C, K, L, P and R). The Savannah River National Laboratory (SRNL) and Savannah River Ecology Laboratory (SREL) are located in A Area. Administrative and support services are located in B Area and construction administration activities are located in N Area. D Area, a heavy water facility, M Area, a fuel and target area, and TNX, a testing facility, have undergone deactivation and decommissioning.

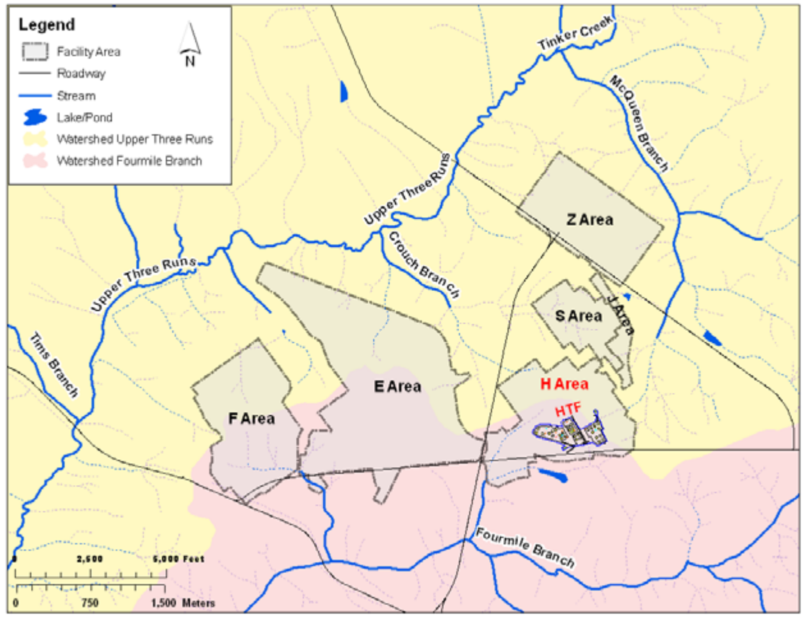
Figure 2.1-3: Predominant SRS Operational Area Location Map



2.1.1.2 Closure Site Description

The HTF is in H Area, which is located in the central region of SRS. Figure 2.1-4 presents the area known as the GSA. The GSA is located atop a ridge that runs southwest to northeast forming the drainage divide between Upper Three Runs (UTR) to the north and Fourmile Branch to the south. The GSA contains the F-Area and H-Area Separations Facilities, the S-Area Defense Waste Processing Facility (DWPF), the Z-Area Saltstone Facility, the J-Area Salt Waste Processing Facility (SWPF) and the E-Area low-level waste disposal facilities.[17] The HTF is an active facility consisting of 29 carbon steel waste tanks (Figure 2.1-5) in varying degrees of service or waste removal activities. The waste was generated primarily from the H-Canyon chemical separations processes. The HTF design features (e.g., waste tanks, transfer lines, evaporator systems) are discussed in more detail in Sections 2.1.11 and 2.1.12.

Figure 2.1-4: Layout of the GSA



2.1.1.3 Population Distribution

According to the United States (U.S.) Census Bureau data, the estimated 2010 population in the eight-county region of influence (ROI) was 571,637. Four of the counties lie in South Carolina and include Aiken, Allendale, Bamberg and Barnwell. The other four counties lie in Georgia and include Burke, Columbia, Richmond and Screven (Figure 2.1-2). The ROI includes the counties immediately adjacent to SRS and the counties where the majority of SRS workers reside. Approximately 85 % of the population in the ROI lives in the following three counties: Aiken (28.0 %), Richmond (35.1 %) and Columbia (21.7 %). Only approximately 15 % of the population in the ROI lives in the remaining counties as shown in Table 2.1-1. [SRR-LWDL-2012-00001]

Figure 2.1-5: General Layout of HTF

From 2000 to 2010, the population in the eight-county region grew an estimated 9.8 %. Columbia County had the highest growth at 38.9 % followed by Aiken County with a growth of 12.3 % and Burke County with a growth of 4.8 %.

[17] See Appendix A for a brief description of DWPF, SWPF and Saltstone Facility operations.

Allendale, Bamberg, Barnwell and Screven Counties experienced a net population loss. [SRR-LWDL-2012-00001]

The *High-Level Waste Tank Closure Final Environmental Impact Statement* contains population projections and further information regarding the region around SRS. [DOE/EIS-0303]

Table 2.1-1: Population Distribution and Percent of Region of Influence (% ROI) for Counties and Selected Communities

Jurisdiction	2000 Population	2010 Population	% Change	2010 % of Region
SOUTH CAROLINA				
Aiken County	142,552	160,099	12.3	28.0
Allendale County	11,211	10,419	-7.1	1.8
Bamberg County	16,658	15,987	-4.0	2.8
Barnwell County	23,478	22,621	-3.7	4.0
GEORGIA				
Burke County	22,243	23,316	4.8	4.1
Columbia County	89,288	124,053	38.9	21.7
Richmond County	199,775	200,549	0.4	35.1
Screven County	15,374	14,593	-5.1	2.6
Eight-County Total	**520,579**	**571,637**	9.8	

[SRR-LWDL-2012-00001]

2.1.1.4 Land Use Present and Planned

Land within a five-mile radius of the HTF is entirely within SRS boundaries and its current use is for industrial purposes or as forested land. The classification of the current land use within the entire GSA is heavy nuclear industrial. Two key planning documents contain the plans for the future of SRS and are identified below.

- The *Savannah River Site End State Vision,* PIT-MISC-0089
- The *Savannah River Site Long Range Comprehensive Plan,* PIT-MISC-0041

The Long Range Comprehensive Plan assumes that the entire site will be owned and controlled by the Federal Government in perpetuity.[18]

2.1.2 Meteorology and Climatology

2.1.2.1 General SRS Climate

The SRS region has a humid subtropical climate characterized by relatively short, mild winters and extended, hot and humid summers. Summer-like conditions (including mid to late summer heat waves) typically last from May through September when the area is frequently under the influence of a western extension of the semi-permanent subtropical high-pressure system, most commonly known in North America as the Bermuda High. Winds in summer are light and cold fronts generally remain well north of the area. On average, greater than one-half of the days register temperatures in excess of 90°F during the summer months. As this maritime tropical mass comes inland, it rises and forms localized scattered afternoon and evening thunderstorms that are often intense. The influence of the Bermuda High begins to diminish during the fall as continental air masses become more prevalent, resulting in lower humidity and more moderate temperatures.

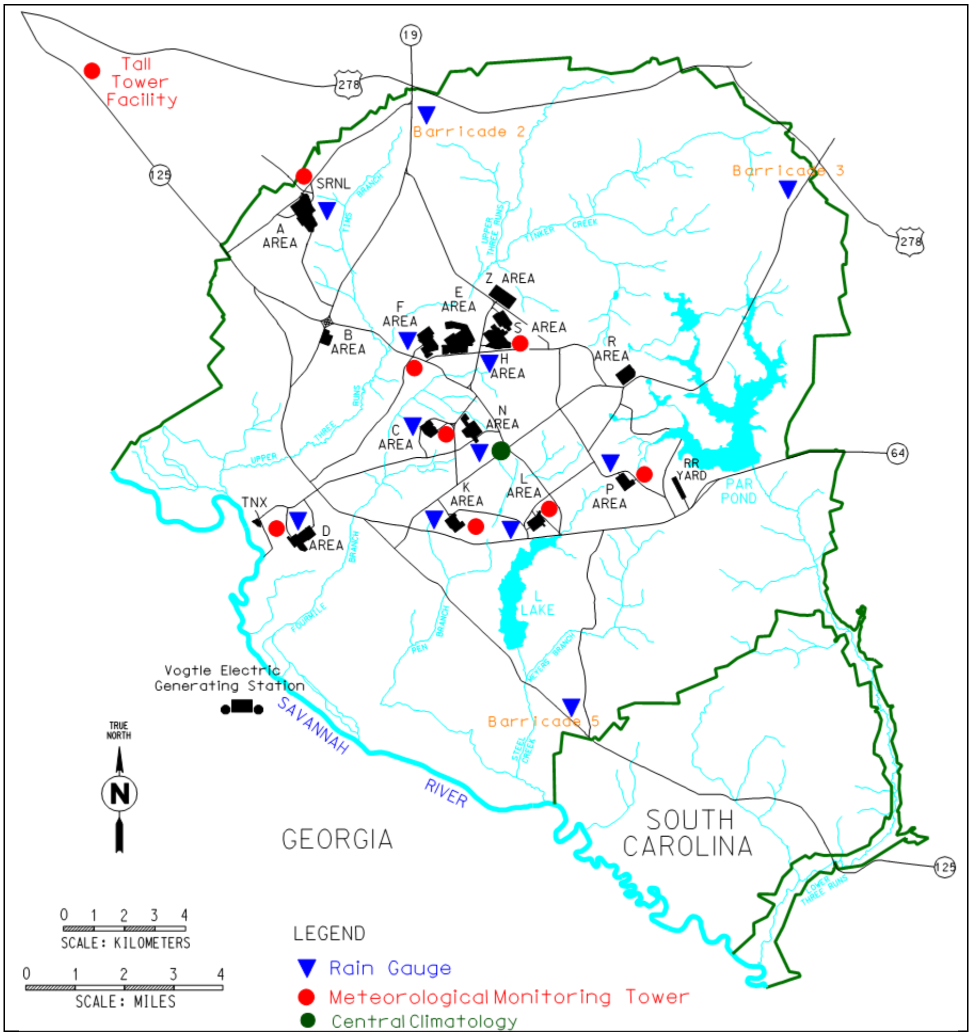
Average rainfall during the fall is usually the least of the four seasons. In the winter months, mid-latitude low-pressure systems and associated fronts often migrate through the region. As a result, conditions frequently alternate between warm, moist, subtropical air from the Gulf of Mexico region and cool, dry polar air. The Appalachian Mountains to the north and northwest of SRS help to moderate the extremely cold temperatures that are associated with occasional outbreaks of Arctic air. Consequently, less than one-third of winter days have minimum temperatures below freezing on average, and days with temperatures below 20°F are infrequent. Measurable snowfall occurs on average once every two years. Tornadoes occur more frequently in spring than the other seasons of the year. Although spring weather is somewhat windy, temperatures are usually mild and humidity is relatively low. [WSRC-TR-2007-00118]

[18] For the purposes of the HTF PA, no federal protection is assumed beyond a 100-year period of institutional control. The 100-year period of institutional control is assumed to begin in the year 2032.

2.1.2.2 Meteorological Data Collection

The collection of SRS meteorological data is from a network of nine primary monitoring stations (Figure 2.1-6). Towers located adjacent to each of eight areas (A, C, D, F, H, K, L and P Areas) are equipped to measure wind direction and wind speed at 201.3 feet above ground and to measure temperature and dew point at both 6.6 feet and 201.3 feet above ground. A ninth tower near N Area, known as the Central Climatology (CLM) site, is instrumented with wind, temperature and dew point sensors at four levels: 6.6 feet (13.2 feet for wind), 59.4 feet, 118.8 feet and 201.3 feet. The CLM site is also equipped with an automated tipping bucket rain gauge, a barometric pressure sensor and a solar radiometer near the tower at ground level. Data acquisition units at each station record a measurement from each instrument at one-second intervals. Every 15 minutes, 900 data points are processed to generate statistical summaries for each variable, including averages and instantaneous maxima. The results are uploaded to a relational database for permanent archival. [WSRC-TR-2007-00118]

Figure 2.1-6: SRS Meteorological Monitoring Network



[WSRC-TR-2007-00118]

In addition, the Tall Tower facility near Beech Island, South Carolina, provides a set of high quality meteorological measurements that is unique to the Southeastern United States. This facility utilizes fast-response sonic anemometers, water vapor sensors, barometric pressure sensors, slow-response temperature sensors and relative humidity sensors. The data are collected at 100 feet, 200 feet and 1,000 feet above ground level. Spread-spectrum modems at each measurement level transmit raw data to a redundant set of personal computers at the SRNL. Data processing software on the personal computers determine mean values and other statistical quantities every 15 minutes and uploads the results to the relational database.

Collection of precipitation measurements are from a network of 13 rain gauges across SRS (Figure 2.1-6). Twelve of these gauges are read manually by site personnel once daily, usually around 6:00 A.M. The daily data are reported to the SRNL Atmospheric Technologies Center, where it is technically reviewed and manually entered into a permanent electronic database. The other is an automated rain gauge at the CLM site previously addressed above.

2.1.2.3 Data Pertinent To PA Modeling

Weather data pertinent to the PA modeling are atmospheric dispersion, precipitation and air temperature. Each is discussed below.

2.1.2.3.1 Atmospheric Dispersion

Since the mid-1970s, a five-year database of meteorological conditions at SRS has been updated in order to support dose calculations for accident or routine release scenarios for on-site and off-site populations. The meteorological database includes wind speed, wind direction, temperature, dew point and horizontal and vertical turbulence intensities. The most recent database is for the time period January 1, 2002 through December 31, 2006, and consists of one-hour time averages of temperature and dew point; wind speed, direction and turbulence. [WSRC-STI-2007-00613] These data are for determining dose release factors in the evaluation for air pathways dose modeling described in Section 4.5 of the HTF PA, and was reported in SRNL-STI-2010-00018.

2.1.2.3.2 Precipitation

Compilations of rainfall data obtained from meteorological data collection described above for years 1952 through 2006 for the site and for years 1961 through 2006 obtained from the 200-F weather station are in WSRC-STI-2007-00184. An average precipitation level result of 48.5 inches/year was gathered from the 55-year monitoring period for the site and 49 inches/year from the 46-year monitoring period for F Area. These data are for determining appropriate rainfall assumptions for the performance evaluation of infiltration through the closure cap described in Section 2.6 and evaluated in WSRC-STI-2007-00184.

2.1.2.3.3 Air Temperature

A compilation of air temperature data obtained from meteorological data collection (described above) for years 1968 through 2005 is in WSRC-STI-2007-00184. For this 37-year period, the annual average air temperature was approximately 64°F with an average monthly air temperature from a low of approximately 46°F, to a high of approximately 81°F. These data are for determining appropriate assumptions for the performance evaluation of infiltration through the closure cap described in Section 2.6 and evaluated in WSRC-STI-2007-00184.

2.1.3 Ecology

Comprehensive descriptions of SRS ecological resources and wildlife are in *SRS Ecology Environmental Information Document* and briefly discussed in this section. [WSRC-TR-2005-00201]

The SRS supports abundant terrestrial and semi-aquatic wildlife, as well as a number of species considered threatened or endangered. Since the early 1950s, the site has changed from 67 % forest and 33 % agriculture to 94 % forest, with the remainder in aquatic habitats and developed areas. Wildlife populations correspondingly shifted from forest-farm edge utilizing species to a predominance of forest-dwelling species. The SRS now supports 44 species of amphibians, 60 species of reptiles, 255 species of birds, and 55 species of mammals. These populations include urban wildlife, several commercially and recreationally important species, and a few threatened or endangered species. Protection and restoration of all flora and fauna to a point where their existence is not jeopardized are principal goals of federal and state environmental programs. Those species of plants and animals afforded governmental protection are referred to collectively as “species of concern.” [WSRC-TR-2005-00201]

The SRS has extensive, widely distributed wetlands, most of which are associated with floodplains, creeks or impoundments. In addition, approximately 200 Carolina bays occur on SRS. Carolina bays are unique wetland features of the Southeastern United States. They are isolated wetland habitats dispersed throughout the uplands of SRS. The approximately 200 Carolina bays on SRS exhibit extremely variable hydrogeology and a range of plant communities from herbaceous marsh to forested wetland. [DOE/EIS-0303]

The Savannah River bounds SRS to the southwest for approximately 20 miles. The river floodplain supports an extensive swamp, covering approximately 15 square miles of SRS with a natural levee separating the swamp from the river. Timber was cut in the swamp from the turn of the century until 1951, when the Atomic Energy Commission assumed control of the area. At present, the swamp forest is comprised of two kinds of forested wetland communities. Areas that are slightly elevated and well drained are characterized by a mixture of oak species, as well as red maple, sweet gum and other hardwood species. Low-lying areas that are continuously flooded are dominated by second-growth bald cypress and water tupelo. [DOE/EIS-0303]

The SRS supports abundant herpetofauna because of its temperate climate and diverse habitats. The species of herpetofauna include 17 salamanders, 27 frogs and toads, one crocodilian, 13 turtles, nine lizards and 36 snakes. The class Amphibia is represented on-site by two orders, 11 families, 16 genera and 44 species. The Reptilia are represented by three orders, 12 families, 41 genera and 59 species. [WSRC-TR-2005-00201]

More than 255 species of birds can be found at SRS. Waterfowl and wading birds, as well as many upland species, use SRS aquatic habitats year round. The site's Carolina bays and emergent marshes are used by 67 % of these birds. This type of habitat is used by 68 % of the upland species. Edge or shoreline areas account for high numbers of upland birds at the Carolina bays and emergent marshes, stream, and small drainage corridors, and river swamp habitats. The aquatic birds are most common in open water habitats. [WSRC-TR-2005-00201]

Large mammals inhabiting the site include white-tailed deer and feral hogs. Raccoon, beaver and otter are relatively common throughout the wetlands of SRS. In addition, the gray fox, opossum, bobcat, gray squirrel, fox squirrel, eastern cottontail, mourning dove, northern bobwhite and eastern wild turkey are common at SRS. Threatened or endangered plant and animal species known to exist or that might be found on the overall site include the smooth purple coneflower, wood stork, red-cockaded woodpecker and short-nose sturgeon. [WSRC-TR-2005-00201]

The HTF is located within a densely developed, industrialized area of SRS. The immediate area provides habitat for only those animal species typically classified as urban wildlife. Species commonly encountered in this type of urban landscape include the Southern toad, green anole, rat snake, rock dove, European starling, house mouse, opossum and feral cats and dogs. Grasses and landscaped areas within the GSA in proximity to the HTF also provide some marginal terrestrial wildlife habitat. A number of ground-foraging bird species (e.g., American robin, killdeer and mourning dove) and small mammals (e.g., cotton mouse, cotton rat and Eastern cottontail) that use lawns and landscaped areas around buildings may be present at certain times of the year, depending on the level of human activity (e.g., frequency of mowing). Pine plantations managed for timber production by the U.S. Forest Service (under an interagency agreement with DOE) occupy surrounding areas.

The Fourmile Branch seepline area is located in a bottomland, hardwood forest community. The canopy layer of this bottomland forest is dominated by sweet gum, red maple and red bay with an occasional sweet bay throughout. The understory consists largely of saplings of these same species, as well as an herbaceous layer of smilax, dog hobble, giant cane, poison ivy, chain fern and hepatica. At the seepline upland edge, scattered American holly and white oak occur. Dominant along Fourmile Branch in this area are tag alder, willow, sweet gum and wax myrtle. The seepline is located in a similar bottomland, hardwood forest community. [DOE/EIS-0303]

No endangered or threatened fish or wildlife species have been recorded near the UTR and Fourmile Branch seeplines. The seeplines and associated bottomland community do not provide habitat favored by endangered or threatened fish and wildlife species known to occur at SRS. The American alligator is the only federally protected species that could potentially occur in the area of the seeplines. Fourmile Branch does support a small population of American alligator in its lower reaches, where the stream enters the Savannah River swamp. [DOE/EIS-0303]

According to summaries on UTR studies documented in the *SRS Ecology Environmental Information Document*, the macroinvertebrate communities of UTR drainage are unusual. [WSRC-TR-2005-00201] They include many rare species and species not often found living together in the same freshwater system. Since UTR is a spring-fed stream and is colder and generally clearer than most surface water at its low elevation, species typical of unpolluted streams in northern North America or the southern Appalachian Mountains are found here along with lowland (Atlantic Coastal Plain) species.

The fish community of UTR is typical of third and higher order streams on SRS that have not been greatly affected by industrial operations, with shiners and sunfish dominating collections. The smaller tributaries of UTR are dominated by shiners and other small-bodied species (i.e., pirate perch, madtoms and darters) indicative of un-impacted streams in the Atlantic Coastal Plain. In the 1970s, the U.S. Geological Survey designated UTR as a National Hydrological Benchmark Stream due to its high water quality and rich fauna. However, this designation was rescinded in 1992 due to increased development of the UTR watershed north of SRS site boundaries. [DOE/EIS-0303]

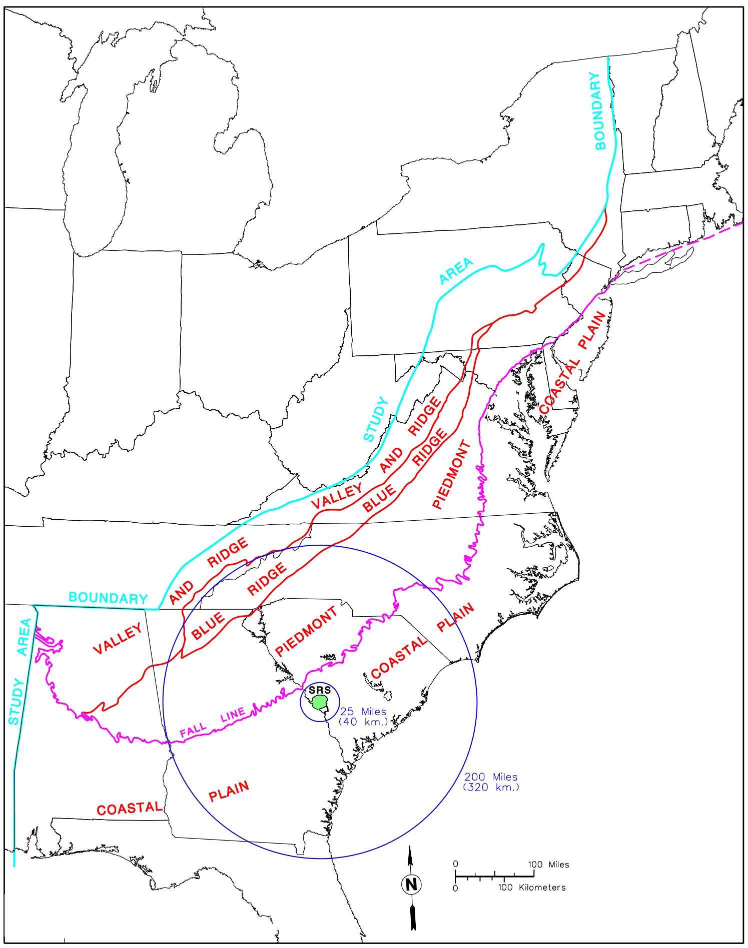
2.1.4 Geology, Seismology and Volcanology

Regional and local information on the geologic and seismic characteristics of the HTF are presented in this section. Because SRS is not located within a region of active-plate tectonics characterized by volcanism, volcanology is not an issue of concern in the HTF PA, and thus further discussion of this topic is omitted from the following discussion. [WSRC-IM-2004-00008]

2.1.4.1 Regional and Site-Specific Topography

The SRS is on the Atlantic Coastal Plain Physiographic Province approximately 25 miles southeast of the Fall Line that separates the relatively unconsolidated coastal plain sediments from the underlying Piedmont Physiographic Province. Beneath the coastal plain, sedimentary sequences reveal two geologic terrains. One is the Dunbarton basin, a Triassic-Jurassic Rift basin filled with lithified terrigenous and lacustrine sediments. The other is a crystalline terrain of metamorphosed sedimentary and igneous rock that may range in age from Precambrian to late Paleozoic derived from the crystalline igneous and metamorphic rocks of possibly late Precambrian to late Paleozoic age in the Piedmont Province. Early to middle Mesozoic (Triassic to Jurassic) rocks occur in isolated fault-bounded valleys either exposed within the crystalline belts or buried beneath the coastal plain sediments. The coastal plain sediments were derived from erosion of the crystalline rocks during late Mesozoic (Cretaceous) in stream and river valleys, and are represented locally by gravel deposits adjacent to present-day streams and by sediments filling upland depressions (sinks and Carolina bays). The Cretaceous and younger sediments are not significantly indurated. The total thickness of the sediment package at SRS varies between approximately 700 feet at the northwest boundary and 1,200 feet at the southeast boundary. [WSRC-TR-95-0046]

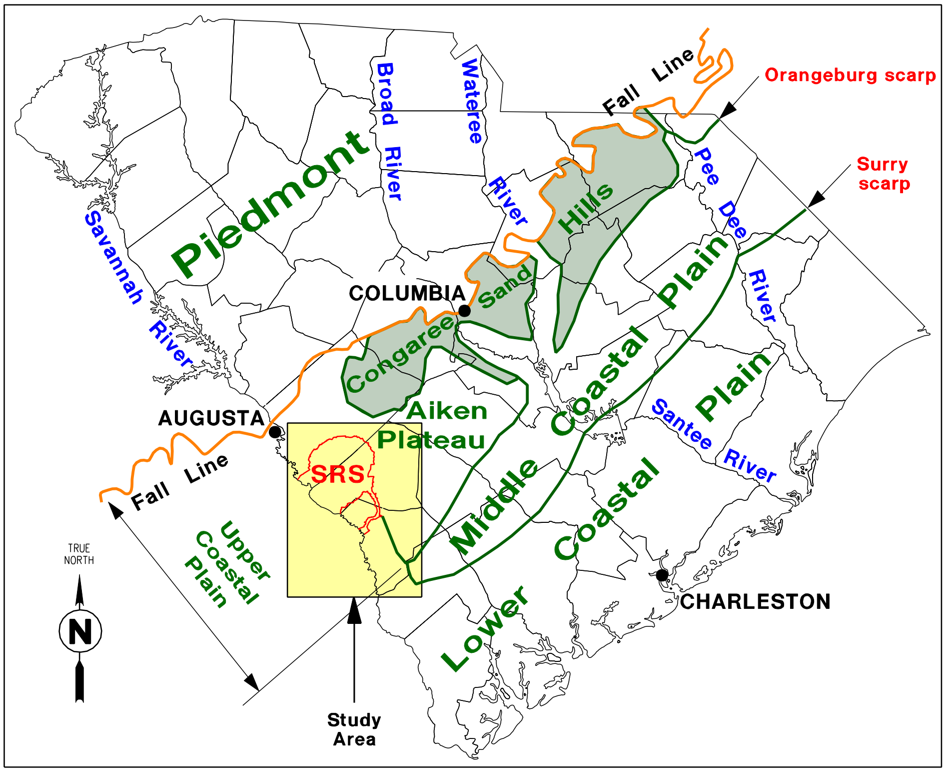
Figure 2.1-7: Regional Geological Provinces of Eastern United States



[WSRC-TR-2000-00310, Figure 1]

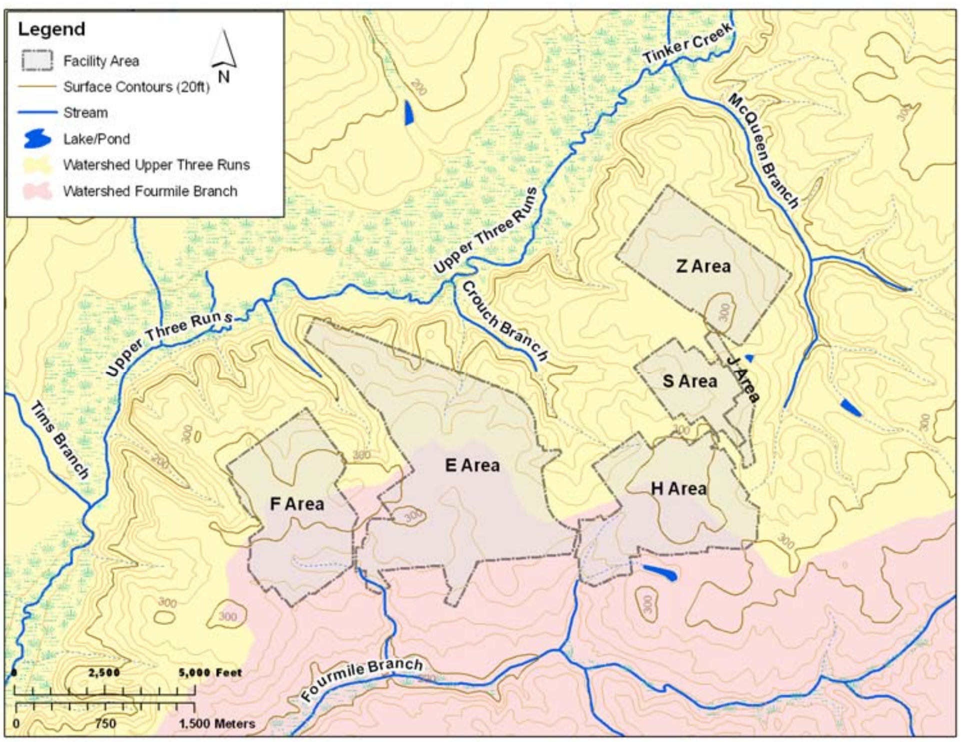
Figure 2.1-7 shows the relationship of SRS to overall regional geological provinces, and Figure 2.1-8 details the regional physiographic provinces in South Carolina. As can be seen on Figure 2.1-8, much of SRS lies within the Aiken Plateau, and this plateau has an approximate 5 % slope to the southeast. Savannah and Congaree Rivers bound the plateau, which extends from the Fall Line to the Orangeburg escarpment. The highly dissected surface of the Aiken Plateau is characterized by broad interfluvial areas with narrow, steep-sided valleys. Local relief can be as much as 300 feet. Figure 2.1-9 shows the topography and 20-foot contour lines of the GSA. [WSRC-TR-95-0046]

Figure 2.1-8: Regional Physiographic Provinces of South Carolina



[WSRC-TR-95-0046, Figure 2-3]

Figure 2.1-9: GSA Topography

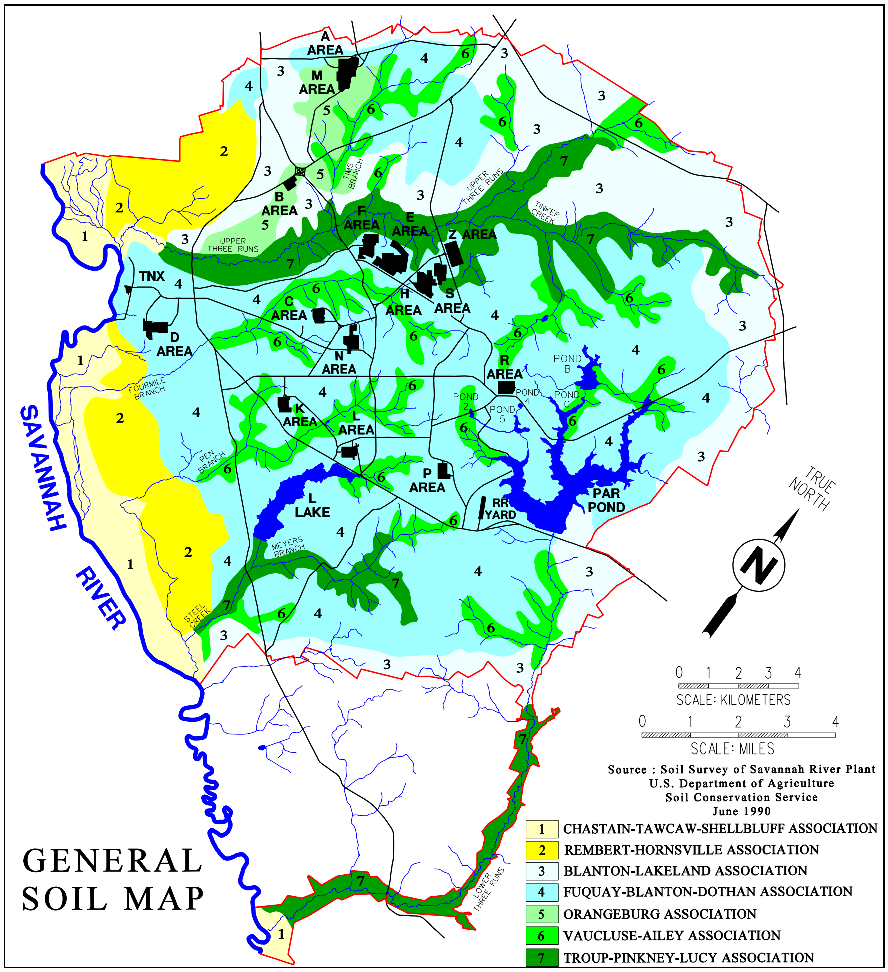


Currently, HTF storm water drainage is directed to an outfall, which will be unaffected by HTF operations and waste tank closure activities. The installation of the HTF closure cap (see Section 2.6) will necessitate changes to the HTF drainage system, which will be designed later as part of the overall closure of HTF.

2.1.4.2 Local Geology and Soils

SRS is comprised of seven major soil associations: Chastain-Tawcaw-Shellbluff, Rembert-Hornsville, Blanton-Lakeland, Fuquay-Blanton-Dothan, Orangeburg, Vaucluse-Ailey and Troup-Pinkney-Lucy. Figure 2.1-10 delineates the general soil associations for SRS. Details regarding these associations may be found in the *Soil Survey of the Savannah River Plant, Parts of Aiken, Barnwell, and Allendale Counties, South Carolina*. [PIT-MISC-0104]

Figure 2.1-10: General Soil Associations for SRS



[PIT-MISC-0104]

The overall general soil association for H Area is the Fuquay-Blanton-Dothan. The most predominant soil types within H Area are classified as Udorthents. Udorthents consist of well-drained soils that formed in heterogeneous materials, which are the spoil or refuse from excavations and major construction operations. Udorthents range from sandy to clayey, depending upon the source of material or geologic parent material. Udorthents are most commonly associated with well drained to excessively drained upland soils. A few small, poorly drained areas that have spoil are also included. Typical profiles for Udorthents are not shown due to the lack of consolidation within short distances. Clayey soil has demonstrated good retention for most radionuclides. There are also areas that consist of cross-bedded, poorly sorted sand with lenses and layers of silt and clay.

The uppermost geologic unit in the HTF is comprised of the middle to late Miocene-age Upland Unit, which extends over much of SRS (see Section 2.1.5.1). The term “Upland Unit” is an informal name used to describe sediments at higher elevations located in the Upper Coastal Plain in southwestern South Carolina. This area has also been referred to as the Aiken Plateau. The Upland Unit includes the vadose zone and a portion of the UTR Aquifer-Upper Zone (UTRA-UZ). The occurrence of cross-bedded, poorly sorted sands with clay lenses in the Aiken Plateau indicates fluvial deposition (high-energy channel deposits to channel-fill deposits) with occasional transitional marine influence. This depositional environment results in wide differences in lithology and presents a very complex system of transmissive and confining beds or zones. The lower surface of the Upland Unit is very irregular due to erosion of the underlying formations. [DOE/EIS-0303]

A notable feature of the Upland Unit is its compositional variability. This formation predominantly consists of red-brown to yellow-orange, gray and tan colored, coarse to fine grained sand, pebbly sand with lenses and beds of sandy clay and clay. Generally vertically upward through the unit, sorting of grains becomes poorer, clay beds become more abundant and thicker, and sands become more argillaceous and indurated. In some areas, small-scale joints and fractures, both of which are commonly filled with sand or silt, traverse the unit. The mineralogy of the sands and pebbles primarily consists of quartz, with some feldspars. In areas to the east-southeast, sediments may become more phosphatic and dolomitic. The soils in the Upland Unit may contain as much as 20 % to 40 % clay. [DOE/EIS-0303]

Below the Upland Unit lies the Tobacco Road Formation, consisting of red, brown, tan, purple, and orange quartz sands, and clayey quartz sands. These sands are fine to coarse moderately to poorly sorted, with minor clay laminae. In general, the sands of the Tobacco Road Formation are muddier, more micaceous and more highly colored than the sands of the underlying Dry Branch Formation. The base of the Tobacco Road Formation is marked in places by a coarse layer that contains flat quartz pebbles. Clay laminae in the upper part of the formation suggest that some of the unit was deposited in a transitional, low-energy environment, such as a tidal flat. The Tobacco Road Formation is approximately 20-foot thick and is part of the UTRA-UZ. [SRNL-STI-2010-00148]

Underlying the Tobacco Road Formation is the Dry Branch Formation, consisting of variably colored, poorly sorted to well-sorted sand with the interbedded tan to gray clay. The upper portion of the Dry Branch Formation is within the UTRA-UZ. The middle to lower portion of the Dry Branch Formation includes the Twiggs Clay; a semi-confining clay layer also designated as the Tan Clay Confining Zone, which separates the UTRA-UZ from the UTRA-Lower Zone (UTRA-LZ).

Below the Twiggs Clay are the Clinchfield and Santee Formations. In H Area, the Santee Formation is composed of mixed clastic and carbonate materials, with clastic material being dominant; the interpreted depositional scenario is a moderate energy, middle shelf environment, with input of both clastic and carbonate sediments. Lithologic and petrographic studies have divided the Santee Formation in the GSA into eight microfacies, quartz sand (stone), terrigenous mud (stone), skeletal lime mudstone, skeletal wackestone, skeletal packstone, skeletal grainstone, microsparite and siliceous mudstone. [WSRC-RP-94-54] None of these depositional environments contains significant amounts of limestone that would be conducive to the formation of large subsurface voids, karst or caves within the vicinity of HTF.

The calcareous zones, located within the Santee Formation, contain “soft zones.” Characterization activities reported in various early documents describe potential voids, drilling fluid losses and grout takes associated with the Santee Formation at SRS. Soft zones have been encountered beneath most of SRS, but are less common in the northwest (updip) and more common in the southeastern (downdip near K Area) regions. This distribution appears to correlate with the well-documented pattern of increasing carbonate content in the Santee Formation to the southeast. This lateral variation in carbonate content reflects the original range of depositional environments, from nearshore and inner shelf environments with primarily terrigenous input in the northwest, to quiet water, outer shelf conditions of carbonate accumulation in the southeast (in the vicinity of K Area). [WSRC-RP-94-54, WSRC-TR-99-4083]

A recent evaluation of more than 60 years of investigation and research into the occurrence, origin and behavior of soft zones confirms that soft zones beneath SRS are not cavernous voids, but are small, isolated, poorly connected three-dimensional features filled with loose, fine-grained, water saturated sediment. [SRNL-TR-2012-00160]

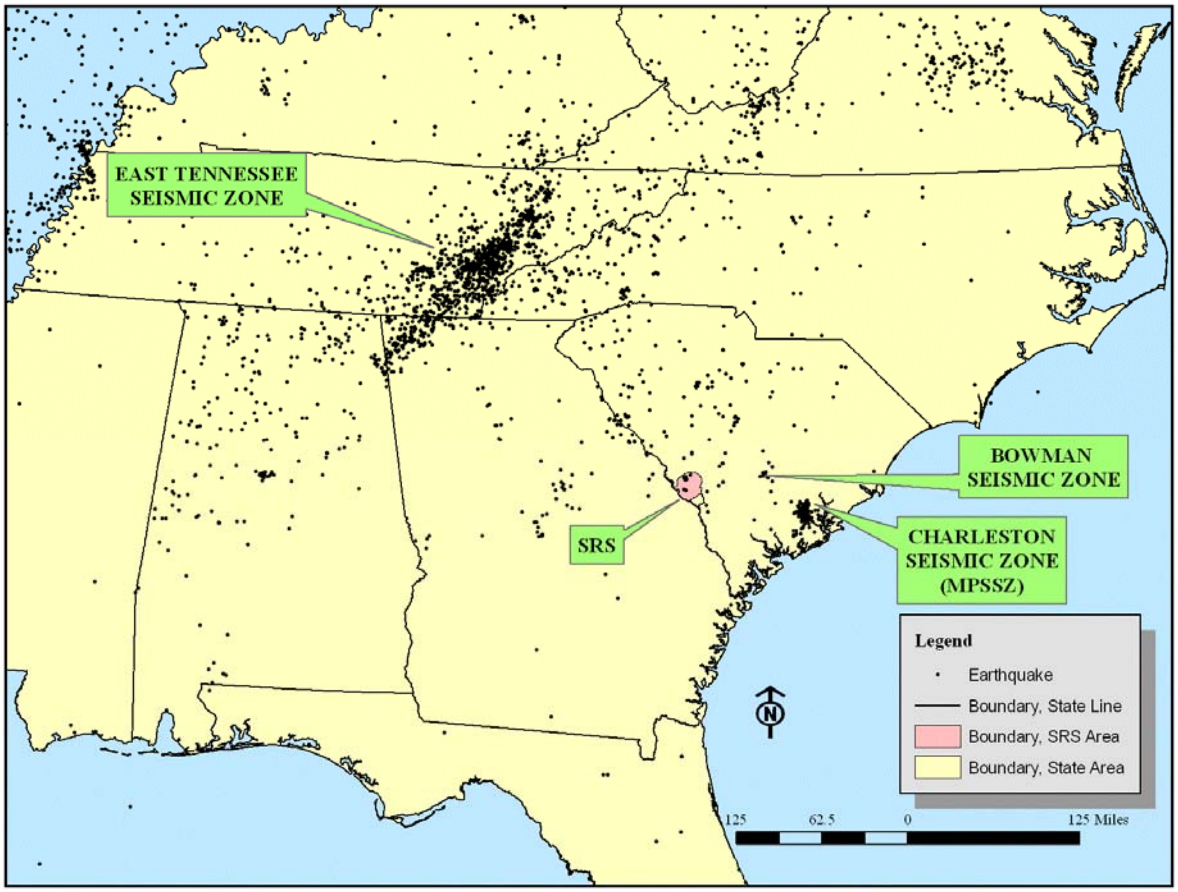
In the GSA, which includes HTF, there is no evidence of actual subsurface voids, karst or caves that would act as open flow conduits. In historical and recent literature, no documentation was found of void spaces or other phenomena that would influence contaminant migration in a manner not already captured in the GSA Database (GSAD). As described in Section 2.1.5.2, the GSAD was developed using field data and interpretations for the GSA and vicinity and is a subset of site-wide data sets of soil lithology and groundwater information. The GSAD is used as the basis of hydrogeologic input values into the computational model for groundwater flow and contaminant transport as described in Section 7.1.2. Underlying the Santee Formation is the Warley Hill Formation, often referred to as the “Green Clay”, which forms the hydrologic barrier separating the UTRA-LZ from the underlying Gordon Aquifer of the Congaree Formation.

A more detailed description of the geology and soils of the H Area can be found in a report titled *Hydrogeologic Framework of West-Central South Carolina*. [PIT-MISC-0112]

2.1.4.3 Seismology

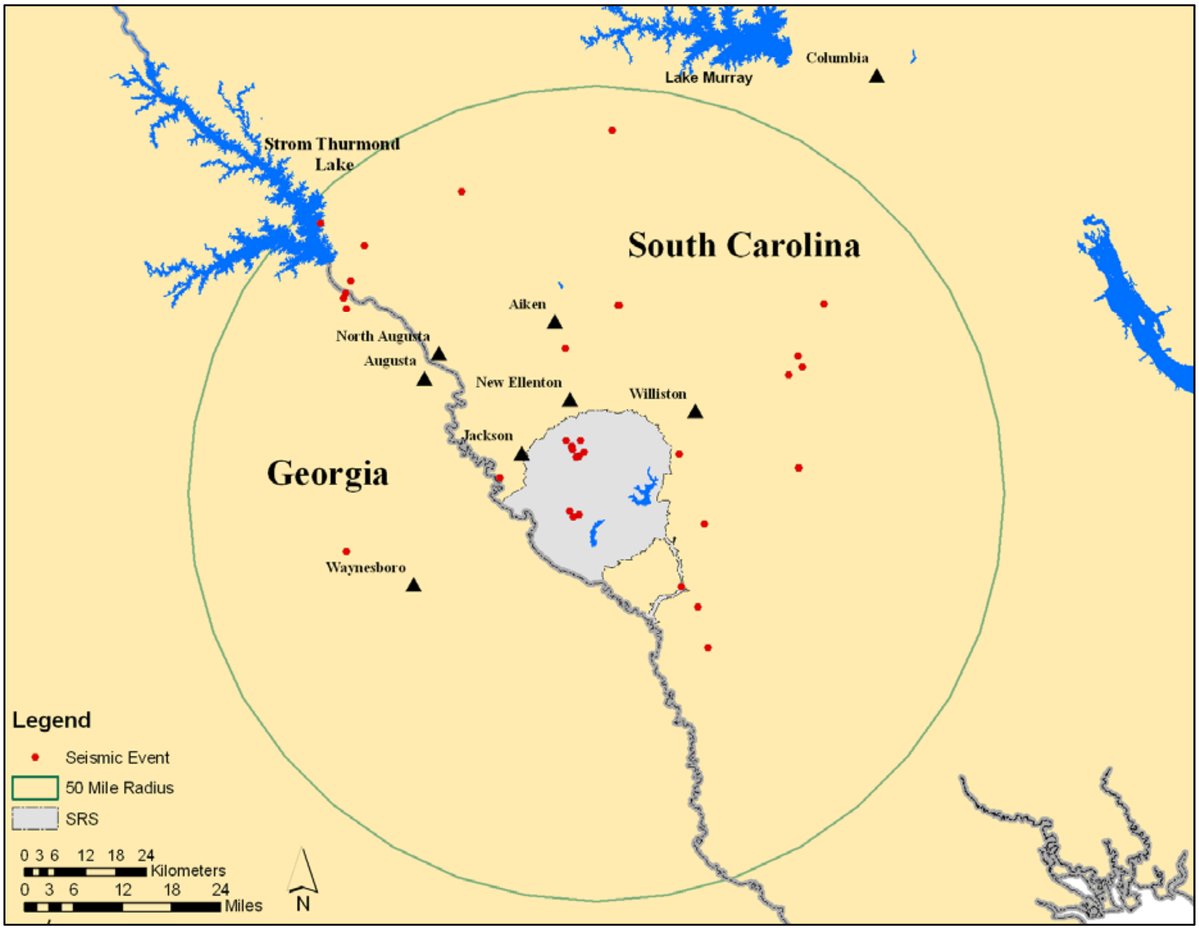
The seismic history of the Southeastern United States (of which SRS is a part) spans a period of nearly three centuries, and is dominated by the Charleston earthquake of August 31, 1886 (estimated magnitude of 7.0). The historical database for the region is essentially composed of two data sets extending back to as early as 1698. The first set is comprised of pre-network, mostly qualitative data (1698 to 1974), and the second set covers the relatively recent period of instrumentally recorded or post-network seismicity, 1974 through April 2009. Figure 2.1-11 shows the locations of historical seismic events in the Southeast. Figure 2.1-12 denotes the epicenter locations of seismic events within a 50-mile radius of SRS. [SRR-CWDA-2010-00128]

Figure 2.1-11: Historical Seismic Events in the Southeast



[SRR-CWDA-2010-00128]

Figure 2.1-12: Seismic Events within a 50-Mile Radius of SRS



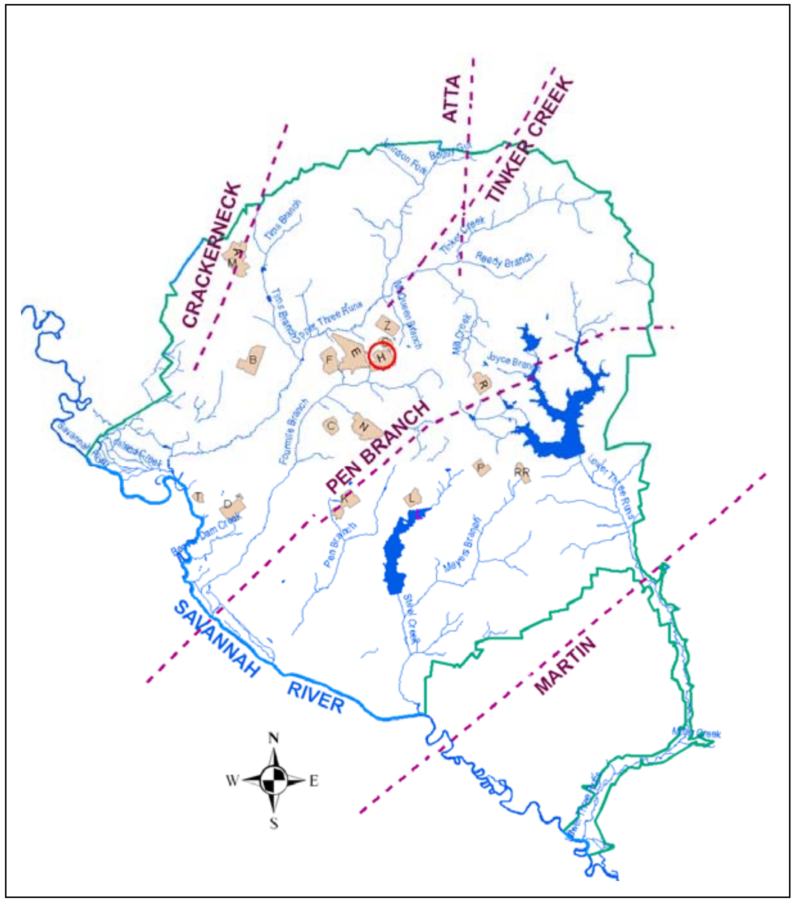
[SRR-CWDA-2010-00128]

The most recent seismic event occurring within a 50-mile radius of SRS was on March 27, 2009, with a magnitude of 2.6. No damage to SRS was recorded. However, there have been four earthquakes with epicenter locations within SRS. They occurred June 9, 1985 (magnitude of 2.6); August 5, 1988 (magnitude of 2.0); May 17, 1997 (magnitude of 2.5), and October 8, 2001 (magnitude of 2.6). No strong motion accelerometers were triggered because of these earthquakes. Note that additional seismic events with epicenter locations within SRS occurred shortly after the October 2001 earthquake, however, these seismic events were attributed to aftershocks and not actual earthquakes. [WSRC-MS-2003-00617]

The regional faults within SRS and vicinity are shown in Figure 2.1-13. A study entitled *Comparison of Cenozoic Faulting at the Savannah River Site to Fault Characteristics of the Atlantic Coast Fault Province: Implications for Fault Capability* (WSRC-TR-2000-00310) provides additional data. This study concludes that these regional faults exhibit the same general characteristics, are closely associated with the faults of the Atlantic Coastal Fault Province, and thus are part of the Atlantic Coastal Fault Province. Several faults of the Atlantic Coastal Fault Province have been the subject of detailed investigations. In all cases, the conclusion has been reached that these faults have not had a movement within the past 35,000 years and no movement of a recurring nature within the past 500,000 years. Inclusion in the Atlantic Coastal Fault Province means that the historical precedent established by decades of previous studies on the seismic hazard potential for the Atlantic Coastal Fault Province is relevant to faulting at the SRS. [WSRC-TR-2000-00310]

In 1976, a short-period seismic network was established. In 1999, a 10-station strong motion accelerometers network was installed throughout the complex. Detailed information regarding seismic characteristics at SRS can be found in the Documented Safety Analysis document, WSRC-IM-2004-00008.

Figure 2.1-13: Regional Scale Faults for SRS and Vicinity



[WSRC-TR-2000-00310, Figure 10]

As noted in Section 2.1.4.2, soft zones have been reported in various early documents. The soft zones described in these documents are described as voids, drilling fluid losses and grout takes associated with the Santee Formation beneath SRS that may be susceptible to seismic activity. However, in spite of their under consolidated nature, soft zones have survived for a very long time and remain structurally competent in the presence of significant overburden stresses. [SRNL-TR-2012-00160]

The predicted behavior of soft zones under both static and dynamic conditions has been modeled for numerous SRS facilities. These calculations show soft zones to be stable under static conditions; dynamic analyses predict that soft zones will not collapse in response to a design basis earthquake. [WSRC-TR-99-4083] The design basis earthquake and associated ground motion, measured in peak ground acceleration for construction of facilities at the SRS (ground motion 0.2 force of gravity) is based on historic seismic events in the region, the geologic literature and attenuation relations. [WSRC-TR-90-0284]

As a conservative approach, the design for some SRS facilities assumes that soft zones will collapse (compress) in response to applied stress. An analysis for a proposed facility (Actinide Packaging and Storage Facility) within the GSA calculated that collapse of a relatively thick (approximately 8 inches) two-layer soft zone would only cause a ground surface settlement of about 4 inches. [K-CLC-F-00034]

Although such conservative calculations are an important aspect of nuclear safety evaluations, it is noteworthy that soft zones in the Eocene age Santee Formation have survived without collapsing for tens of millions of years and have presumably persisted in spite of many earthquakes, including design basis earthquakes, and less frequent events of even greater magnitude. [SRR-CWDA-2011-00054]

A structural assessment was prepared for operationally closed waste tanks. Waste tank settlement can occur due to two loads, static load and seismic loads. Static settlement is likely to occur due to the large overburden load from the closure cap. This settlement is expected to be relatively uniform. Any static differential settlement would be small in magnitude and cause a grout-filled waste tank to rotate as a rigid body. Small magnitudes of rigid body rotation will induce only small lateral forces that can be considered negligible. Therefore, static differential settlement is not considered further. [T-CLC-F-00421]

Seismic differential settlement can occur due to liquefaction and soft zone settlement. Soft zones are often areas of under-consolidated material in a stronger matrix material that essentially forms a soil arch, allowing the soft zones to remain under-consolidated. A large seismic event could cause the soil arch to fail resulting in settlement as consolidation occurs in the under consolidated material until it is normally consolidated. The maximum tensile stresses resulting from this consolidation on the grout-filled waste tanks is an overstress of 4 %, occurring for a small depth. Since this stress occurs only for an extreme settlement case and due to the many bounding assumptions made in the structural assessment, it was concluded that there is very high confidence the grout filled waste tanks will not crack. [T-CLC-F-00421]

In addition, for the E-Area vaults in the GSA, a structural degradation study was prepared. This study included an evaluation of ground motion effects on the vaults. Ground motion magnitudes were extrapolated from SRS Performance Category (PC)-1 to PC-4 site-specific seismic criteria.[19] For horizontal acceleration, a 0.45 force of gravity value was obtained by extrapolating the zero period accelerations (i.e., peak ground acceleration) of the SRS design response for PC-1 to PC-4. [T-CLC-E-00018]

For vertical acceleration (2.0 force of gravity), a bounding approach was taken by extrapolating the peak of the SRS horizontal design response spectra for PC-1 to PC-4. This approach results in the large discrepancy between horizontal and vertical acceleration. This bounding approach for vertical acceleration was used in the structural degradation study because the item of concern was a buried roof slab with voids below. Therefore, the E-Area vault roof could respond differently than the ground (i.e., not peak ground acceleration). As the stabilized waste tanks will have no significant voids after grouting, this issue is not a concern. [T-CLC-E-00018]

Due to the lack of vertical/horizontal studies for low probability of exceedance events at SRS, the same bounding criteria used in the E-Area study were used for the structural assessment for closed waste tanks. [T-CLC-F-00421] However, it is recognized that 2.0 force of gravity is a bounding number. It is not a realistic number for ground acceleration at SRS. At the nearby Vogtle Electric Generating Plant, the vertical/horizontal ratio for the maximum considered event was 1.0, so a similar ratio should be considered acceptable for the SRS tank farms. [NUREG-1923] Based on a vertical/horizontal ratio of 1.0, the maximum vertical acceleration would be 0.45 force of gravity, much less than 2.0 assumed.

The PC-3 return period is 2,500 years (probability of exceedance 4.0E-04), and the PC-4 return period is 10,000 years (probability of exceedance 1.0E-04). In the E-Area analysis, one-dimensional soil analyses indicated the differential lateral displacement between the top and bottom elevations of the E-Area vault (approximately 28 feet in height) were 0.05 inches for a PC-3 event and 0.09 inches for a PC-4 event. The height differential in the E-Area vaults is similar to the height differential of the waste tanks. Extrapolating to probability of exceedance 1.0E-06 (a very low probability event) gives a maximum lateral differential displacement of 0.22 inches. For this small amount of deformation, the soil would deform locally at the boundaries of the grout-filled waste tank and stresses induced in the waste tank structure will be minimal. [T-CLC-E-00018]

The impacts from seismic events are considered in the conceptual model. To simulate potential conditions in the HTF closure system, multiple waste tank configurations were identified for analysis. While the configurations and the potential seismic events are not explicitly linked, the types of cracks caused by the credible seismic events at the HTF are assumed bounded by the configurations and the occurrence probability associated with the configurations in the stochastic modeling.

Seismic considerations are also included in the design of the conceptual closure cap to ensure seismic induced degradation mechanisms are addressed. Section 2.6 discusses the conceptual closure cap design, which will further consider and handle static loading induced settlement, seismic induced liquefaction and subsequent settlement, and seismic induced slope instability.

2.1.5 Hydrogeology

An understanding of the hydrogeology of the HTF is required in order for an estimate of the fate and transport of the residual HTF contaminants to be modeled. Characterization and monitoring data in the

[19] Performance category classification is a graded approach used to establish design and evaluation requirements for structures, systems and components. Performance categories range from 0 to 4 in order of increasingly stringent mitigation and performance requirements and with decreasing values of annual probability of exceedance of acceptable behavior limits. Performance categories are developed with regards to acts of nature (e.g., earthquake, wind, hurricane, tornado, flood, rain or snow precipitation, volcanic eruption, lightning strike or extreme cold or heat) which may threaten workers, the public or the environment by potential damage to structures, systems and components.

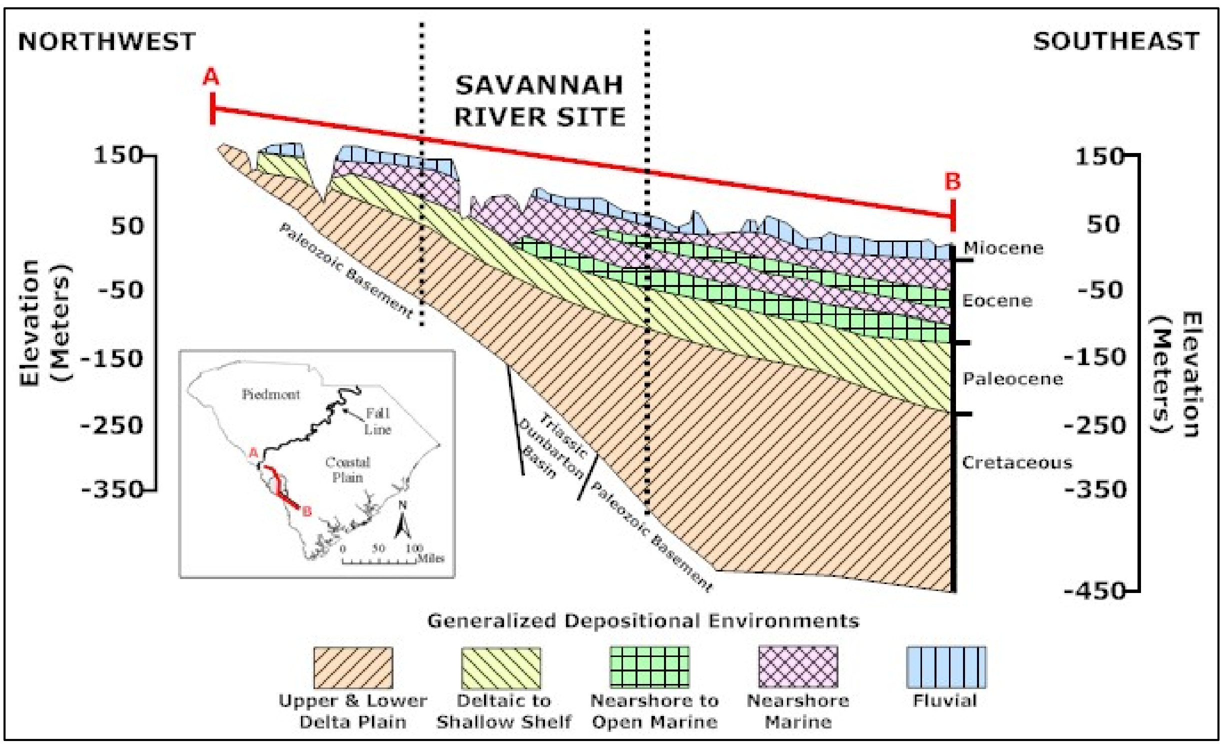
SRS GSA is extensive and provides a clear understanding of hydrogeology containing the HTF, and permitted generation of the GSAD. Additional background information supporting this conclusion is presented in Section 2.1.5.2.

2.1.5.1 Regional Hydrogeology

The SRS lies in the Atlantic Coastal Plain, a southeast-dipping wedge of unconsolidated and semi-consolidated sediment, which extends from its contact with the Piedmont Province at the Fall Line to the continental shelf edge. Sediments range in geologic age from late Cretaceous to recent and include sands, clays, limestones and gravels. This sedimentary sequence ranges in thickness from essentially zero at the Fall Line to more than 4,000 feet at the Atlantic Coast. At SRS, coastal plain sediments thicken from approximately 700 feet at the northwestern boundary to approximately 1,400 feet at the southeastern boundary of the site and form a series of aquifers and confining or semi-confining units. Aquifer systems include the Floridan and Dublin-Midville systems. [WSRC-STI-2006-00198]

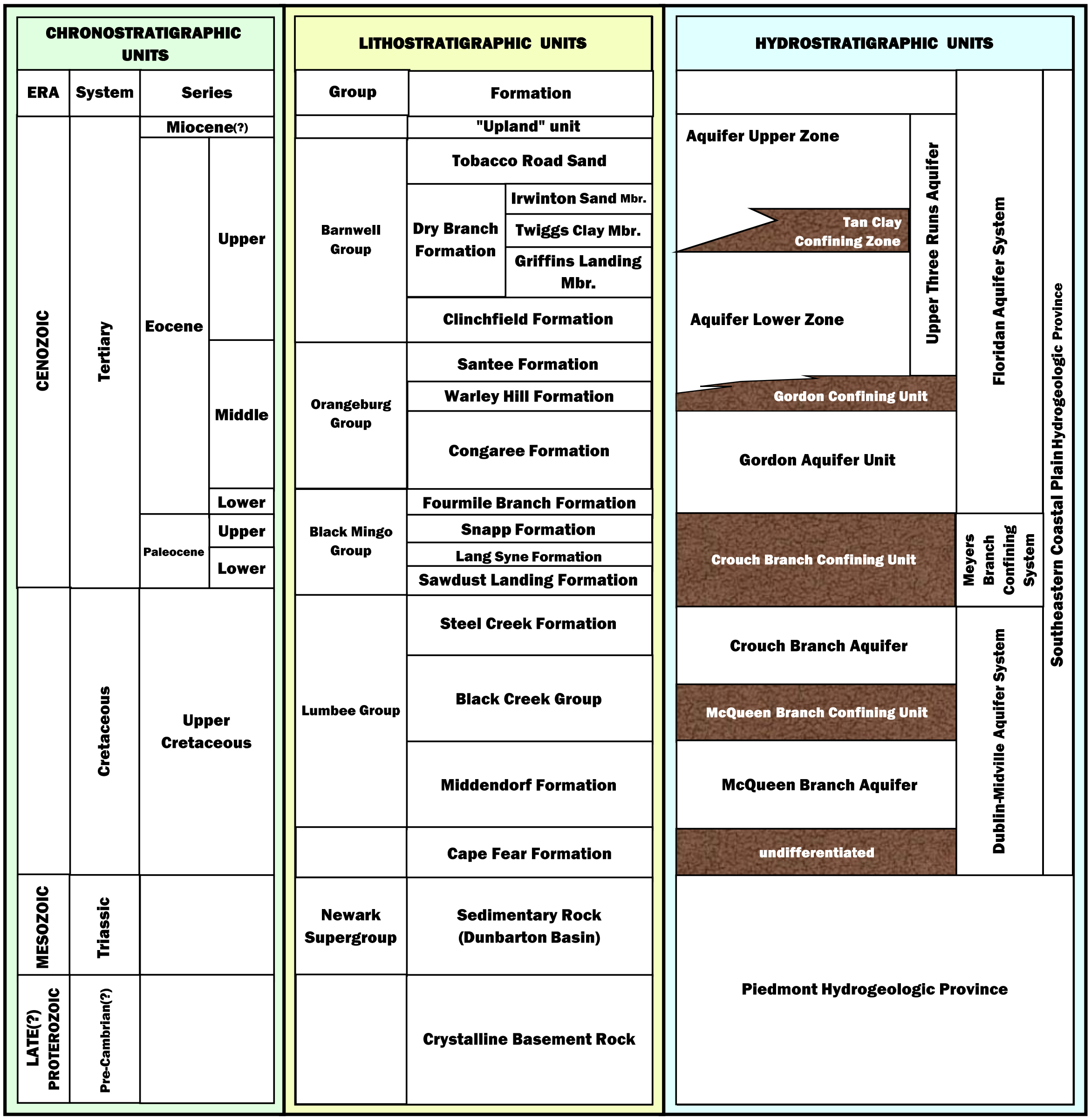
Figure 2.1-14 shows a generalized cross section of the sedimentary strata and their corresponding depositional environments for the Upper Coastal Plain down-dip through SRS into the Lower Coastal Plain. Figure 2.1-15 shows the regional lithologic units discussed in Section 2.1.4.2 and their corresponding hydrostratigraphic units at SRS. This classification system is consistent with the established system and is now widely used as SRS standard. [SRNL-STI-2010-00148]

Figure 2.1-14: Regional NW to SE Cross Section



[WSRC-STI-2006-00198]

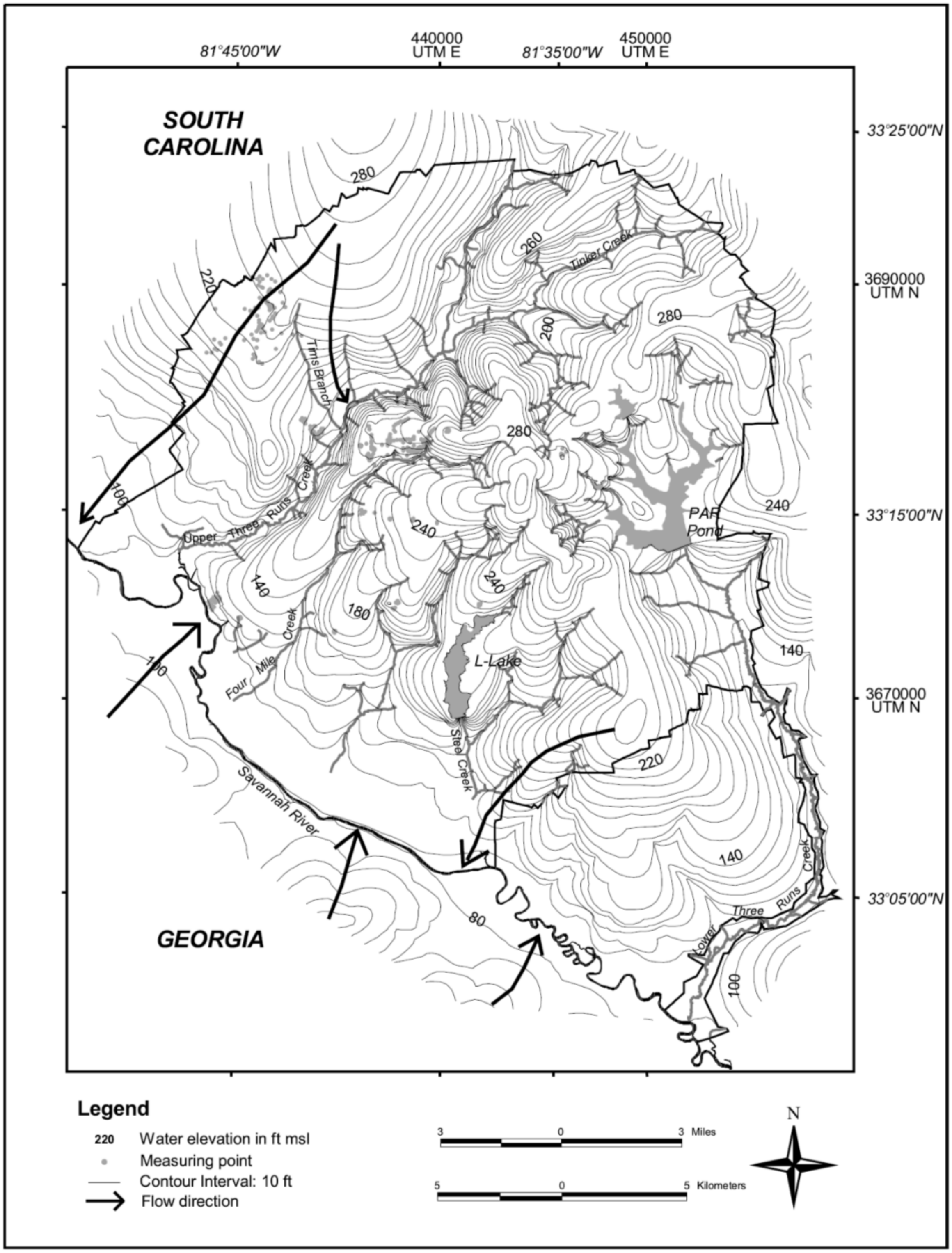
Figure 2.1-15: Comparison of Chronostratigraphic, Lithostratigraphic, and Hydrostratigraphic Units in the SRS Region



[SRNL-STI-2010-00148]

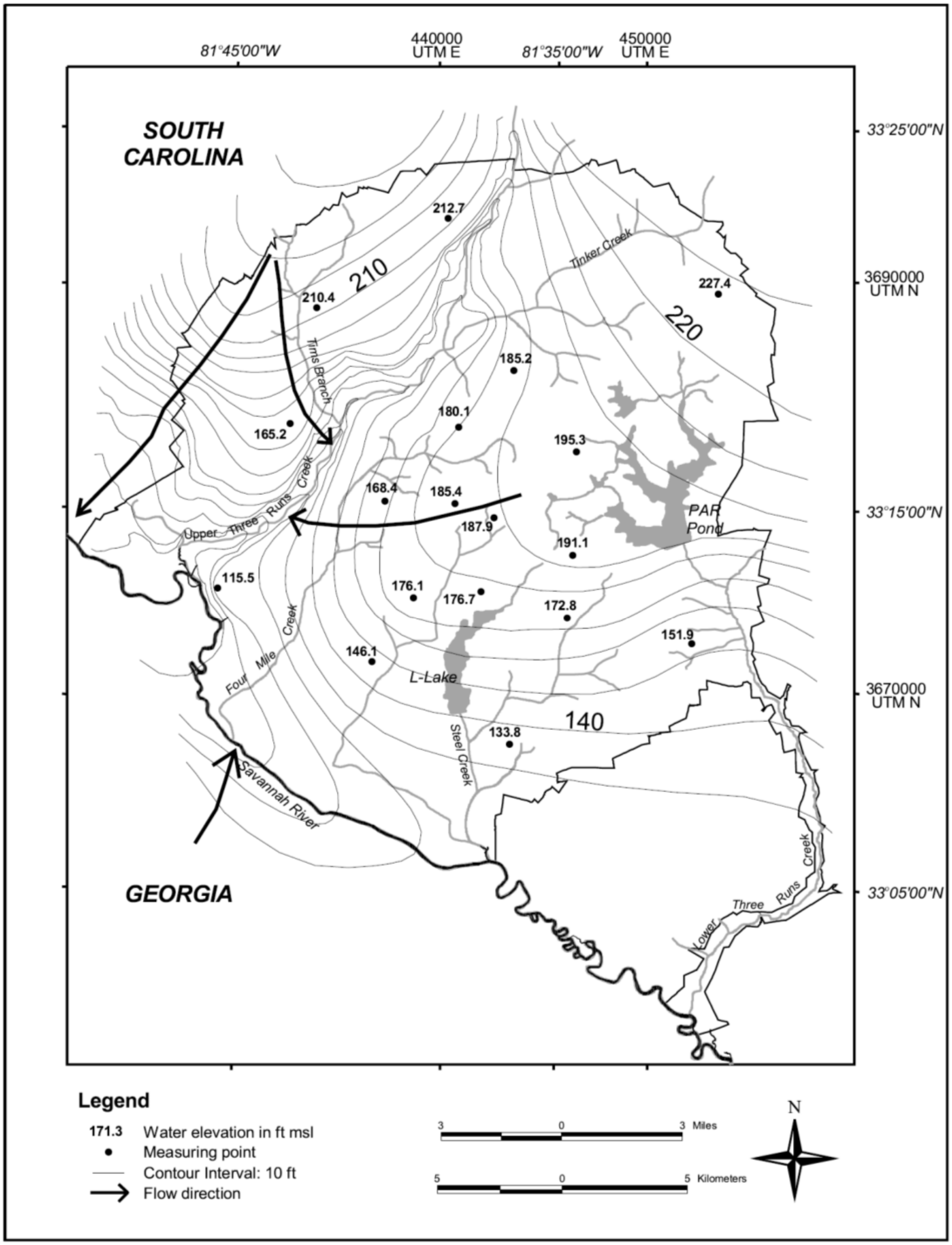
Figure 2.1-16 and Figure 2.1-17 illustrate potentiometric maps of the UTRA and Gordon Aquifer. Groundwater within the Floridan Aquifer system flows toward streams and swamps and into the Savannah River at rates ranging from inches to several hundred feet per year. The depth to which nearby streams cut into sediments, the lithology of the sediments and the orientation of the sediment formations control the horizontal and vertical movement of the groundwater. The valleys of smaller perennial streams in the GSA, such as Fourmile Branch, McQueen Branch and Crouch Branch, allow discharge from the shallow saturated geologic formations. The valleys of major tributaries of the Savannah River (e.g., UTR) drain formations of greater depth. With the release of water to the streams, the hydraulic head of the aquifer unit releasing the water can become less than that of the underlying unit. If this occurs, groundwater has the potential to migrate upward from the lower unit to the overlying unit. [DOE/EIS-0303]

Figure 2.1-16: Potentiometric Surface of the UTRA



[SRNS-STI-2011-00059]

Figure 2.1-17: Potentiometric Surface of the Gordon Aquifer

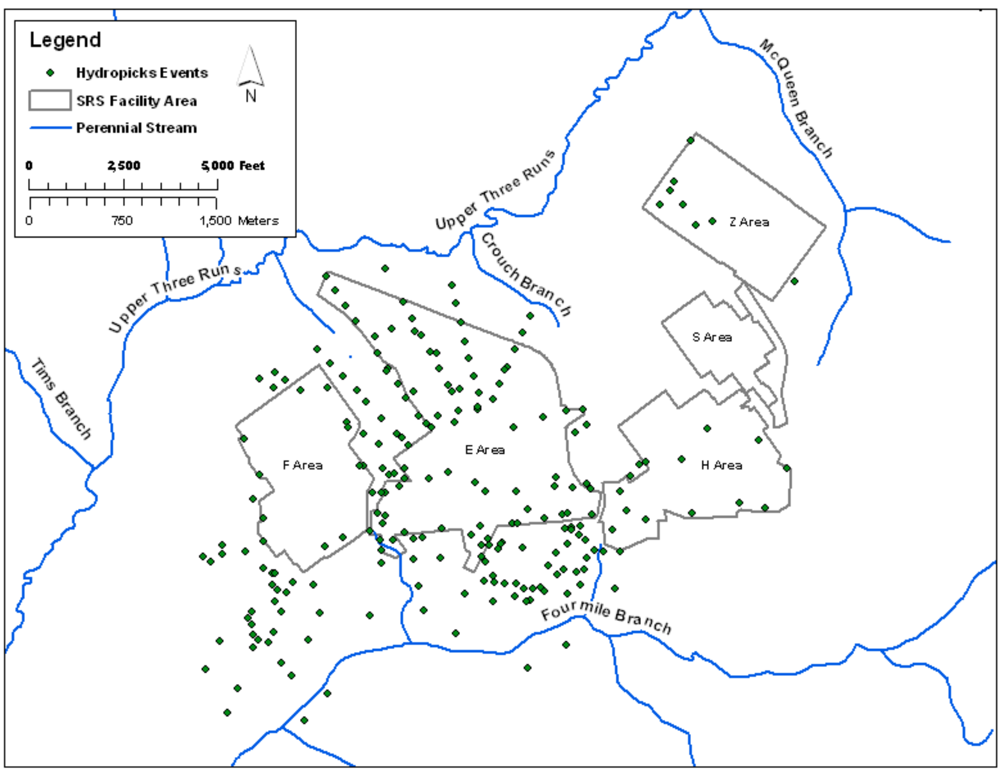


[SRNS-STI-2011-00059]

2.1.5.2 Characterization of Local Hydrogeology

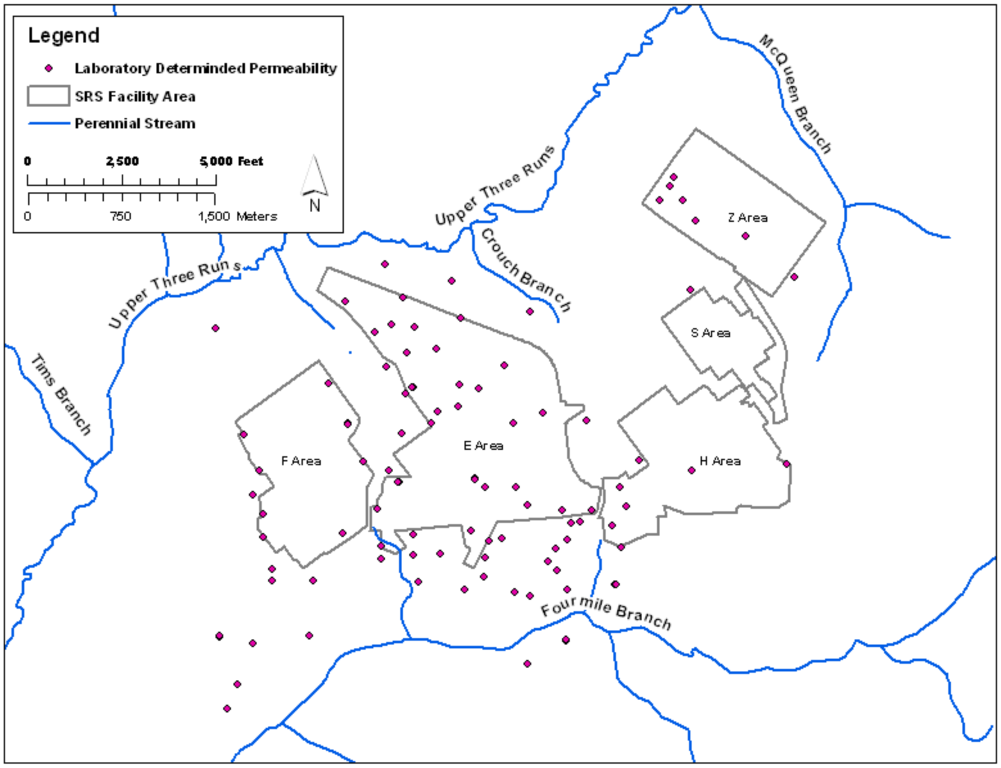
The GSA has been the focus of numerous geological and hydrogeological investigations. Early work included installation of monitoring wells in the 1950s and 1960s. Further characterization and monitoring were conducted in the area during the 1970s through present time, largely to support groundwater monitoring and decommissioning activities. The GSAD was developed using field data and interpretations for the GSA and vicinity through 1996. Although characterization and monitoring have been ongoing, the additional data has not altered fundamental understanding of groundwater flow patterns and gradients in the GSA. The GSAD is a subset of site-wide data sets of soil lithology and groundwater information. Figure 2.1-18 shows the location of all hydrostratigraphic picks used in the GSAD. Picks were made based on a combination of geophysical logs, Cone Penetration Test logs and core descriptions. Figures 2.1-19 through 2.1-22 show the locations of laboratory permeability data, multiple well pump tests, single well pump tests and slug test data used in the GSAD. Table 2.1-2 presents a summary of the characterization and monitoring data in the GSAD. These data provide detailed understanding of local hydrogeology beneath the HTF. See WSRC-TR-96-0399, Volumes 1 and 2, for a more comprehensive discussion of the data set. The GSAD, comprising SRS characterization and monitoring data and interpretations, is used as the basis of hydrogeologic input values into the computational model for groundwater flow and contaminant transport as described in Section 4.2.2.1.3 of the HTF PA. [SRR-CWDA-2010-00128]

Figure 2.1-18: Hydrostratigraphic Picks in GSAD



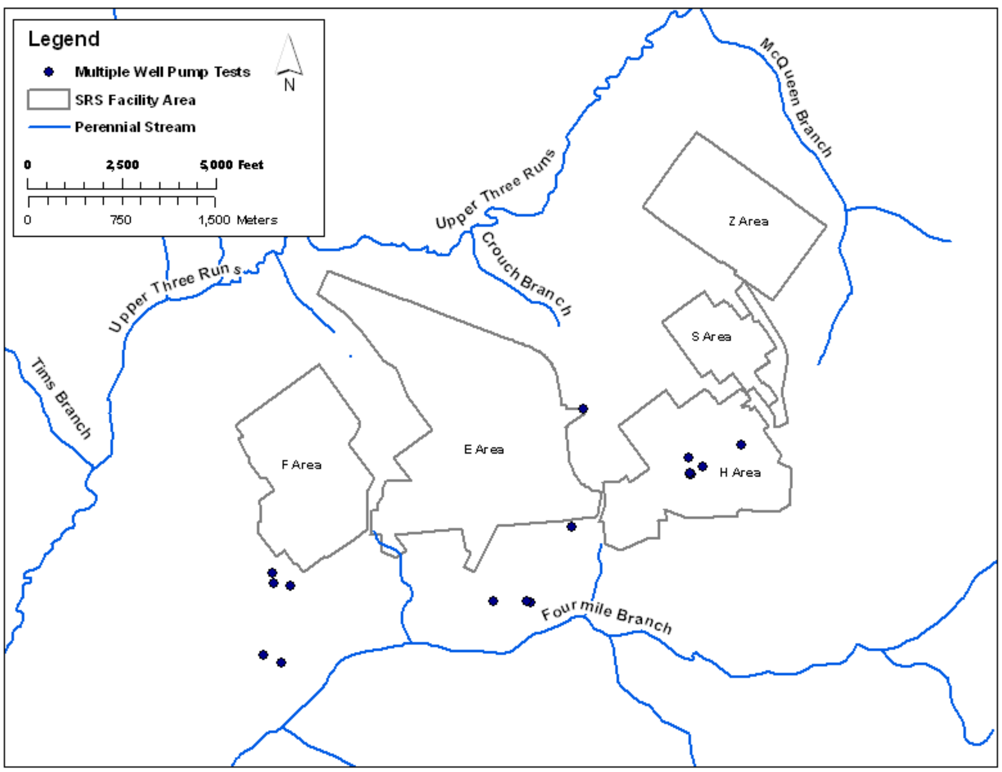
[WSRC-TR-96-0399-Vol. 1]

Figure 2.1-19: Laboratory Determined Permeability Data in GSAD



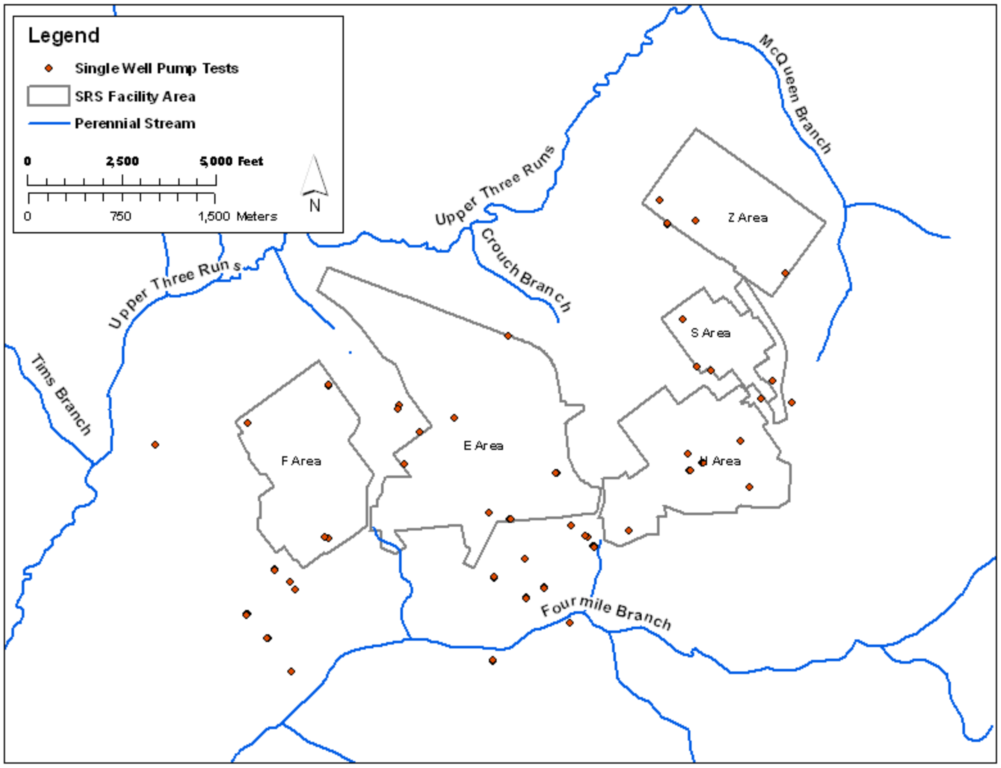
[SRNL-ESB-2007-00035]

Figure 2.1-20: Multiple Well Pump Test Data in GSAD



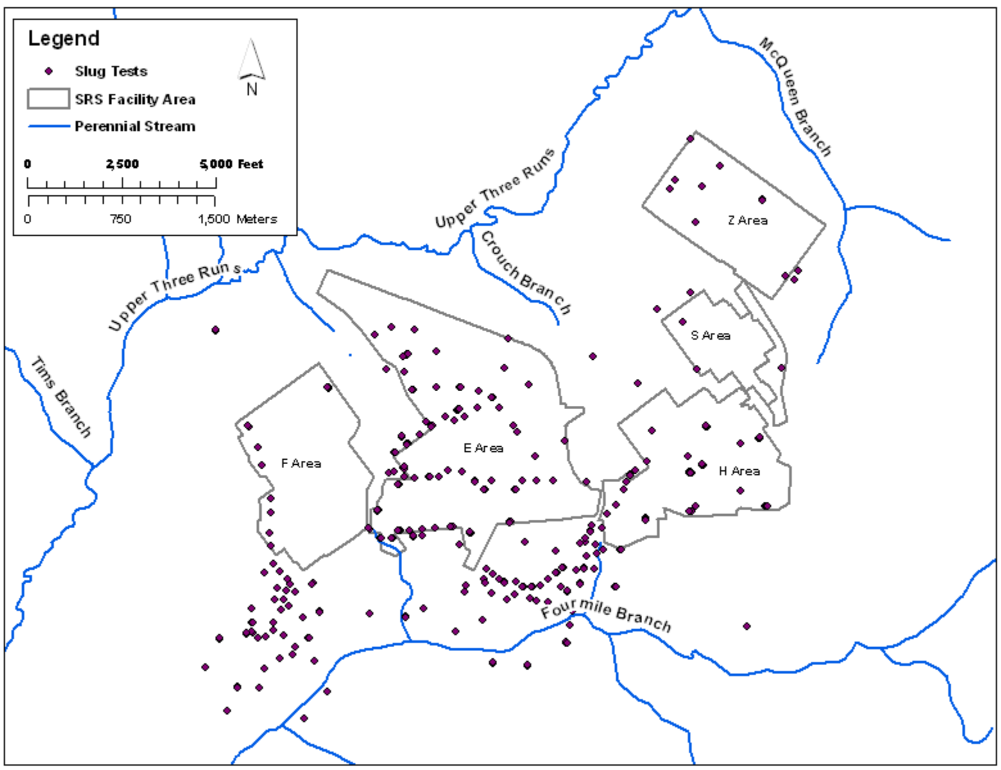
[WSRC-TR-96-0399-Vol. 2]

Figure 2.1-21: Single Well Pump Test Data in GSAD



[WSRC-TR-96-0399-Vol. 2]

Figure 2.1-22: Slug Test Data in GSAD



[WSRC-TR-96-0399-Vol. 2]

Table 2.1-2: Characterization and Monitoring Data in the GSAD

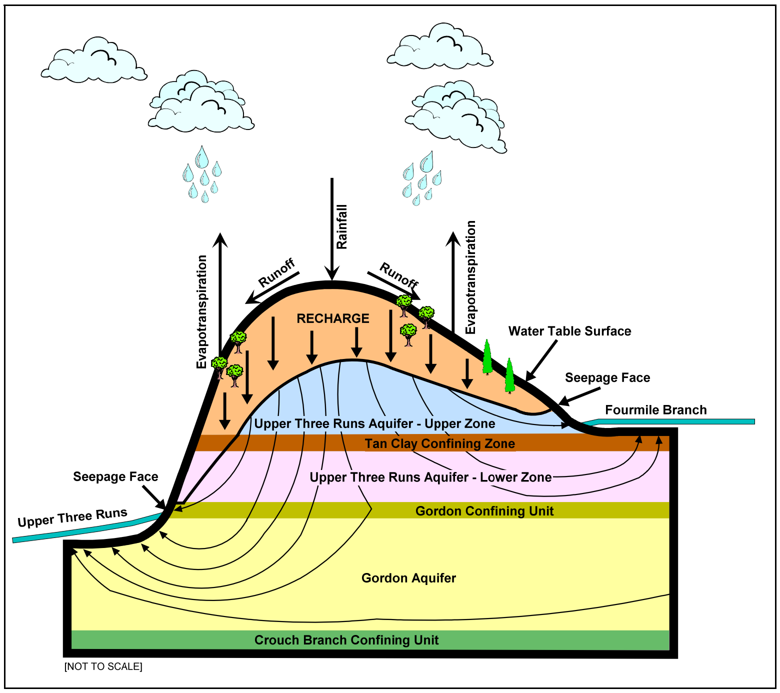
Data Type	Quantity	Reference
Sediment Core Descriptions	204 Locations; ~37,500 feet	WSRC-TR-96-0399-Vol. 1, App. B
Tops of Hydrostratigraphic Units/Zones		
Crouch Branch Confining Unit Gordon Aquifer Unit Gordon Confining Unit Upper Three Runs – Lower Zone Aquifer Tan Clay Confining Zone	52 Locations 146 Locations 161 Locations 222 Locations 225 Locations	WSRC-TR-96-0399-Vol. 1, App. A-3
Permeability Measurements		
Pump Tests Slug Tests Laboratory Permeability	85 Values 481 Values 258 Values	WSRC-TR-96-0399-Vol. 2, App. B
Water Levels		
Gordon Aquifer Unit Upper Three Runs – Lower Zone Aquifer Upper Three Runs – Upper Zone Aquifer	79 Locations 173 Locations 387 Locations	WSRC-TR-96-0399-Vol. 2, App. C

As described in Section 3.1.4.2 of the HTF PA, calcareous zones within the UTRA-LZ have been documented to contain soft zones, often related to dissolution of carbonate material. Soft zones at the SRS have not been studied using tracer tests; however, no unusual hydraulic gradients or unexpected flow conditions have been documented in the HTF or the GSA. Soft zones have, however, been the subject of many general and facility-specific investigations. These studies have shown that the soft zones are isolated, discrete, poorly connected, non-uniformly distributed features within the UTRA-LZ. Although their size and shape vary, their average thickness is generally only a few feet with a postulated maximum lateral dimension approximately 10 to 20 feet or less. [K-ESR-G-00013]

2.1.5.3 Groundwater Flow in the GSA

The aquifers of primary interest for HTF modeling are the UTRA-UZ/LZ and Gordon Aquifer. Plate 17 of the *Hydrogeological Framework of West-Central South Carolina* (PIT-MISC-0112) gives the leakance coefficient of the Crouch Branch Confining Unit (of the Meyers Branch Confining System) as roughly 3E-06 per day, which corresponds to 0.13 inch/year for every 10 feet of head difference. The measurement of head difference across the Crouch Branch Confining Unit is zero to 20 feet causing an upward flow averaging 0.13 inch/year. [PIT-MISC-0112] Flow across the unit is therefore a small fraction of total recharge, and is negligible in the HTF modeling. Potential contamination from the HTF is not expected to enter the deeper Crouch Branch Aquifer because an upward gradient exists between the Crouch Branch and Gordon Aquifers near UTRA. Figure 2.1-23 is

Figure 2.1-23: Conceptual Diagram of Groundwater Flow beneath the GSA



a cross-sectional schematic representation of groundwater flow patterns in the UTRA and Gordon Aquifer along a north-south cross section running through the center of HTF, shown with significant vertical exaggeration. Section 4.2.2.1.3 of the HTF PA provides the modeling inputs associated with groundwater flow characteristics obtained from the GSAD. [SRR-CWDA-2010-00128]

Although calcareous zones containing soft zones have been identified in the UTRA-LZ (see Section 3.1.4.2 of the HTF PA), during the 20-year period spanned by investigations used to populate the GSAD at more than 15 locations near HTF, no open flow conduits or other factors have been identified that would critically influence contaminant transport.

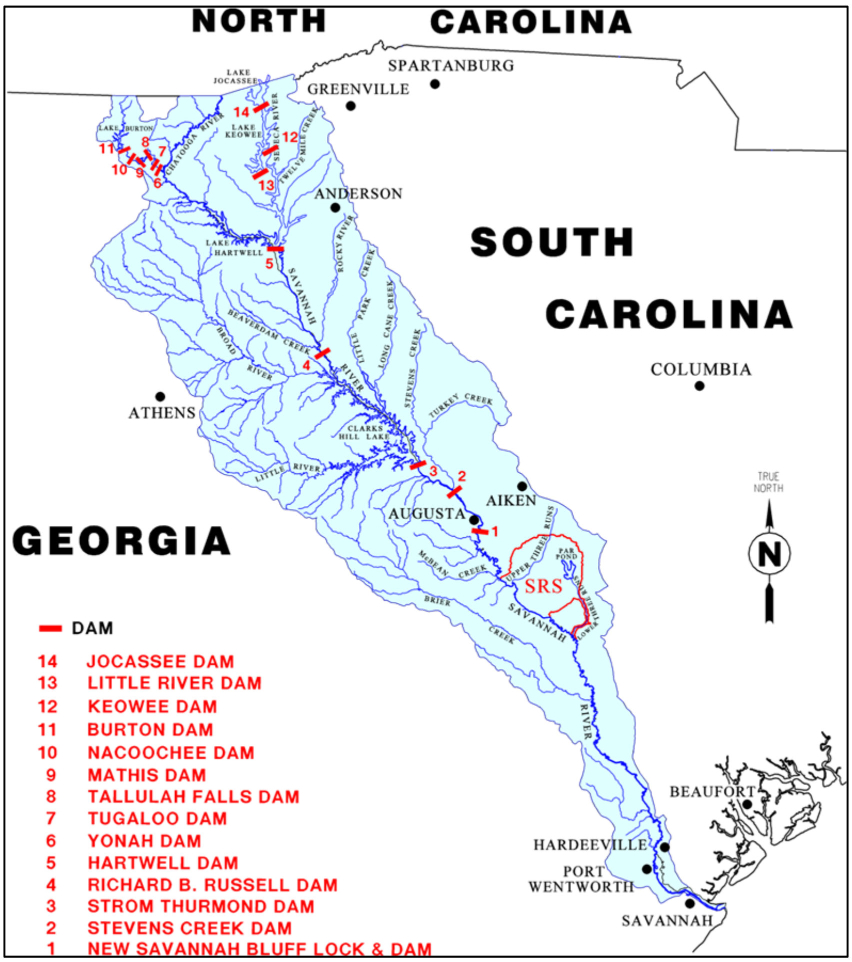
In addition, a further evaluation of more than 60 years of onsite investigation and research into soft zone occurrence, origin and behavior concludes that soft zones at the SRS appear not to be a critical influence on either groundwater flow or contaminant transport. [SRNL-TR-2012-00160]

Calcareous zones and associated soft zones are not treated separately in the flow model because they are isolated and discontinuous in the GSA, representing only a small fraction of the UTRA-LZ. These features occur near the base of the UTRA-LZ in the GSA and do not extend through the entire thickness of the aquifer. [WSRC-TR-99-4083]

2.1.5.4 Surface-Water Flow in the GSA

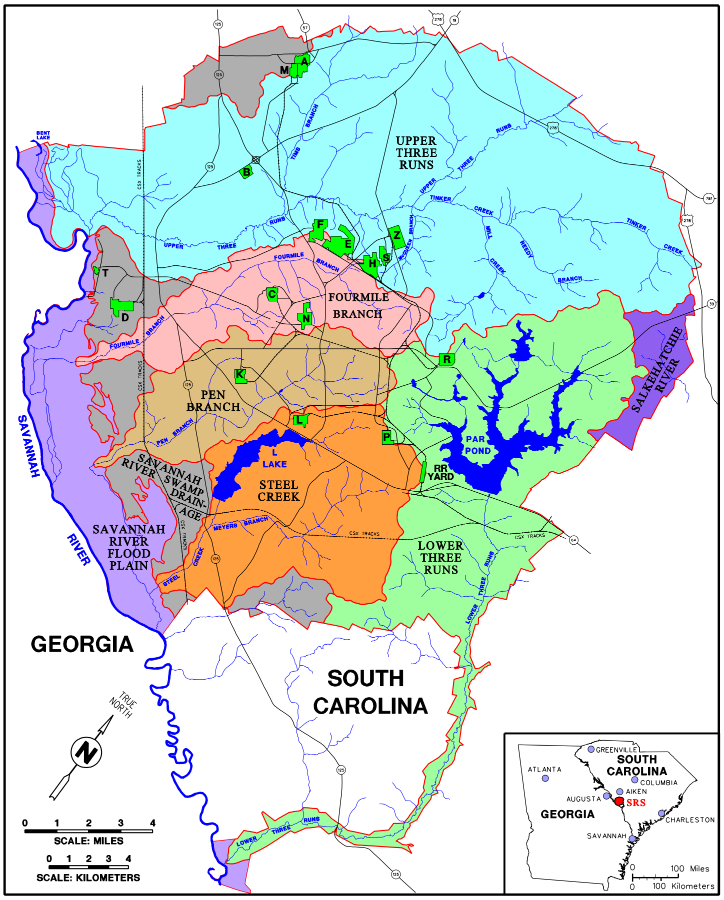
The Savannah River, which forms the boundary between Georgia and South Carolina, is the principal surface-water system near SRS. The river adjoins the site along its southwestern boundary for a distance of approximately 20 miles and the site is 160 river-miles from the Atlantic Ocean. Five upstream reservoirs – Jocassee, Keowee, Hartwell, Richard B. Russell and Clarks Hill Lake (also known as Thurmond Lake), minimize the effects from droughts and the impacts of low flow on downstream water quality and fish and wildlife resources in the river. Figure 2.1-24 shows the Savannah River Basin dams. The long-term yearly Savannah River flow at SRS averages approximately 10,400 cubic feet per second at SRS. [WSRC-TR-2005-00201, Table 4-24] For 2010, the average annual measured flow rate was 6,603 cubic feet per second. [SRNS-STI-2011-00059]

Figure 2.1-24: Savannah River Basin Dams



The major tributaries that occur on SRS are UTR, Fourmile Branch, Pen Branch, Steel Creek and Lower Three Runs (Figure 2.1-25). These tributaries drain all of SRS with the exception of a small area on the northeast side, which drains to a tributary of the Salkehatchie River. Each of these streams originates on the Aiken Plateau in the coastal plain and descends 50 to 200 feet before discharging into the river. The source of most of the surface water on SRS is either natural rainfall (see Section 2.1.2), water pumped

Figure 2.1-25: SRS Watershed Boundaries and Major Tributaries



[WSRC-STI-2008-00057]

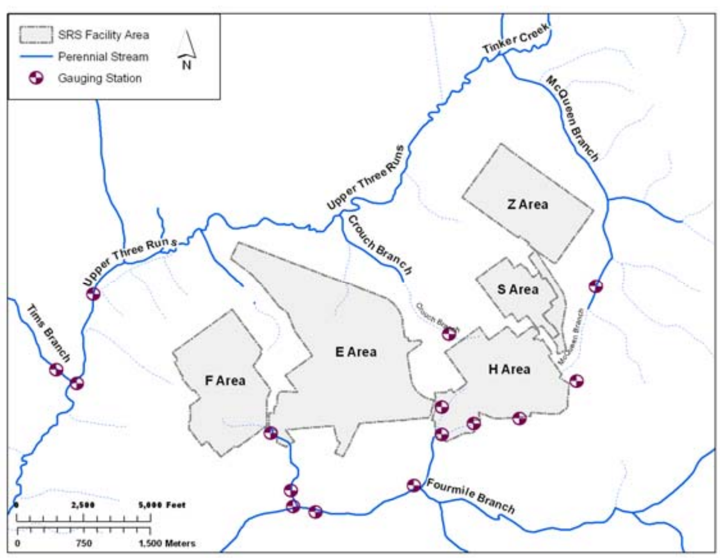
from the Savannah River and used for cooling site facilities, or groundwater discharging to surface streams. The streams, which historically have received varying amounts of effluent from SRS operations, are not commercial sources of water. Downstream of SRS, the river supplies domestic water and is used for commercial and sport fishing, boating and other recreational activities. [DOE/EIS-0303]

The natural flow of SRS streams range from eight cubic feet per second in smaller streams to 245 cubic feet per second in UTR. [WSRC-IM-2004-00008] Gauging stations located in the GSA (Figure 2.1-26) monitor flows for UTR and Fourmile Branch. Both Fourmile Branch and UTR are measured monthly for water flow, temperature and quality. The annual *Savannah River Site Environmental Report* for 2010 contains detailed information on flow rates and water quality of the Savannah River and SRS streams. [SRNS-STI-2011-00059]

The SCDHEC regulates the physical properties and concentrations of chemicals and metals in SRS effluents under the National Pollutant Discharge Elimination System (NPDES) program. Also regulated by SCDHEC, biological water quality standards for SRS waters, have classified the Savannah River and SRS streams as “Freshwaters.” [DOE/EIS-0303] Freshwaters are described as suitable for primary and secondary contact recreation and as a source for drinking water supply after treatment in accordance with SCDHEC requirements. Freshwaters are suitable for fishing, for the survival and propagation of a balanced indigenous aquatic community of fauna and flora and for industrial and agricultural uses. [SCDHEC R.61-68]

The longest of SRS streams, UTR is a large blackwater stream in the northern part of SRS that discharges to the Savannah River. It drains an area of over 195 square miles and is approximately 25 miles long, with its lower 17 miles within SRS boundaries. This stream receives more water from underground sources than other SRS streams and is the only stream with headwaters arising outside the site. The UTR is the only major tributary on SRS that has not received thermal discharges. The UTR valley has meandering channels,

Figure 2.1-26: GSA Gauging Stations



especially in the lower reaches, and its floodplain ranges in width from 0.25 to 1 mile. It has a steep southeastern side and gently sloping northwestern sides. [DOE/EIS-0303]

Fourmile Branch is a blackwater stream that originates near the center of the SRS and flows southwest for 15 miles before emptying into the Savannah River. It drains an area of approximately 22 square miles inside SRS including much of F, H and C Areas. Fourmile Branch flow is generally perpendicular to the Savannah River behind natural levees and enters the river through a breach downstream from Beaver Dam Creek. In its lower reaches, Fourmile Branch broadens and flows via braided channels through a delta formed by the deposition of sediments eroded from upstream during high flows. Downstream from the delta, the channels rejoin into one main channel. Most of the flow discharges into the Savannah River while a small portion flows west and enters Beaver Dam Creek. The valley is V-shaped, with sides varying from steep to gently sloping. The floodplain is up to 1,000 feet wide. [DOE/EIS-0303]

Flood hazard recurrence frequencies have been calculated for the various SRS site areas. The calculated flood water levels for Fourmile Branch near H Area, for the probability of 100-year, 1,000-year and 10,000-year returns are about 234.3, 235.2 and 235.8 feet above mean sea level (MSL), respectively. As shown in Section 2.1.11, the lowest elevation of any waste tank basemat in HTF is 239.9 feet above MSL; thus, the highest flood water level of approximately 236 feet above MSL is below the lowest elevation of residual radioactive material. In addition, the lowest elevation of the lower foundation layer of the proposed closure cap is 280 feet above MSL, which is about 44 feet above the highest flood water level of 236 feet. Therefore, flooding will not affect the HTF and is therefore not considered in the HTF PA. [WSRC-TR-99-00369, SRNL-ESB-2008-00023]

2.1.6 Geochemistry

The migration of radionuclides in the subsurface environment is dependent on physical and chemical parameters or properties of cementitious materials, soils and groundwater. Studies and analyses have been conducted to determine appropriate distribution coefficient values. The data used in the radionuclide transport model is presented in Section 4.2.2 and 4.2.3.2 of the HTF PA specific to the GSA and is not reproduced in this section. [SRR-CWDA-2010-00128]

2.1.7 Natural Resources

Natural resources at SRS are managed under the *Natural Resources Management Plan for the Savannah River Site* (NRMP) prepared for the DOE by the U.S. Department of Agriculture Forest Service - Savannah River. [NRMP-2005] The NRMP, which governs SRS natural resource management, was updated in May 2005 and fosters the following principles :

- All work will be done in accordance with integrated safety management components found in DOE Policy 450.4A, *Integrated Safety Management Policy.*
- Environmental stewardship activities will be compatible with future SRS missions.
- The SRS will continue to protect and manage SRS natural resources.
- Sustainable resource management will be applied to SRS natural resources.
- Close cooperation will be maintained among organizations when managing and protecting SRS natural resources.
- The results of research, monitoring and operational findings will be used in the management of SRS natural resources.
- Restoration of native communities and species will continue.
- Employees, customers, stakeholders, state natural resource officials and regulators will be invited to participate in the natural resource planning process.
- The SRS will maintain the area as a National Environmental Research Park.

2.1.7.1 Water Resources

The SRS monitors non-radioactive liquid discharges to surface waters through the NPDES, as mandated by the Clean Water Act. As required by EPA and SCDHEC, SRS has NPDES permits in place for discharges to the waters of the United States and South Carolina. These permits establish the specific sites to be monitored, parameters to be tested, and monitoring frequency, as well as analytical, reporting, and collection methods. Continuous surveillance monitoring of site streams occurs downstream of several process areas to detect and quantify levels of radioactivity in effluents transported to the Savannah River. [SRNS-STI-2011-00059]

Table 2.1-3 characterizes Savannah River water quality both upstream and downstream of SRS. Table 2.1-4 characterizes water quality in UTR and Fourmile Branch downstream of the GSA.

Table 2.1-3: Water Quality in the Savannah River Upstream and Downstream from SRS (Calendar Year 2010)

		Upstream[b]		Downstream[c]	
Parameter	Unit of Measure	Minimum	Maximum[a]	Minimum	Maximum[a]
Aluminum	mg/L	0.105	0.487	0.11	0.57
Cadmium	mg/L	ND	ND	ND	ND
Chromium	mg/L	ND	ND	ND	ND
Copper	mg/L	ND	0.517	ND	0.0083
Dissolved Oxygen	mg/L	4.6	19.9	4.28	11.31
Gross Alpha Radioactivity	pCi/L	ND	1.59	ND	1.31
Lead	mg/L	ND	ND	ND	0.0023
Mercury	mg/L	ND	0.000023	ND	0.000024
Nickel	mg/L	ND	ND	ND	0.0066
Nitrate (as N)	mg/L	0.18	0.38	0.12	0.58
pH	pH units	6.25	7.32	6.42	7.41
Phosphate	mg/L	0.095	0.17	0.079	0.17
Suspended solids	mg/L	2	10	5	20
Temperature	°F	44.2	75.9	43.3	79.2
Tritium	pCi/L	ND	265	98.6	957
Zinc	mg/L	0.0022	0.0087	0.0013	0.0352

a The maximum listed concentration is the highest single result found during one sampling event.
b Data from sampling location RM-160.
c Data from sampling location RM-118.8.
Note: Information extracted from SRNS-STI-2011-00059 accompanying data files. Parameters are those DOE routinely measures as a regulatory requirement, or as part of ongoing monitoring programs.
ND - Non Detectable

Table 2.1-4: Water Quality in Selected SRS Streams (Calendar Year 2010)

	Temperature (°F)	pH	Dissolved Oxygen (mg/L)	Total Suspended Solids (mg/L)
Sampling Location: Fourmile Branch (Downstream of GSA)[a]				
Mean	60.2	6.8	7.0	2.9
Range	39.0 – 77.2	6.4 – 7.2	3.3 – 11.5	0 - 6
Sampling Location: Upper Three Runs (Downstream of GSA)[b]				
Mean	58.2	6.2	7.8	6.1
Range	42.5 – 75.0	5.7 - 7.2	4.9 – 16.1	1 - 12

a Data from sampling location FM-6.
b Data from sampling location U3R-4.
Note: All data extracted from SRNS-STI-2011-00059 accompanying data files

2.1.7.1.1 Groundwater

The Safe Drinking Water Act was enacted in 1974 to protect public drinking water supplies. SRS domestic water is supplied by 17 separate systems, all of which utilize groundwater sources. The A-Area and D-Area drinking water facilities are actively regulated by SCDHEC, while the remaining smaller water systems receive a reduced level of regulatory oversight. The K-Area drinking water system was incorporated into the A Area system in 2010, and removed from SCDHEC's water system inventory. [SRNS-STI-2011-00059]

Table 2.1-5 provides the summary of maximum groundwater monitoring results for those areas that most likely discharge to UTR or Fourmile Branch obtained from the *Savannah River Site Environmental Report for 2008*, which represents the latest annual summary of well monitoring results summarized by area. [SRNS-STI-2009-00190] The groundwater in these areas is not being consumed and active remediation projects are in progress to address the groundwater conditions.

Table 2.1-5: Well Monitoring Results for Major Areas within SRS, 2007–2008

Location	Major Contaminants	Units	2007 Maximum	MCL	2008 Maximum	Likely Outcrop Point
E Area	Tritium TCE	pCi/L ppb	30,800,000 370	20,000 0.5	29,200,000 460	UTR/Crouch Branch in North; Fourmile Branch in South
F Area	TCE Tritium Gross alpha Beta	ppb pCi/L pCi/L pCi/L	52.2 73,000 2,120 380	5.0 20,000 15 4 mrem/yr[a]	60 130,000 1,470 628	UTR/Crouch Branch in North; Fourmile Branch in South
F-Area Seepage Basin	Tritium Gross alpha Beta	pCi/L pCi/L pCi/L	5,710,000 523 1,870	20,000 15 4 mrem/hr[a]	4,810,000 777 2,100	Fourmile Branch
H Area	Tritium Gross alpha Beta	pCi/L pCi/L pCi/L	67,200 25.5 55.6	20,000 15 4 mrem/yr[a]	74,800 14.9 81.9	UTR/Crouch Branch in North; Fourmile Branch in South
H-Area Seepage Basins	Tritium Gross alpha Beta	pCi/L pCi/L pCi/L	3,020,000 88.4 2,970	20,000 15 4 mrem/yr[a]	3,120,000 85 2,050	Fourmile Branch

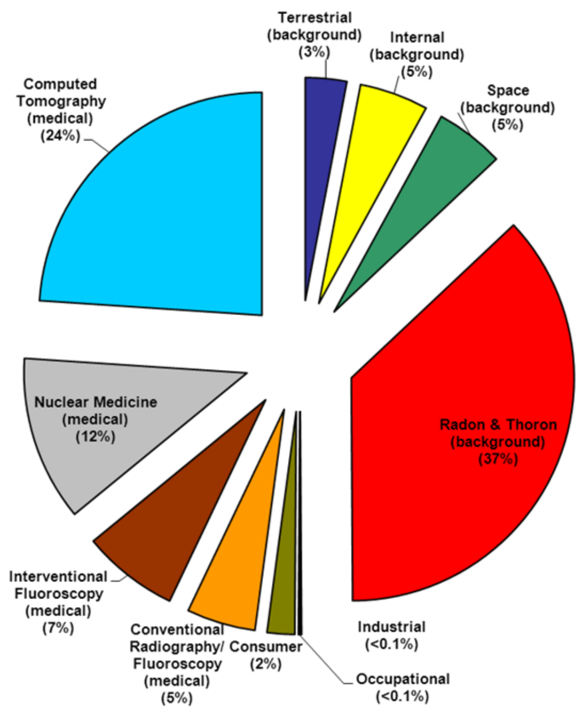
[a] The activity (pCi/L) equivalent to 4 mrem/yr varies according to which specific beta emitters are present in the sample. [SRNS-STI-2009-00190]

2.1.8 Natural and Background Radiation

All human beings are exposed to sources of ionizing radiation that include naturally occurring and man-made sources. An individual's average dose contribution estimates from various sources were obtained from information presented in National Council on Radiation Protection and Measurements (NCRP) Report 160 and are shown in Figure 2.1-27. [NCRP-160] On average, a person living in the United States or the Central Savannah River Area (CSRA) receives approximately the same annual radiation dose of 620 mrem/yr. The dose from SRS operations to the maximally exposed off-site individual during calendar year 2010 was estimated to be 0.1 mrem. [SRNS-STI-2011-00059]

The major sources of radiation exposure to an average member of the public in the CSRA is attributed to naturally occurring radiation (311 mrem/yr) and medical exposure (300 mrem/yr). This naturally occurring radiation is often referred to as natural background radiation and includes dose from background radon and its decay products (228 mrem/yr), cosmic radiation (33 mrem/yr), internal radionuclides occurring naturally in the body (29 mrem/yr) and natural radioactive

Figure 2.1-27: Major Sources of Radiation Exposure in the Vicinity of SRS



material in the ground (21 mrem/yr). The dominant medical sources include dose from computed tomography (147 mrem/yr), nuclear medicine (77 mrem/yr) and radiography/fluoroscopy (77 mrem/yr). The remainder of the dose is from consumer products (13 mrem/yr), industrial/educational/research activities (less than 1 mrem/yr) and occupational exposure (less than 1 mrem/yr). [NCRP-160]

2.1.9 Tank Farm Operations

Since initiation of operations at SRS, the tank farms combined have received over 140,000,000 gallons of liquid waste. The vast majority of this liquid waste originated from the chemical separation processes in F and H Canyons associated with three major missions: 1) reprocessing of spent nuclear fuel; 2) production of nuclear materials for weapons; and 3) production of material for National Aeronautics and Space Administration (NASA) space missions. [SRR-LWP-2009-00001] In addition to the Canyon waste streams, the DWPF returns a liquid waste stream (referred to as “DWPF recycle”) to the FTF and HTF. This “DWPF recycle” liquid waste stream is a by-product of the production of waste canisters in DWPF. These canisters contain SRS high-level waste stabilized in borosilicate glass. [DOE/EIS-0303]

The F- and H-Canyon chemical separations processes used acids to dissolve irradiated reactor target or fuel assemblies to prepare the desired products for extraction. The DWPF process also uses an acid-based process. The resultant waste stream from all of these processes is acidic. Before transferring the waste material from the F and H Canyons and DWPF to the tank farms, sodium hydroxide is added adjusting the waste to a high alkaline state to prevent corrosion of the carbon steel waste tanks. This chemical adjustment results in the precipitation of solids. These solids settle in the waste tanks forming a layer that is commonly referred to as “sludge.” These solids are comprised of fine particles of settled metal oxides, including, in small part, uranium, strontium and plutonium hydroxides. These solids are insoluble due to the chemical nature of the solution. After settling of the solids has occurred, the liquid salt waste solution (supernate) above this sludge layer is transferred out of the waste tank. To maximize the space available in the waste tanks for storing additional waste, DOE’s practice at SRS has been to use the tank farm evaporator systems to reduce the volume of the decanted supernate by concentrating the waste. [HLW-2002-00025]

During the evaporation process, the liquid salt waste is concentrated. After the concentrated salt waste is returned to the waste tank, the concentrated salt waste forms two distinct phases (collectively called salt waste): 1) concentrated supernate solution and 2) solid saltcake. The predominant radionuclide present in the salt waste is Cs-137. Because of the high solubility of Cs-137, approximately 95 % of the Cs-137 is present in the concentrated supernate solution and the liquid found within the interstitial spaces in saltcake. The solid saltcake is composed predominantly of nitrate and nitrite salts and contains relatively small quantities of insoluble radioactive solids. When saltcake is dissolved and removed from the tank, these entrained insoluble solids eventually settle on the waste tank bottom adding to the sludge inventory. [SRR-LWP-2012-00029]

As of April 2, 2012, as the result of the evaporation process, the combined total of more than 140,000,000 gallons of liquid waste originally received in FTF and HTF had been reduced to approximately 37,200,000 gallons. [SRR-LWP-2009-00001, SRR-LWP-2012-00029] The SRS no longer conducts weapons or NASA-related material recovery activities or the weapons-related spent nuclear fuel reprocessing that generated the original waste. The DOE has deactivated the Plutonium Uranium Extraction (PUREX) process in F-Canyon (one of the two chemical separations canyon facilities) and is no longer generating radioactive liquid waste for storage in the FTF. H Canyon continues to generate radioactive liquid waste when performing stabilization missions such as recovering and blending highly enriched uranium for non-defense related use. DOE carefully controls waste transferred to the HTF waste tanks and ancillary structures through a waste compliance program and waste acceptance criteria which establish the physical, chemical and radionuclide limits for all waste entering the waste tanks and ancillary structures. All generating facilities, including H Canyon, are required to develop and maintain a Waste Compliance Plan which describes the controls or procedures imposed within the facility to ensure that the HTF waste acceptance criteria are met for any material transferred to the HTF waste tanks and ancillary structures. [X-SD-G-00001]

Ongoing SRS operations continue to require the need for waste tank space. Most of the SRS Type III/IIIA waste storage tanks, tanks that meet current secondary containment and leak detection standards and have no prior leak sites, are already at or near full capacity. Projected available waste tank space is carefully tracked to ensure the tank farms do not become "water logged," a term meaning that so much of the useable compliant waste tank space has been filled that normal operations, waste removal and waste processing, cannot effectively continue. Substantial amounts of waste tank space are required to safely and effectively remove tank waste and prepare it for disposal. This includes the preparation of high-activity sludge waste for vitrification in DWPF.

The preparation of saltcake for disposition also requires significant waste tank space because the solid saltcake must be dissolved to make it mobile for processing. The dissolution of saltcake typically requires a ratio of approximately three gallons of water to one gallon of saltcake to properly dissolve the saltcake into liquid salt solution. [CBU-PIT-2005-00031]

Waste tank space for this liquid addition to the tank farm inventory must be available to allow for efficient salt processing and disposition and, ultimately, tank closure activities. A portion of the available waste tank space must also be reserved as contingency space in the event a new waste tank leak occurs. The tank farms also receive new waste from the H-Canyon and other waste streams as discussed in Section 2.2.1 of this Draft HTF 3116 Basis Document.

2.1.10 H-Tank Farm

The H Area occupies approximately 395 acres. It includes HTF and the H-Canyon Separations Facility. The HTF is located in the central region of H Area and occupies approximately 45 acres. The HTF is an active waste storage facility used to store liquid radioactive waste generated primarily during prior operations of H-Canyon. Figure 2.1-28 shows an aerial view of the HTF.

Figure 2.1-28: General Layout of HTF

The HTF consists of:

- 29 carbon steel waste tanks (i.e., Tanks 9 through 16, Tanks 21 through 24, Tanks 29 through 32, Tanks 35 through 43 and Tanks 48 through 51),
- ancillary structures:
  - the HTF transfer line system including approximately 74,800 linear feet of underground waste transfer lines,
  - 10 pump pits (HPP-1 through HPP-10),
  - nine pump tanks (HPT-2 through HPT-10),
  - one 11,700 gallon catch tank,
  - three evaporator systems (242-H, 242-16H and 242-25H),
  - the 242-3H and 242-18H concentrate transfer systems (CTSs),
  - eight diversion boxes (HDB-1 through HDB-8), and
  - 11 valve boxes (valve box 15/16, Tanks 21 and 22 valve boxes, Tank 40 valve box, Tank 40 drain valve box, Tank 42 valve box, Tank 49 valve box, Tank 50 valve box, Tank 51 valve box, Tank 51 drain valve box and 241-96H valve box).

This equipment is discussed separately as follows:

- waste tanks (Type I, II, III/IIIA and IV)
- ancillary structures

2.1.11 Waste Tanks

All 29 of the HTF waste tanks are built of carbon steel and reinforced concrete, but the designs vary. There are four principal types of waste tanks in the HTF, designated as Type I, II, III/IIIA and IV tanks. The waste tanks were numbered sequentially based on time of design and siting, and are not tank farm specific. For example, the original twelve tanks constructed at SRS were of Type I design and were numbered Tanks 1 through 8 in FTF and Tanks 9 through 12 in HTF. Table 2.1-6 summarizes the important design features.

Table 2.1-6: Waste Tank Nominal Capacities, Nominal Dimensions and Other Features

Type	Waste Tank Numbers	Diameter (ft)	Height (ft)	Capacity (gallons)	Cooling Coils	Secondary Containment	Elevation (ft)[a]
I	9, 10, 11, 12	75.0	24.5	750,000	Yes	Yes	239 - 241
II	13, 14, 15, 16	85.0	27.0	1,030,000	Yes	Yes	270
III/IIIA[b]	29, 30, 31, 32, 35, 36, 37, 38, 39, 40, 41 ,42, 43, 48, 49, 50, 51	85.0	33.0	1,300,000	Yes	Yes	281
IV	21, 22, 23, 24	85.0	34.5	1,300,000	No	No	280 - 293

[a] Approximate feet above MSL for the waste tank basemat.
[b] Tanks 29 through 32 are Type III tanks. The remaining waste tanks are Type IIIA.

The general design features of the waste tanks are summarized below, followed by brief descriptions and illustrations of the different waste tanks types.

2.1.11.1 General Tank Design Features

Each Type I, II, III and IIIA tank has a primary tank and a carbon steel secondary containment liner. The secondary liner for Type III and IIIA tanks extends the full height of the primary tank. The Type I and II tank secondary liner extends only 5 feet above the bottom of primary tank floor and is sometimes referred to as an "annulus pan." Because the secondary liner is larger in diameter than the primary tank, an annular space exists between them. This waste tank annulus, which differs in size and capacity for each waste tank type, provides a collection point for any potential leakage from the primary tank, as well as a method for heating or cooling the primary tank wall in conjunction with the annulus ventilation system. Reinforced concrete vaults surround the secondary liner.

The Type IV waste tank consists of a reinforced concrete vault surrounding a single carbon steel liner. The Type IV tanks do not have an annulus. The reinforced concrete vault provides both structural support and radiation shielding for all the waste tanks. The bottom part of the vault is called the basemat. Underneath the basemat of the Type I, II, III and IIIA tanks lies a concrete working slab. The Type IV waste tanks do not have a concrete working slab below the basemat.

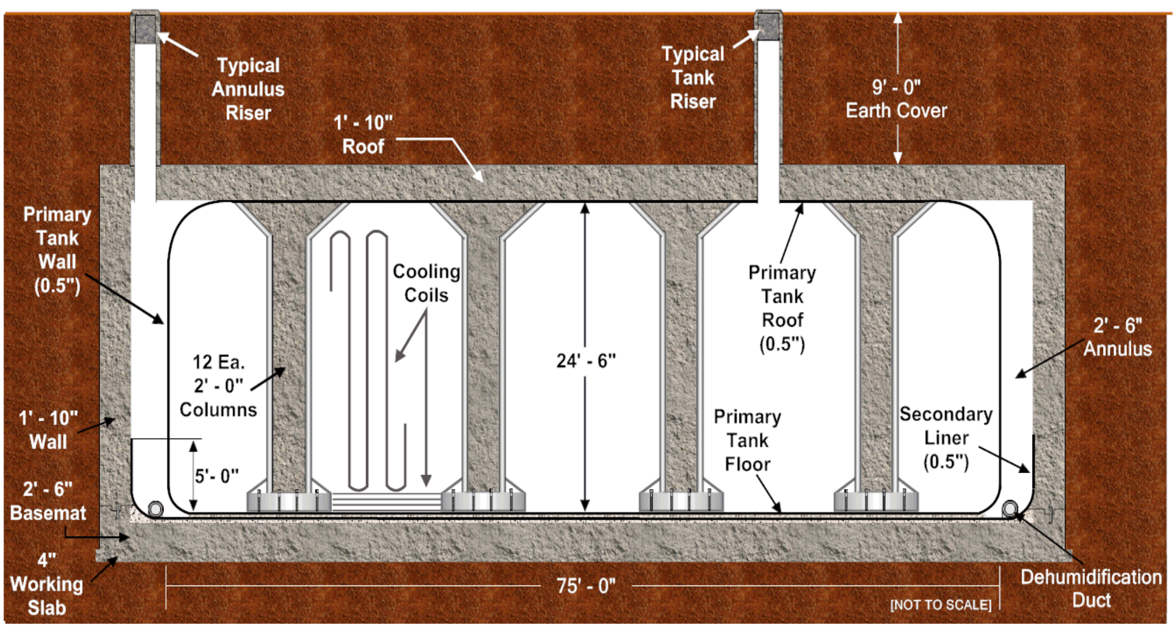
Chromate cooling water provides the primary cooling for the waste stored in the waste tanks, which flows through cooling coils located inside the primary waste tank. The cooling coils are installed in Type I, II, III and IIIA tanks and vary in design for each waste tank type. Type IV tanks do not contain cooling coils.

Risers provide access to the primary waste tank and annulus interiors. Risers are used primarily for inspections, level detection, dip samples and the installation of equipment such as annulus jets, dip tubes, thermocouples, conductivity probes, ventilation inlet and outlets, reel tapes, hydrogen monitors and waste removal equipment. Lead or concrete plugs are inserted in the riser opening if no equipment is installed. The riser structures are made of concrete and lined with carbon steel. Riser layout is dependent on the specific waste tank.

2.1.11.2 Type I Tanks

Type I tanks (Tanks 9 through 12) were constructed in the early 1950s. These waste tanks are 75 feet in diameter and 24.5 feet in height with a nominal operating capacity of 750,000 gallons. The tank tops are approximately 9 feet below grade. All Type I tanks have a secondary carbon steel liner 80 feet in diameter and 5 feet high (2.5 feet annulus space). All Type I tanks have similarly configured vertical and horizontal cooling coils. A typical[20] Type I tank cross section is shown in Figure 2.1-29, waste tank concrete basemat construction is shown in Figure 2.1-30 and a waste tank primary tank and secondary liner construction is shown in Figure 2.1-31. Additional Type I tank details are provided in Section 3.0 of the HTF PA. [SRR-CWDA-2010-00128]

Figure 2.1-29: Typical Type I Tank Cross Section



[20] The word "typical" as used throughout this section refers to representative design features of the system being described.

The primary tank is made of 0.5-inch thick carbon steel. The walls are joined to the roof and floor of the primary tank by curved knuckle plates made of the same material and are welded in place. The secondary liner is also made of 0.5-inch thick carbon steel. Transfer line penetrations allow three-inch diameter inlet waste transfer lines to enter the primary waste tank near the top through the top knuckle. Each transfer line is enclosed in a four-inch diameter carbon steel jacket pipe where it bridges the waste tank annulus. [SRR-CWDA-2010-00128]

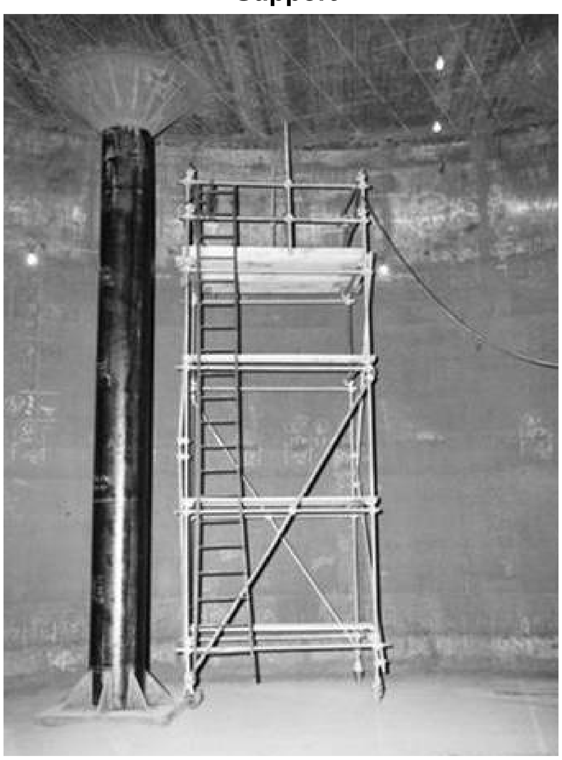
Figure 2.1-30: Type I Tank Basemat Construction

Figure 2.1-31: Type I Tank Primary and Secondary Liner Construction

The waste tank vault is constructed of 22-inch thick reinforced concrete with an inner diameter of 80 feet. Approximately 9 feet of soil covers the vault roof as shown in Figure 2.1-29. [SRR-CWDA-2010-00128]

Each Type I tank has 12 concrete filled steel columns to support the roof. These columns have an outer diameter of 2 feet of 0.5-inch carbon steel pipe filled with concrete and welded to the top and bottom of the primary tank. A waste tank column at the time of construction is shown in Figure 2.1-32. [SRR-CWDA-2010-00128]

Figure 2.1-32: Typical Type I Tank Column Support

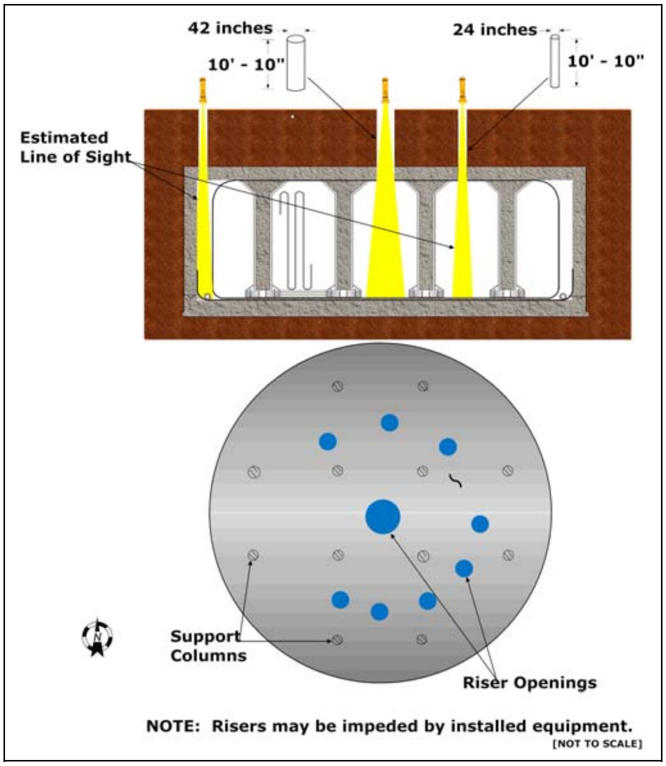


Cooling coils in Type I tanks are configured in both a horizontal and a vertical array, which creates obstacles to waste removal and other activities inside the waste tank (Figure 2.1-33). Each Type I tank contains 34 vertical cooling coils that are supported from the primary tank roof by hanger and guide rods, which are welded to the primary tank. All combined, the vertical coils consist of 604 vertical sections 18.5 feet long with 604 loops (half circle with a 24-inch radius) that connect the vertical sections. Two horizontal cooling coils (upper and lower) extend across the bottom of the waste tanks and are supported by guide rods welded to the primary tank floor. The lower horizontal cooling coil is approximately 1 inch above the tank floor and the upper horizontal cooling coil is approximately 4 inches above the primary tank floor. The horizontal coils consist of 26 horizontal sections and 26 loops (half circle with a 24-inch radius) that connect the horizontal sections. The horizontal cooling coil runs at the bottom of the Type I tanks were “field to fit” during the time of waste tank construction. In addition, there are supply pipes that connect the tank top cooling water system to the cooling coils. There are approximately 22,800 linear feet of two-inch carbon steel pipe cooling coils in a Type I tank. [D116048, C-CLC-G-00364, D116001]

Visual and equipment manipulation access within the Type I tank is limited by the tank riser design configuration. Riser configuration, above the tank top, limits direct access to equipment and allows a limited view of the primary tank floor as shown in Figure 2.1-34. Additionally, the size of the access ports limits the manipulation of long-handled mechanical tools. Due to access port geometry, choices are limited as to the types of remote equipment that can be successfully deployed. Type I tanks have a 42-inch diameter center riser and eight 24-inch perimeter risers. Each riser is approximately 10-feet-10-inches in length (Figure 2.1-34). [W146625]

Figure 2.1-33: Typical Type I Tank Cooling Coil Obstacles

Figure 2.1-34: Type I Waste Access Area for Waste Removal Equipment Diagram



2.1.11.3 Type II Tanks

Type II tanks (Tanks 13 through 16) were constructed between 1955 and 1956. These waste tanks are 85 feet in diameter and 27 feet in height with a nominal operating capacity of 1,030,000 gallons. The backfill around the waste tanks was brought to an elevation level with the top of the waste tanks (approximately 395 feet above MSL) and extended laterally for a minimum of 21 feet. The backfill was then sloped down at an angle less than 1:1 for a lateral distance of 31 feet, reaching final grade at an elevation of 300 feet above MSL. All Type II tanks have a secondary carbon steel liner 90-foot 3-inch diameter and 5 feet high (2-foot 6.125-inch annulus space). All Type II tanks have similarly configured vertical and horizontal cooling coils. A typical[21] Type II tank cross section is shown in Figure 2.1-35, waste tank concrete basemat construction is shown in Figure 2.1-36 and a waste tank primary tank and secondary liner construction is shown in Figure 2.1-37. Additional Type II tank details are provided in Section 3.0 of the HTF PA. [SRR-CWDA-2010-00128]

[21] The word "typical" as used throughout this section refers to representative design features of the system being described.

Figure 2.1-35: Typical Type II Tank Cross Section

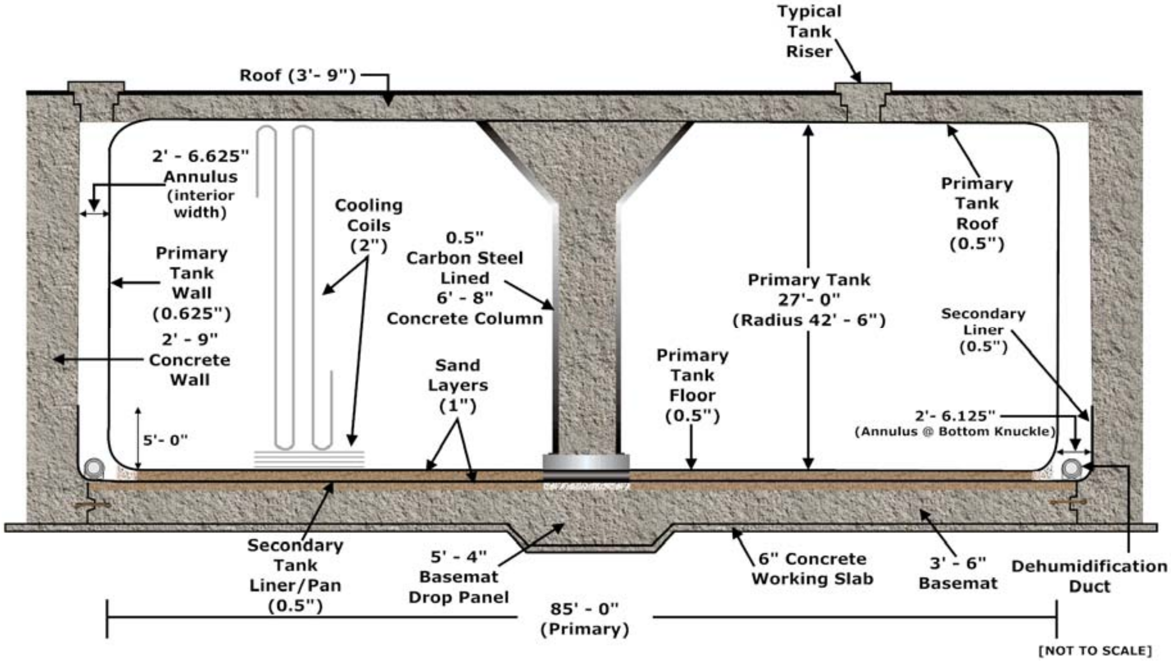
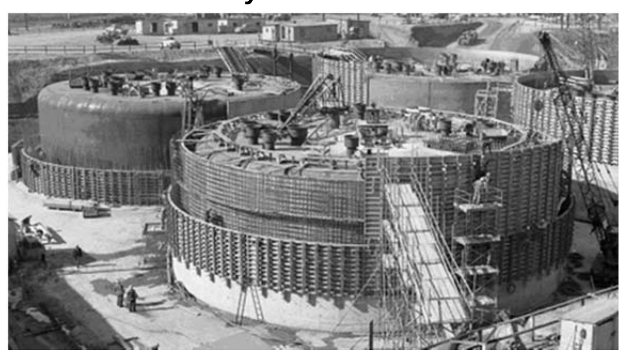


Figure 2.1-36: Type II Tank Basemat Construction

Figure 2.1-37: Type II Tank Primary and Secondary Liner Construction



The primary tank is made of carbon steel with varying thicknesses shown in Table 2.1-7. The walls are joined to the roof and floor of the primary tank by curved knuckle plates made of the same material and are welded in place. The secondary liner is also made of 0.5-inch thick carbon steel. Transfer line penetrations allow three-inch diameter inlet waste transfer lines to enter the primary waste tank near the top through the top knuckle. Each transfer line is enclosed in a four-inch diameter carbon steel jacket pipe where it bridges the waste tank annulus. [SRR-CWDA-2010-00128]

Table 2.1-7: Type II Tanks Primary Tank Liner Plate Data

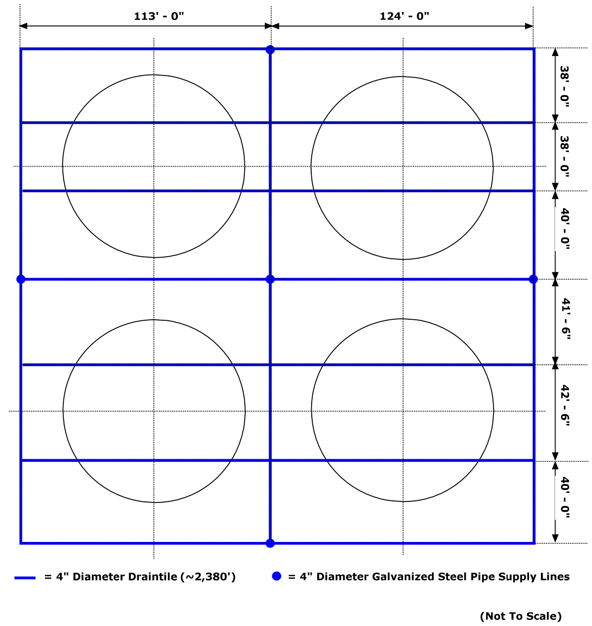
Location	Thickness (inch)
Primary tank roof	0.5
Primary tank floor	0.5
Upper knuckle	0.562
Primary tank wall	0.625
Lower knuckle	0.875

A soil hydration system and five feed wells were installed beneath the Type II tanks to address potential issues with soil shrinkage and settlement. The hydration system consists of an interconnecting grid comprised of four-inch diameter drain tile (perforated piping) located 18 inches below the working slab (Figure 2.1-38). The soil hydration system was never used for soil hydration since the water table under the Type II tanks is higher than anticipated and soil dehydration is not a problem. However, in the past, this soil hydration system was used to monitor groundwater levels. The soil hydration system wells were used in the 1960s and 1970s to pump water from beneath Tank 16 as part of the Tank 16 groundwater monitoring effort.

The waste tank vault is constructed of 33-inch thick reinforced concrete walls and 45-inch thick reinforced concrete roof with an outer diameter of 95 feet 8.5 inches. [SRR-CWDA-2010-00128]

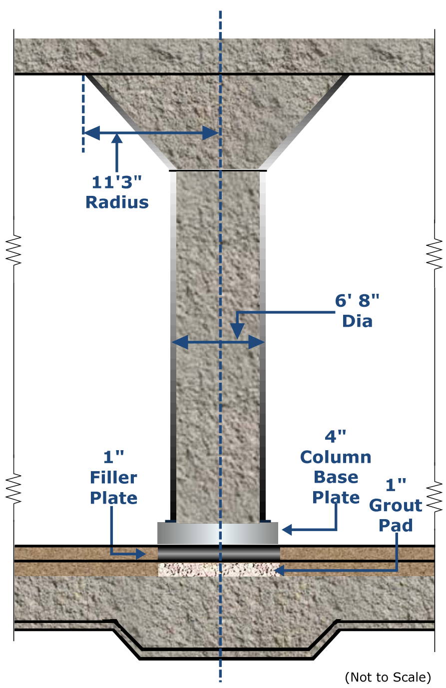
Each Type II tank has one central filled steel column to support the roof. This column has an inner diameter of 6 feet 8 inches of 0.5-inch thick carbon steel that was welded to the bottom of the primary tank and filled with concrete. A waste tank support column dimension detail is shown in Figure 2.1-39. [SRR-CWDA-2010-00128]

Figure 2.1-38: Soil Hydration System Below Type II Tanks



Cooling coils in Type II tanks are configured in both a horizontal and a vertical array, which creates obstacles to waste removal and other activities inside the waste tank (Figure 2.1-40). Each Type II tank contains 40 vertical cooling coils (20 operating, 20 auxiliary) that are supported from the primary tank roof by hanger and guide rods, which are welded to the primary tank. The vertical coils consist of approximately 20 foot-long vertical sections connected with 24-inch radius half circle loops. Four horizontal cooling coils (two upper operating, two lower auxiliary) extend across the bottom of the waste tanks and are supported by guide rods welded to the primary tank floor. The lower horizontal cooling coil is approximately 1 inch above the tank floor and the upper horizontal cooling coil is approximately 4 inches above the primary tank floor. The horizontal coils consist of 40 horizontal sections and 36 loops (half circle with a 24-inch radius) that connect the horizontal sections. In addition, there are supply pipes that connect the tank top cooling water system to the cooling coils. There are approximately 29,400 linear feet of two-inch carbon steel pipe cooling coils in a Type II tank. [SRR-CWDA-2010-00128, W163593, W163658]

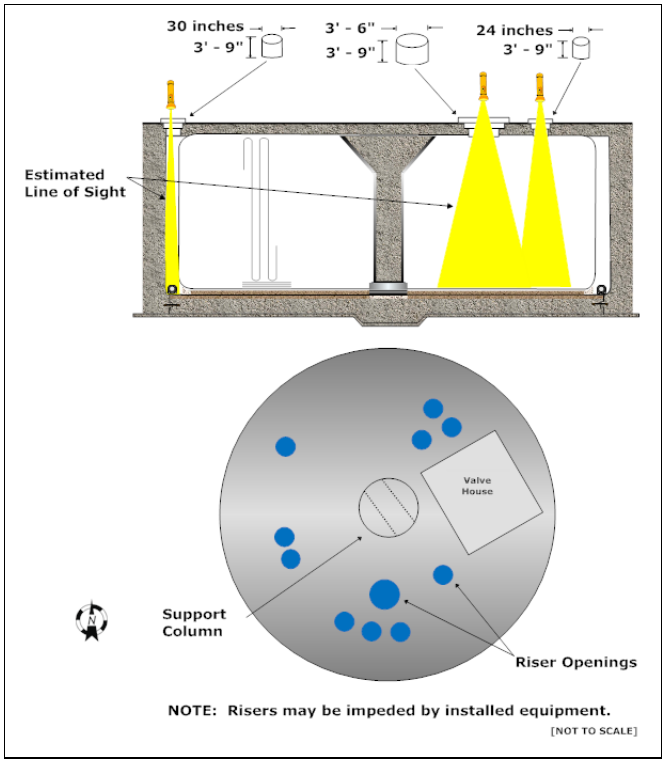
Figure 2.1-39: Typical Type II Support Column Dimension Details



Visual and equipment manipulation access within the Type II tank is limited by the tank riser design configuration. Riser configuration, above the tank top, limits direct access to equipment and allows a limited view of the primary tank floor as shown in Figure 2.1-41. Additionally, the size of the access ports limits the manipulation of long-handled mechanical tools. Due to access port geometry, choices are limited as to the types of remote equipment that can be successfully deployed. Type II tanks were constructed with ten 24-inch risers and one 42-inch riser. Each riser is approximately 3-feet 9-inches in length (Figure 2.1-41). [SRR-CWDA-2010-00128, W163012]

Figure 2.1-40: Typical Type II Tank Cooling Coil Obstacles

Figure 2.1-41: Type II Waste Access Area for Waste Removal Equipment Diagram



2.1.11.4 Type III/IIIA Tanks

The Type III tanks were constructed between 1966 and 1970 (Tanks 29 through 32). The Type IIIA tanks were complete between 1974 and 1981 (Tanks 35 through 37, 38 through 43 and 48 through 51) All Type III/IIIA tanks have full secondary containment by a secondary steel liner, which is 90 feet in diameter and 33 feet in height (2.5-foot annulus). Note that Tanks 35, 36 and 37 have been designated as Type IIIA tanks, but they differ from Figure 2.1-43 in that these waste tanks have a flat roof with a uniform four-foot concrete thickness, similar to the Type III tanks. Additionally, Tank 35 has insertable cooling coils rather than permanently installed cooling coils. [SRR-CWDA-2010-00128]

Each Type III tank has a minimum 3-foot-6-inch thick reinforced concrete basemat placed on top of a six-inch concrete working slab. The Type IIIA tanks have a minimum 3-foot-7-inch thick reinforced concrete basemat placed on top of a four-inch concrete working slab. Both Type III and IIIA tanks have a center drop panel that varies the basemat thickness for each tank type. Additional Type III/IIIA tank details are available in Section 3.0 of the HTF PA. [SRR-CWDA-2010-00128]

Tanks 35 through 37 each had 56 thermocouples installed on the outside of the primary tank. Tank 38 has 34 thermocouples that were installed on the outside of the primary tank. Each of the remaining Type IIIA tanks (39 through 43 and 48 through 51) have 22 thermocouples that were installed on the outside of the primary tank. All Type IIIA tanks have a thermocouple located on the top of the basemat and another thermocouple located just below the working slab. Tanks 35 through 37 have an additional thermocouple that was installed approximately 10 feet below the working slab. [SRR-CWDA-2010-00128]

A typical HTF Type III tank cross section is shown in Figure 2.1-42, typical Type IIIA tank cross section is shown in Figure 2.1-43 and Typical Type III/IIIA tank basemat construction is shown in Figure 2.1-44.

Figure 2.1-42: Typical HTF Type III Tank Cross Section

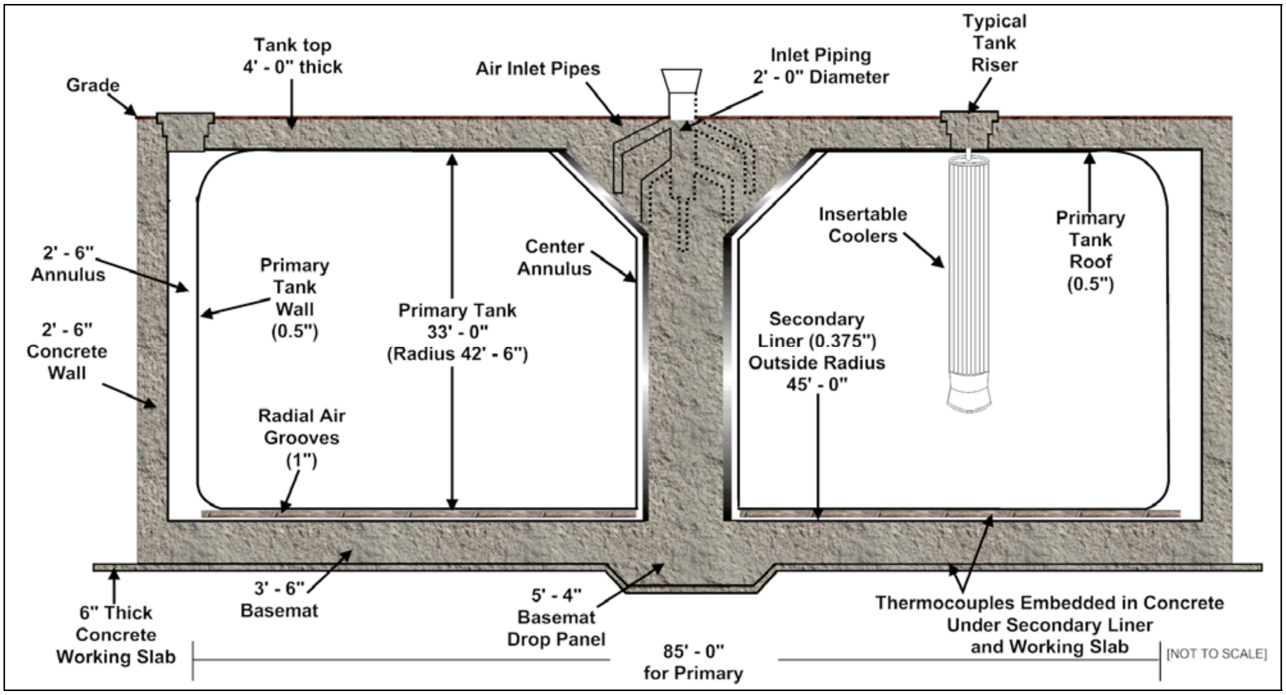
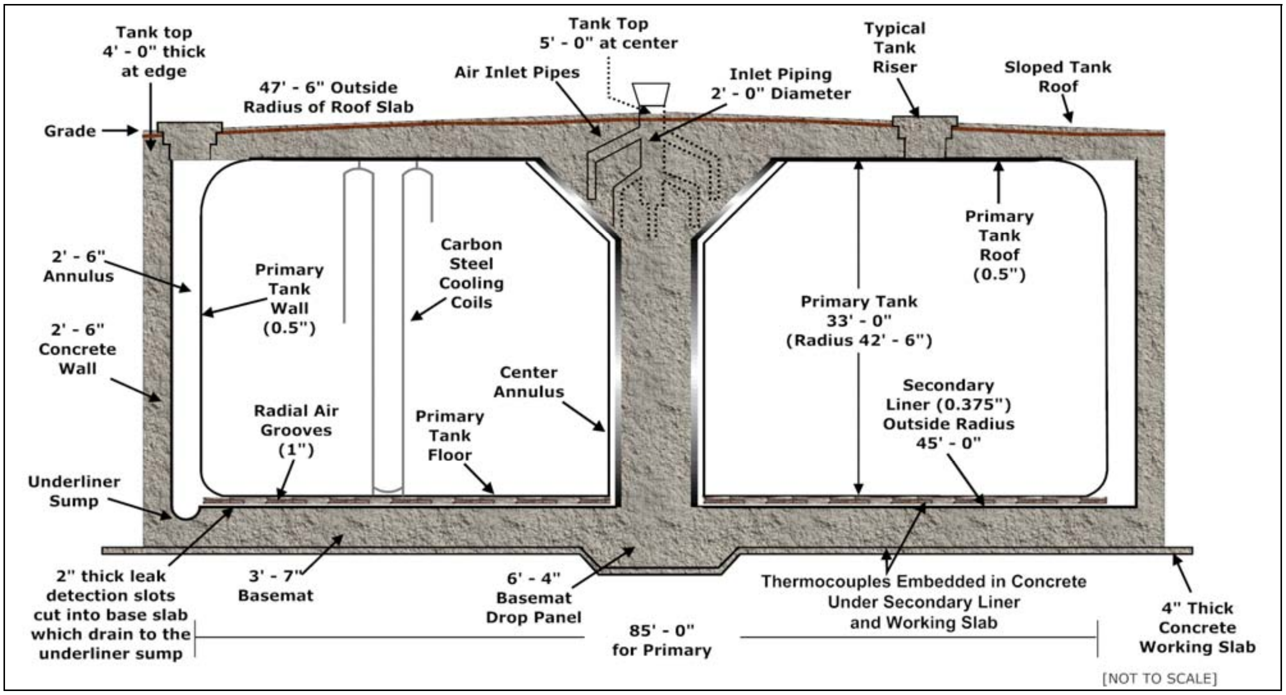


Figure 2.1-43: Typical Type IIIA Tank Cross Section



The Type III/IIIA tank primary tanks are made of carbon steel. The walls are joined to the roof and floor plates by curved knuckle plates made of the same material. The primary tank and secondary liner for a Type IIIA tank late in the construction phase are shown in Figure 2.1-45. The Type III/IIIA tank primary tanks were fully stress-relieved by heating after fabrication. [SRR-STI-2012-00346] The waste tank primary tank and secondary liner plate data are summarized in Table 2.1-8. [SRR-CWDA-2010-00128]

Both Type III and IIIA tanks contain multiple penetrations through a carbon steel primary tank (e.g., two-inch or three-inch diameter pipe in six-inch or ten-inch diameter sleeves, respectively) near the top of the waste tank for transfer lines into and out of the tank. [SRR-CWDA-2010-00128]

Figure 2.1-44: Typical Type III/IIIA Tank Basemat Construction

Figure 2.1-45: Typical Type IIIA Tank Primary Tank and Secondary Liner - Late Construction (Vault Wall Not Constructed)

Table 2.1-8: Type III/IIIA Tanks Primary Tank and Secondary Liner Plate Data

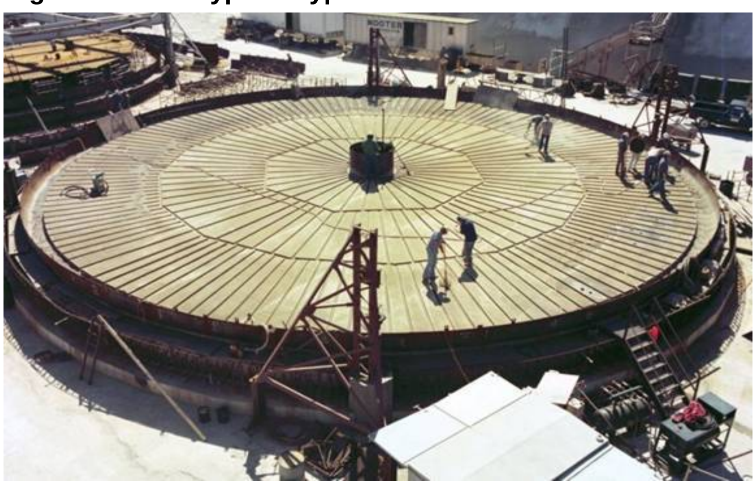
Location	Tanks 29 - 32 Thickness (inch)	Tanks 35 - 37 Thickness (inch)	Tanks 38 - 43 Thickness (inch)	Tanks 48 - 51 Thickness (inch)
Primary tank roof	0.5	0.5	0.5	0.5
Primary tank floor	0.5	0.5	0.5	0.5
Upper knuckle	0.5	0.5	0.5	0.5
Secondary liner - upper band	0.5	0.5	0.5	0.5
Secondary liner - middle band	0.5	0.625	0.625	0.625
Secondary liner - lower band	0.5	0.5	0.875	0.875
Primary tank wall - upper band	0.5	0.625	0.5	0.5
Primary tank wall - lower band	0.5	0.875	0.625	0.625
Lower knuckle - secondary	1.0	0.875	0.875	0.875
Lower knuckle - primary	0.625	0.625	0.625	0.625

The Type III/IIIA primary waste tanks are completely enclosed in a concrete vault. The vault roof is at least 48 inches thick and the walls are 30 inches thick; therefore, there is no earthen cover for shielding on top of these waste tanks.

Type III/IIIA tanks have both a center and outer annulus. The center annulus is formed between the primary waste tank wall and the roof support column. This design allows for ventilation airflow to the underside of the primary tank floor and then out to the outer annulus through the radial air grooves, as shown in Figure 2.1-46.

Type IIIA tank tops are 5 feet thick at the waste tank center, 4 feet thick at the edge and sloped to allow rainwater drainage. In the Type III/IIIA designs, the primary waste tank roof is supported by a steel-lined center support column that is integrated into the concrete basemat (Figure 2.1-42 and Figure 2.1-43). Ventilation systems are embedded in the center column. Air flows through the column, into the center annulus, through the radial air grooves and exits through the outer annulus. [SRR-CWDA-2010-00128]

Figure 2.1-46: Typical Type III/IIIA Tank Radial Air Grooves



Type III tanks cooling coil piping consists of insertable coolers (consolidated bundles, conical coolers and cylindrical coolers as shown in Figure 2.1-47). These coolers were inserted through the risers in the closed position and in the case of the conical and cylindrical coolers deployed (opened) once inside the waste tank. The coolers are supported by the tank top. The bottoms of the waste tanks are cooled by the air passing through the annulus and radial air grooves. Type IIIA tanks, except Tank 35, have permanently installed cooling coils as shown in Figure 2.1-48. The Type IIIA cooling coils have top and bottom supported vertical coils. There are 246 vertical coils mounted nine inches off the bottom of the waste tank and spaced on three 8-foot centers. These are made of two-inch diameter carbon steel pipe. [SRR-CWDA-2010-00128]

Figure 2.1-47: Typical Type III Tank Insertable Cooling Coils

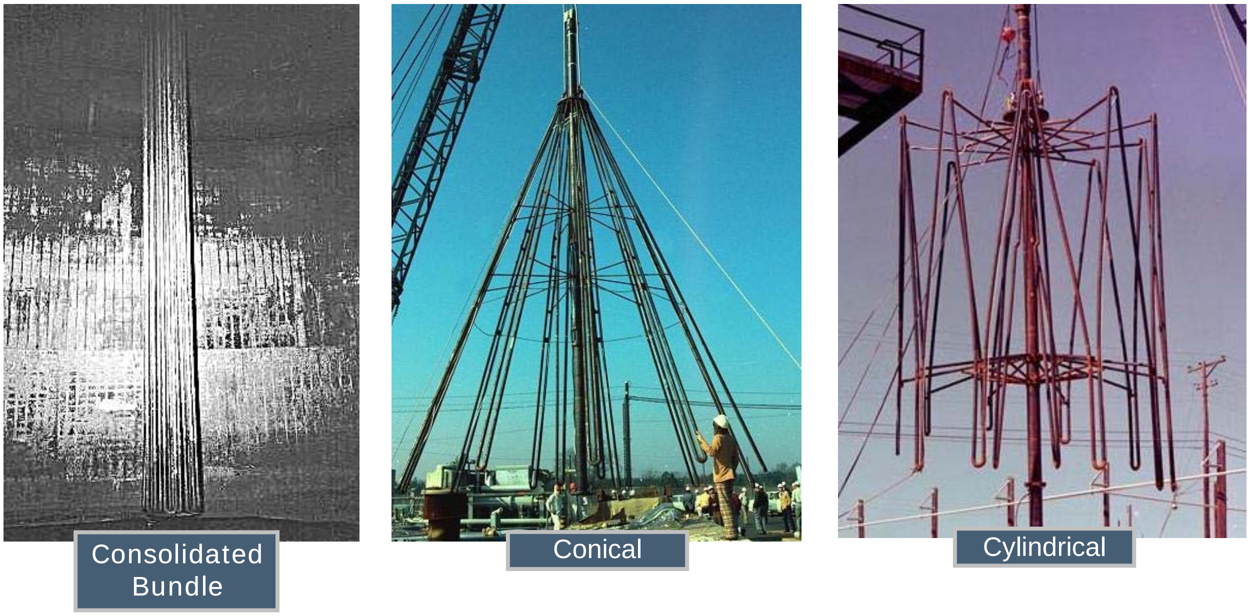
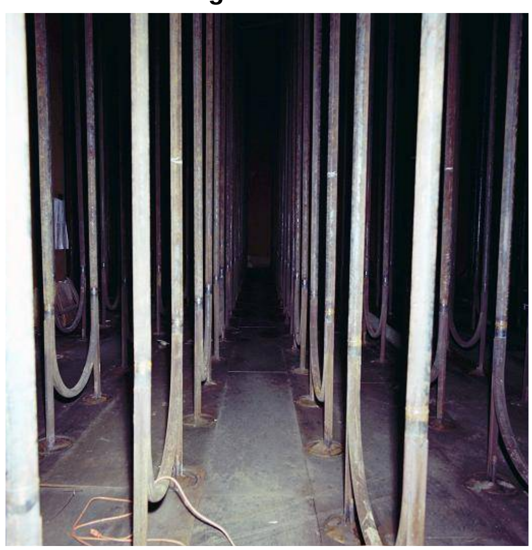


Figure 2.1-48: Typical Type IIIA Tank Cooling Coils During Construction



The waste tank riser design configuration restricts visual and equipment access into Type III/IIIA tanks. These waste tanks have 37 to 42 risers, ranging from 8 to 52 inches in diameter, and are approximately 4.5 feet in length as shown in Figure 2.1-49 and Figure 2.1-50. [W704010, W449795]

Figure 2.1-49: Typical Type III Tank Access Area for Waste Removal Equipment Diagram

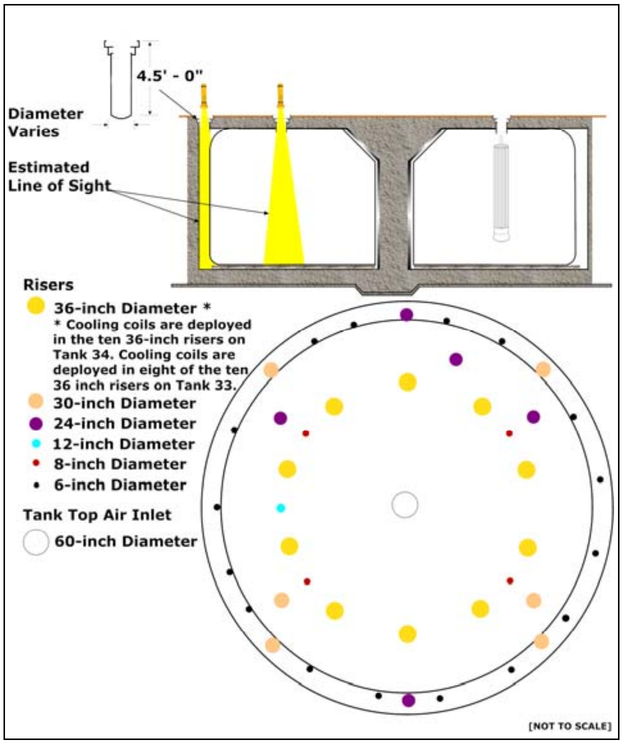
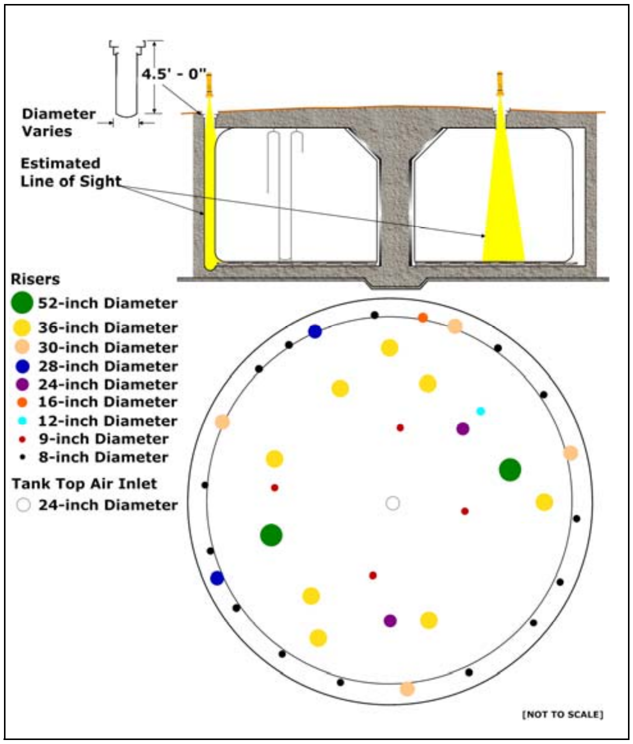


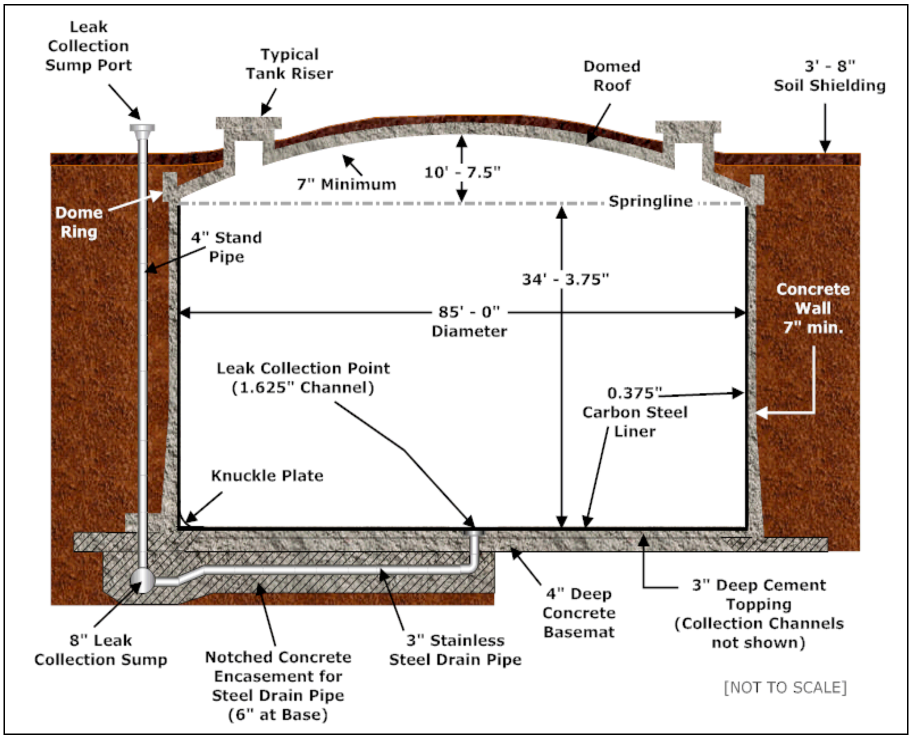
Figure 2.1-50: Typical Type IIIA Tank Access Area for Waste Removal Equipment Diagram



2.1.11.5 Type IV Tanks

The Type IV tanks were constructed between 1958 and 1962. Type IV tanks are 85 feet in diameter and approximately 34 feet in height at the side wall with a nominal operating capacity of 1,300,000 gallons. Type IV tanks do not have a secondary liner or cooling coils. These waste tanks have a single carbon steel liner with a self-supporting, reinforced concrete dome roof. A typical HTF Type IV tank cross section is shown in Figure 2.1-51. Additional Type IV tank details are available in Section 3.0 of the HTF PA. [SRR-CWDA-2010-00128]

Figure 2.1-51: Typical HTF Type IV Tank Cross Section



The Type IV tank primary liner is an open-top carbon steel cylinder. The sides and bottom are formed of 0.375-inch plates with 0.4375-inch thick knuckle plates, as shown in Figure 2.1-51. The primary waste tank liner is reinforced internally with three, circumferential, 4-inch carbon steel stiffener angles, as shown in Figure 2.1-52, and is anchored externally to the concrete wall. Each waste tank has concrete wall penetrations through the vault and waste tank liner located just below the dome for transfer lines into and out of the waste tank. [SRR-CWDA-2010-00128]

Figure 2.1-52: Typical Type IV Tank Stiffener Angles

Each Type IV tank is enclosed in a concrete vault. Each vault was constructed in layers using a shotcrete technique as shown in Figure 2.1-53. No secondary containment structure or annulus exists with this design.

The concrete vault walls are cylindrical with an inside diameter of 85 feet and a height of 34 feet 3.75 inches at the springline surmounted by a dome ring. The core wall is 7 inches at the top and 11 inches at the bottom. This core wall was prestressed with steel bands that remained in place and were covered with sprayed-on concrete. [SRR-CWDA-2010-00128]

Type IV concrete vault sidewalls are surrounded by three layers of backfill. Bags of vermiculite were placed around the vault in brick-like pattern, covered with a special manually-compacted soil and topped with test controlled, compacted soil fill.

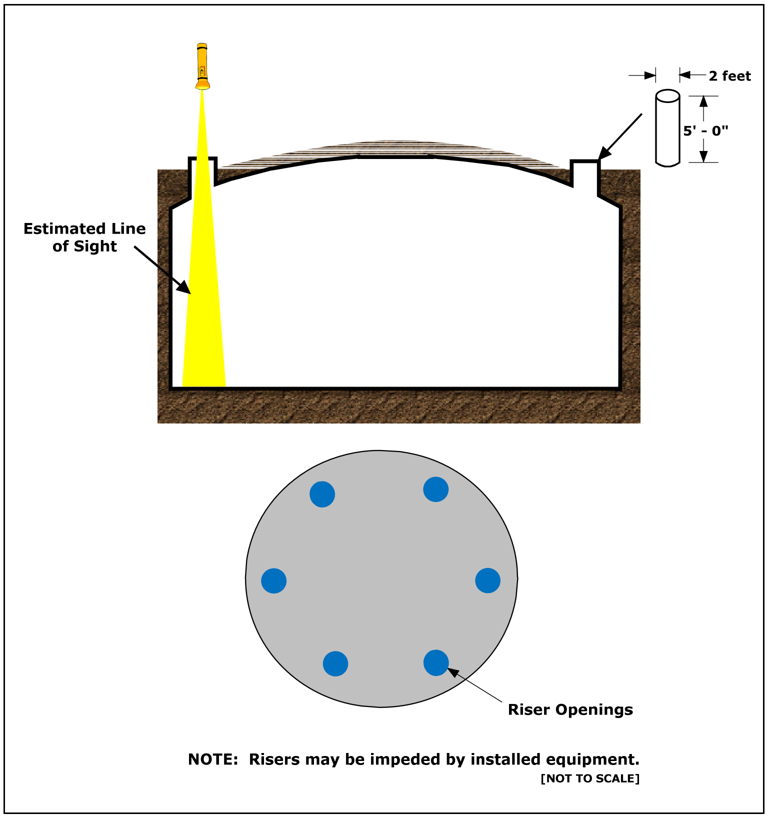
The dome roof is 7 inches to 10 inches thick, with the greater thickness near the risers, and is reinforced throughout with steel bars. The dome has an internal curvature radius of 90-foot-4-inches and a rise of 10-foot-7.5-inches above the springline. The Type IV tank dome and risers are shown, near the end of the concrete construction phase, in Figure 2.1-54. [SRR-CWDA-2010-00128]

The concrete roof of a Type IV waste tank is not lined with carbon steel on the inside. Each waste tank has six peripheral risers which have an inner diameter of 2 feet and are approximately 5 feet in length. The waste tank riser design configuration provides limited access to the tank interior as shown in Figure 2.1-55. [SRR-CWDA-2010-00128, W231206]

Figure 2.1-53: Typical Type IV Tank Shotcrete Application

Figure 2.1-54: Typical Type IV Tank Domes and Risers During Construction

Figure 2.1-55: Typical Type IV Tank Access Area for Waste Removal Equipment Diagram



2.1.12 Ancillary Structures

In addition to the waste tanks, HTF contains ancillary structures with a residual inventory that must be accounted for as part of HTF closure. These ancillary structures include buried pipe (transfer lines), pump tanks and evaporators, all of which have been in contact with liquid waste. The ancillary structures are used in the HTF to transfer waste (e.g., transfer lines, pump tanks) and reduce waste volume through evaporation. The amount of contamination on these components depends on such factors as the service life of the component, its materials of construction and the contamination medium in contact with the component. Figure 2.1-56 identifies locations of HTF-specific ancillary structures.

A description of the HTF ancillary structures is provided as follows:

- the HTF transfer line system (approximately 74,800 linear feet of underground waste transfer lines), including transfer line jackets, leak detection boxes, modified leak detection boxes and the Type I tank transfer line encasements,
- the HTF pump tanks (HPT-2 through HPT-10, CTS PT-242-3H, and CTS PT-242-18H), HTF pump pits (HPP-1 through HPP-10, CTS PP-242-3H, and CTS PP-242-18H) and the HTF catch tank,
- the 242-H Evaporator System, including the evaporator cell and support tanks (e.g., mercury collection tank, cesium removal column pump tank and overheads tanks),
- the 242-16H Evaporator System, including the evaporator cell and support tanks (e.g., mercury collection tank, cesium removal column pump tank and overheads tanks),
- the 242-25H Evaporator System, including the evaporator cell and support tanks (e.g., condenser, mercury collection tank and overheads tanks),
- the HTF diversion boxes (HDB-1 through HDB-8), and
- the HTF valve boxes (valve box 15/16, Tanks 21 and 22 valve boxes, Tank 40 valve box, Tank 40 drain valve box, Tank 42 valve box, Tank 49 valve box, Tank 50 valve box, Tank 51 valve box, Tank 51 drain valve box and 241-96H valve box).

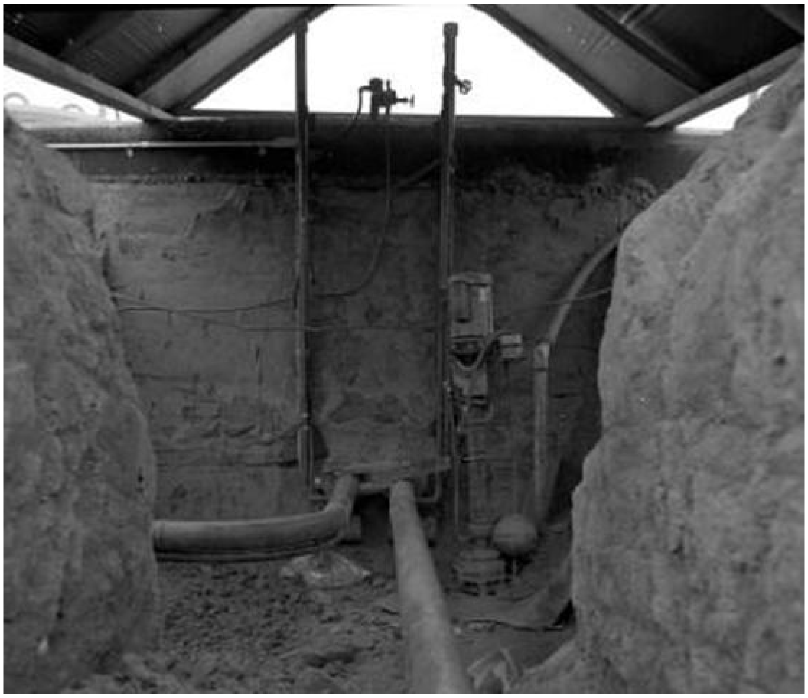
[SRR-CWDA-2010-00128]

Figure 2.1-56: General Layout of HTF

2.1.12.1 Waste Transfer Lines

There are over 74,800 linear feet of waste transfer line in HTF, with the line segments ranging from a few feet to over 3,400 feet in length. The HTF waste transfer lines are typically constructed of a stainless steel primary core pipe and are normally located below ground. Those lines that are above ground or near the surface are shielded to minimize radiation exposure to personnel. Most primary waste transfer lines have some type of secondary containments. The majority of primary transfer lines are surrounded by another pipe (jacket) constructed of carbon steel, stainless steel or cement-asbestos. These jackets drain to leak detection boxes, modified leak detection boxes or to another primary or secondary containment such as a waste tank. A few primary transfer lines are located inside a covered, concrete encasement. [SRR-CWDA-2010-00128]

Figure 2.1-57: HTF Waste Tank Transfer Line During Construction

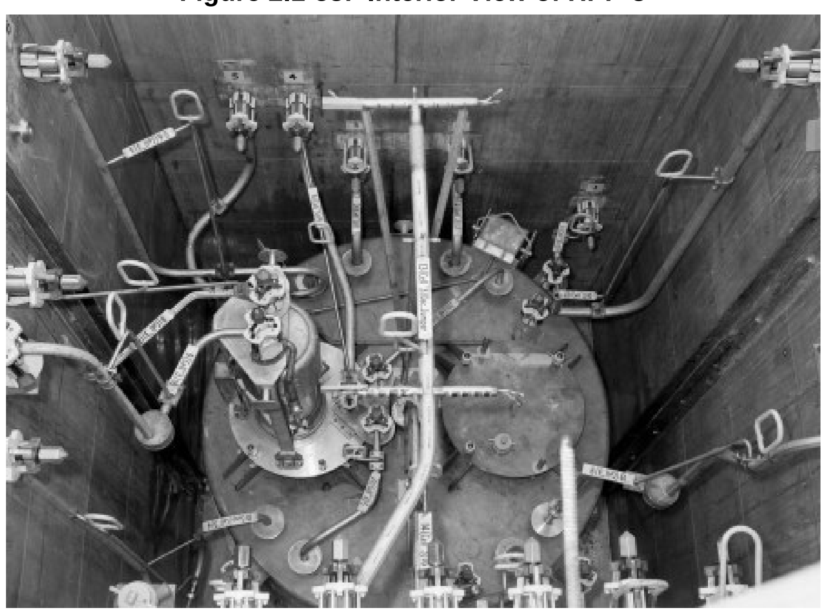


Waste transfer lines are typically sloped to be self-draining and, where a pipe transitions from one size to another, the bottom of the pipe is generally aligned to allow for draining. The line segments are supported using rod or disk type core pipe spacers, core pipe supports, jacket supports, jacket guides or other approved methods. Typically, core pipe spacers and supports are of stainless steel and welded to the core pipe and jacket, while the jacket supports and guides are of stainless steel with a concrete support. Figure 2.1-57 shows waste transfer lines during construction. [SRR-CWDA-2010-00128]

2.1.12.2 Pump Pits, Pump Tanks and Catch Tanks

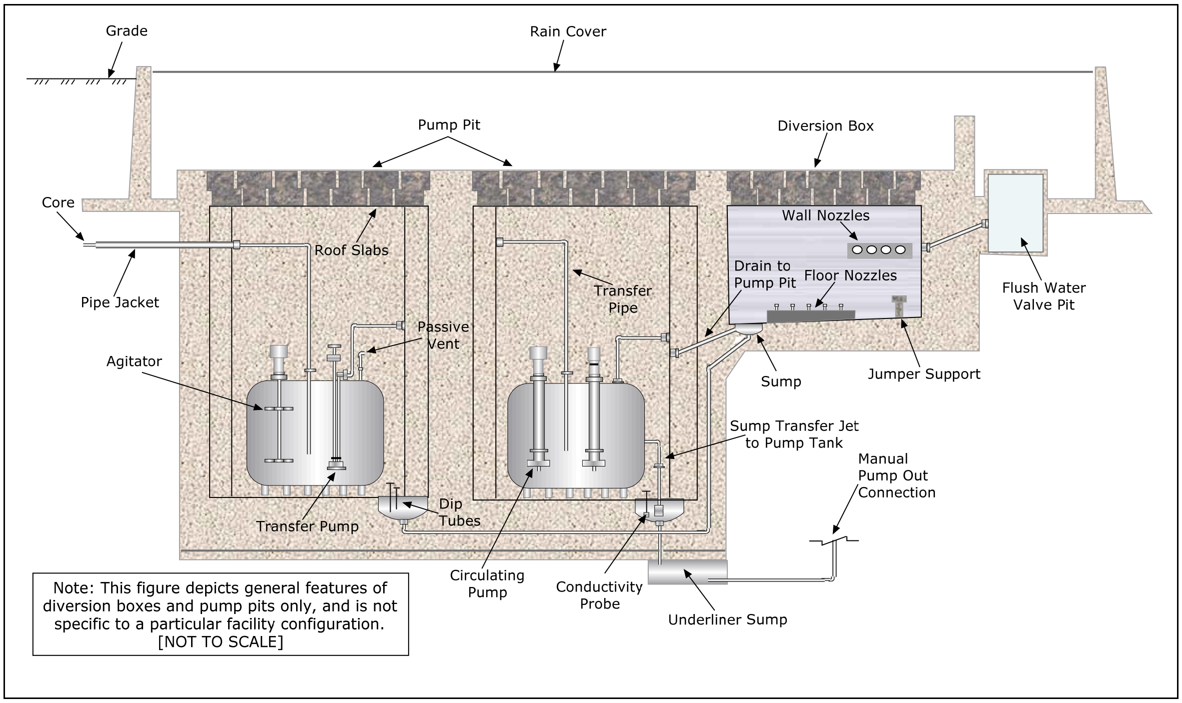
The pump pits are shielded reinforced concrete structures located below grade at the low points of transfer lines and are lined with stainless steel. The pump pit walls are approximately 2 to 3 feet thick, sloped floors are approximately 3 feet thick and cell covers are concrete slabs approximately 2 to 4 feet thick. All HTF pump pits house a pump tank (with the exception of HPP-1) with the pump pits providing secondary containment for pump tanks. Figure 2.1-56 shows the location of the pump pits in HTF. HPP-1 through HPP-4 and HPP-7 through HPP-10 are co-located with a diversion box. [SRR-CWDA-2010-00128]

Figure 2.1-58: Interior View of HPP-3



The pump pits were often constructed in conjunction with a diversion box (diversion box details are discussed later in this section). Figure 2.1-58 is a photograph of the interior view of HPP-3. A typical diversion box/pump pit configuration is depicted in Figure 2.1-59.

Figure 2.1-59: Typical Diversion Box and Pump Pit Design



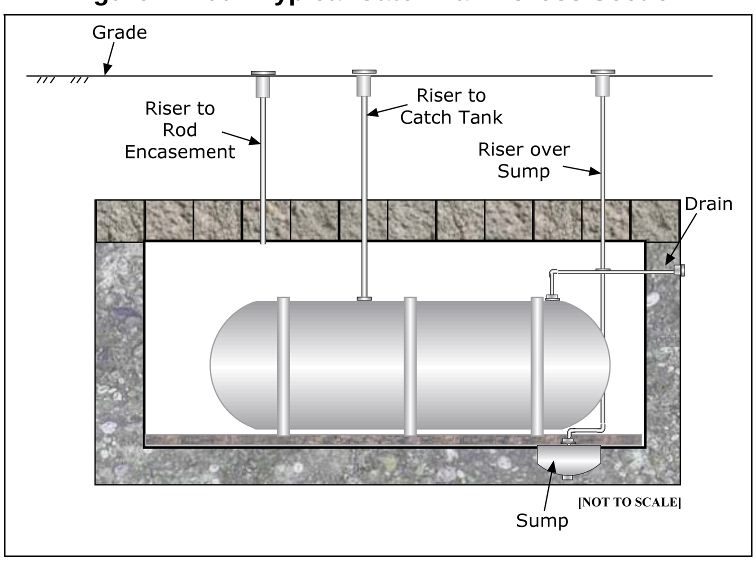
The following is a description of pump pit and pump tank features.

- **HPP-1 through HPP-4/HPT-2 through HPT-4:** These pump pits have an interior floor that is 15 feet square. HPT-2 through HPT-4 have an approximately 7,200-gallon capacity. There is not a pump tank in HPP-1.
- **HPP-5 and HPP-6/HPT-5 and HPT-6:** These pump pits have an interior floor that is 18 feet x 15 feet. HPT-5 and HPT-6 have an approximately 7,200-gallon capacity.
- **HPP-7 through HPP-10/HPT-7 through HPT-10:** These pump pits have an interior floor that is 18 feet square. HPT-7 through HPT-10 have an approximately 6,000-gallon capacity.
- **CTS PP 242-3H and CTS PP 242-18H/CTS PT 242-3H and CTS PT 242-18H:** These pump pits have an interior floor that is 14 feet square. The CTS PT 242-3H and CTS PT 242-18H have an approximately 3,000-gallon capacity. CTS PP 242-3H was retired from service in 1979 and replaced with CTS PP 242-18H to accommodate additional waste tanks.

[SRR-CWDA-2010-00128]

There is a single catch tank in HTF designed to collect drainage from HDB-1 and the Type I tank transfer line encasements. The stainless steel catch tank capacity is approximately 11,700 gallons and is located in an underground reinforced concrete cell. The catch tank encasement has walls that are 2 feet 8 inches thick, a cover that is 2 feet 11 inches thick and a floor that is 3 feet 10 inches thick. (Figure 2.1-60). [SRR-CWDA-2010-00128]

Figure 2.1-60: Typical Catch Tank Cross Section



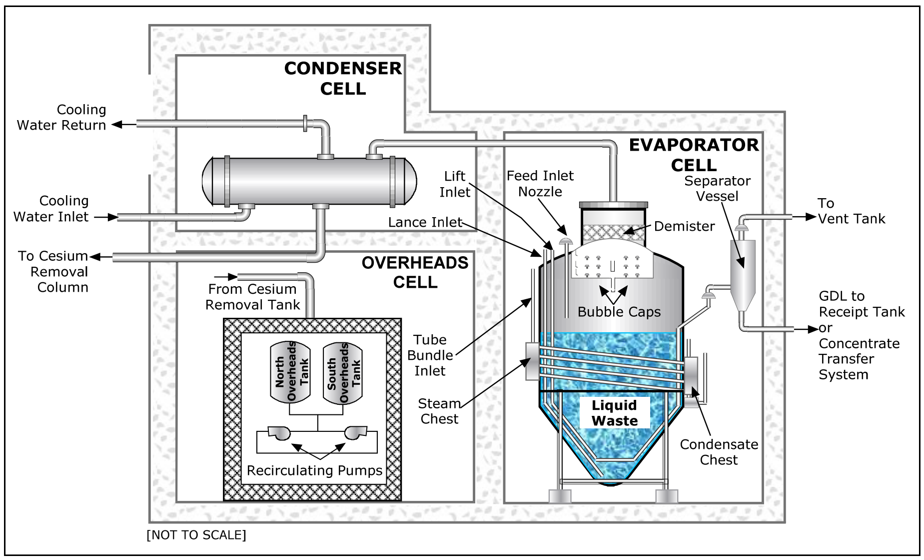
2.1.12.3 Evaporator Systems

There are three evaporator systems in the HTF, the 242-H Evaporator System (1H Evaporator), 242-16H Evaporator System (2H Evaporator) and the 242-25H Evaporator System (3H Evaporator). Evaporators are used to reduce the volume of liquid radioactive waste within HTF by driving off a portion of the water in the waste. The evaporator systems are principally comprised of the evaporator, the overheads system and the condenser. [SRR-CWDA-2010-00128]

2.1.12.3.1 242-H Evaporator System

The 242-H Evaporator Facility was constructed and placed into service in 1963 and was removed from service in 1994. [HLW-2002-00025] Figure 2.1-61 provides a schematic of the 242-H Evaporator System.

Figure 2.1-61: 242-H Evaporator System Schematic



- **242-H Evaporator Cells:** The evaporator cell is a cuboid with a 16-foot x 15-foot base and a height of 25 feet. The cell includes a floor sump 2 feet x 2 feet x 2.5 inches deep. The cell provided containment for the evaporator and served as shielding for personnel protection. The cell includes a stainless steel liner.
- **242-H Evaporator Vessel:** The evaporator vessel, located inside the 242-H evaporator cell, is a stainless steel, cylindrical vessel with a cone bottom. The cylindrical portion is 8 feet in diameter and the overall height is 15 feet. The evaporator was used to concentrate liquid by evaporating water from the waste to reduce waste volumes.
- **242-H Overheads System:** The receiver cell is cuboid with a 15 feet x 8 feet x 10-inch base and a height of 16-foot-6-inches. The receiver cell includes a floor sump with a 1.5 feet x 1.5 feet base and a depth of 1.5 feet. The receiver cell provided containment for the two overheads vessels. The overheads vessels functioned as receipt tanks for liquids condensed from evaporator vapors via the 242-H Condenser.

[SRR-CWDA-2010-00128]

2.1.12.3.2 242-16H Evaporator System

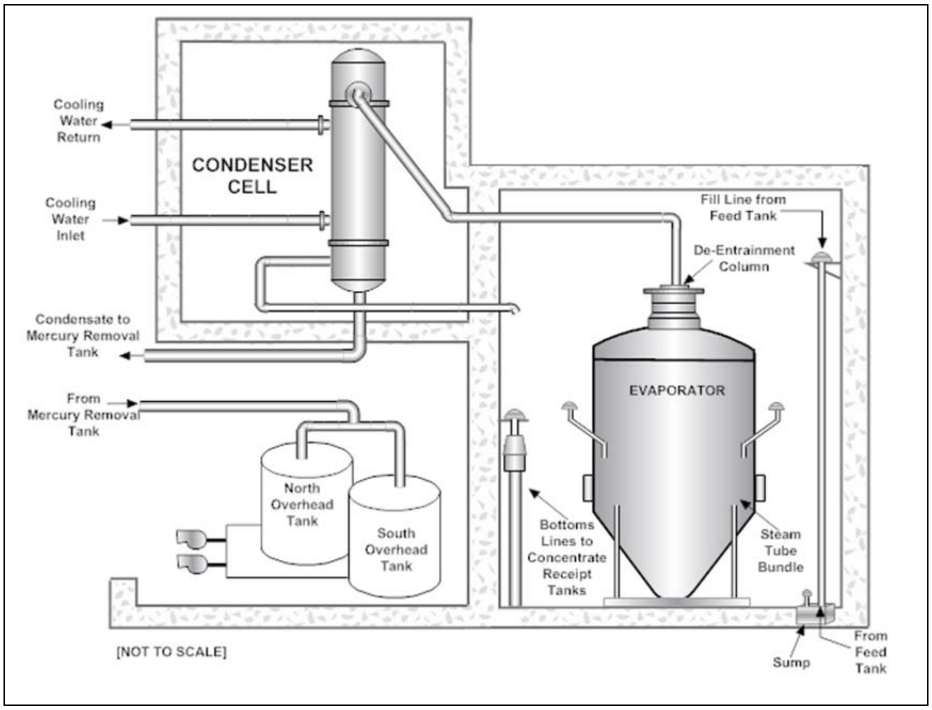
The 242-16H Evaporator System was placed into service in 1982 and continues to operate. [HLW-2002-00025] The 242-16H evaporator system is arranged into three cells and a gang valve house. The evaporator cell contains the evaporator, the condenser cell contains the condenser and an overheads cell contains overheads system components other than the condenser. Figure 2.1-62 provides a schematic of the 242-16H Evaporator System.

- **242-16H Evaporator Cells:** The evaporator cell is a cuboid with a 16 feet x 16 feet base and a height of 25 feet, with walls constructed of stainless steel-lined, grooved concrete that is 3.5 feet thick and a roof 1 foot thick, composed of concrete slab sections with a sloped, galvanized steel rain cover with access points. The evaporator cell is stainless steel-lined for collecting leakage from equipment inside the evaporator or condenser cells, leakage from the lift/lance/evaporator cell sump-gang valve vent header and liquid from cell spray operations. An evaporator underliner sump collects any leakage through the concrete or stainless steel liner.

The condenser cell is 10 feet x 6 feet x 9 feet 8 inches and 15 feet 6 inches high with walls constructed of two-foot thick concrete and has a roof composed of one-foot thick concrete slab sections, and a sloped, galvanized steel rain cover with access ports. The condenser cell contains a 1-foot high stainless steel liner pan on a sloped floor. The condenser cell has an opening to the evaporator cell for the de-entrainment column piping and permits airflow to the evaporator cell.

The overheads cell (which is open to the environment) is 15 feet x 21 feet and 21 feet high. The walls are constructed of concrete and the cell contains the mercury removal tank, cesium removal column feed tank, two cesium removal column pumps and two overheads tanks, and two overheads pumps.

Figure 2.1-62: 242-16H Evaporator System Schematic



- **242-16H Evaporator Vessel:** The evaporator vessel is 8 feet in diameter with a height of 19 feet, and a cone-shaped bottom. The vessel is constructed of 0.5-inch stainless steel. There are multiple evaporator vessel service/equipment lines installed in, or penetrating, the vessel, including the feed inlet nozzle, steam tube bundle, warming coil, lift lines, de-entrainment column, lance lines and the seal pot.
- **242-16H Overheads System:** The overheads system includes the condenser, mercury removal tank, cesium removal column feed tank, two cesium removal column pumps, two overheads tanks and two overhead pumps. The condenser is a vertical, single-pass, counter-flow tube and shell type heat exchanger located in the condenser cell. The mercury removal tank receives condensed overheads from the condenser. When full, the stainless steel tank overflows to the cesium removal column feed tank, permitting the heavier mercury to settle out and remain in the tank. The tank vents to the condenser cell, which vents and drains to the evaporator cell. The path from the evaporator vessel to the overheads tanks travels through a stainless steel cesium removal column feed tank.

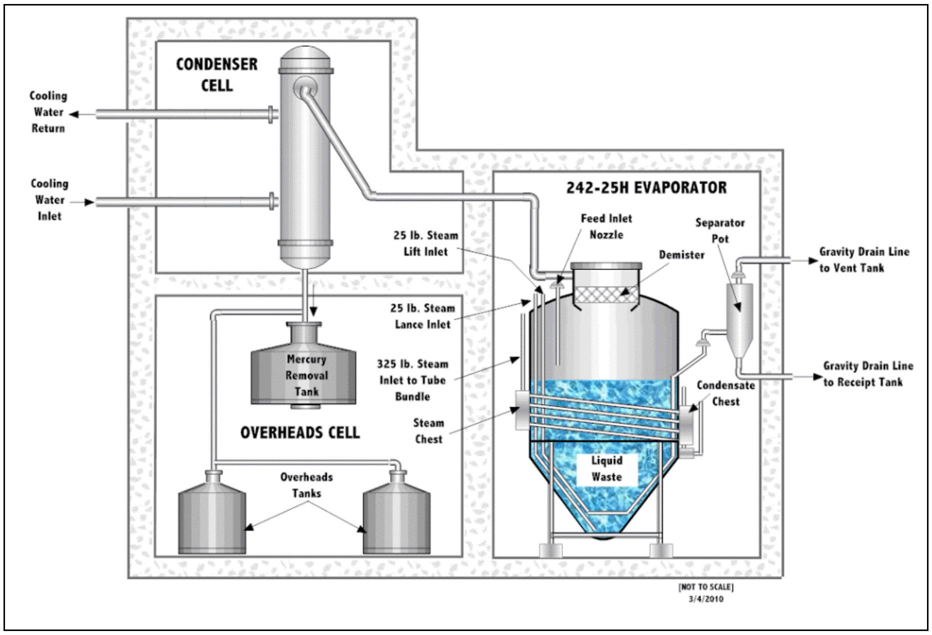
[SRR-CWDA-2010-00128]

2.1.12.3.3 242-25H Evaporator System

The 242-25H Evaporator System was placed into service in 2000 and continues to operate. [HLW-2002-00025] The system houses the evaporator vessel, the condenser cell and condenser, and an overheads cell, which contains the overheads system (that includes the mercury removal tank, mercury removal station, two overheads tanks, and two overheads pumps). Figure 2.1-63 provides a schematic of the 242-25H Evaporator System.

- **242-25H Evaporator Cells:** The evaporator cell is a cuboid with a 27 feet 6 inches x 20 feet base and a height of 32 feet 9 inches with walls constructed of 3-foot 6-inch thick concrete and has a roof composed of 3-foot 6-inch thick concrete slab sections. The evaporator cell is stainless steel-lined. The condenser cell is 10 feet 9 inches x 19 feet and 18 feet high with walls constructed of two-foot thick concrete and has a roof composed of two-foot thick concrete slabs. The condenser cell has an opening to the evaporator cell for the de-entrainment column piping and permits airflow to the evaporator cell. The overheads cell (which is open to the environment) is 25 feet x 24 feet and 23 feet high. This cell contains a mercury removal tank, two overheads tanks, an overheads tank sample system, and two overheads pumps.

Figure 2.1-63: 242-25H Evaporator System Schematic



- **242-25H Evaporator Vessel:** The evaporator vessel has a capacity of approximately 19,000 gallons. The insulated vessel is 14 feet in diameter with a height of 26 feet 6.375 inches, and a cone-shaped bottom. The vessel is constructed of 0.5625-inch stainless steel and the cone is comprised of 0.4038-inch stainless steel. There are multiple evaporator vessel service/equipment lines installed in, or penetrating, the vessel, including the feed inlet nozzle, steam tube bundle, warming coil, lift lines, de-entrainment column, lance lines and the seal pot.
- **242-25H Overheads System:** The overheads system includes the condenser, mercury removal tank, two overheads tanks and two overheads pumps. The condenser is a vertical, single-pass, counter-flow tube and shell type heat exchanger located in the condenser cell. The mercury removal tank receives condensed overheads from the condenser. A drain valve leads from the bottom of the removal tank to the mercury collection station located in the overheads receiver cell. The overheads are pumped to the Effluent Treatment Facility (ETF) by one of the two-recirculation pumps. The removal tank vents to the condenser cell, which vents and drains to the evaporator cell.

[SRR-CWDA-2010-00128]

2.1.12.4 Diversion Boxes

The diversion boxes are shielded, reinforced concrete structures containing transfer line nozzles to which jumpers are connected to direct waste transfers to the desired location. The diversion boxes are often constructed in conjunction with a pump pit.

The following is a description the features associated with the HTF diversion boxes: [SRR-CWDA-2010-00128]

- **HDB-1** is 78 feet long x 7 feet wide and 21 feet high. The walls are reinforced concrete and are a minimum of 1 foot 6 inches thick and taper to accommodate the two layers of concrete slabs that form a roof approximately 2 feet 8 inches thick. The sloped, reinforced concrete floor is a minimum of 2 feet 6 inches thick.
- **HDB-2** is 26 feet long x 15 feet wide that is incorporated with HPP-1 through HPP-4. The walls are reinforced concrete a minimum of 3 feet thick with a sloped floor of reinforced concrete approximately 4 feet 6 inches thick. The diversion box covers are concrete slabs and the walls and floor are lined with stainless steel.
- **HDB-3** is a square with outside dimensions of 6 feet 8 inches. The concrete walls and floor are 10 inches thick and the concrete slabs that comprise the roof are 8 inches thick.
- **HDB-4** is an octagon with an outer dimension of 10 feet and inside diameter of 7 feet. It is comprised of reinforced concrete walls a minimum of 18 inches thick and a sloped, reinforced concrete floor that is approximately 2 feet 6 inches thick. The cover is a reinforced concrete plug 7 feet 8 inches inside diameter and 3 feet thick. Stainless steel plate covers the walls, floor, and sump.
- **HDB-5** is an octagon with an outer dimension of 10 feet and an inside diameter of 7 feet. It is comprised of reinforced concrete walls that are a minimum of 18 inches thick and a sloped, reinforced concrete floor that is approximately 2 feet 4 inches thick. The cover is a reinforced concrete plug with an inside diameter of 7 feet 8 inches and a thickness of 3 feet. Stainless steel plate covers the walls, floor, and sump.
- **HDB-6** is a 15 foot square with walls and floor that are comprised of reinforced concrete. The walls are minimum 18 inches thick and the sloped floor is approximately 2 feet 11 inches thick. The cover for the diversion box is comprised of reinforced concrete slabs that are 3 feet thick. Stainless steel sheets cover the wall, floor, and sump.
- **HDB-7** is a 25-foot long x 19-foot wide rectangle with walls and floor that are comprised of reinforced concrete. The walls are minimum 2 feet 6 inches thick and the sloped floor is approximately 3 feet 4 inches thick. The cover for the diversion is comprised of reinforced concrete slabs that are 3 feet thick. Stainless steel covers the walls, floor, and sump.
- **HDB-8** is a 20-foot long x 24-foot wide rectangle that is incorporated with HPP-7 through HPP-10. The HDB-8 walls are reinforced concrete with a minimum thickness of 3 feet. The floor is reinforced concrete that is 3 feet thick. The diversion box cover is comprised of reinforced concrete slabs approximately 4 feet 3 inches thick. The walls, floor, and sump are lined with stainless steel.

[SRR-CWDA-2010-00128]

2.1.12.5 Transfer Valve Boxes

Transfer valve boxes facilitate specific waste transfers that are conducted frequently. The valves are generally manual ball valves in removable jumpers with flush water connections on the transfer lines. For HTF valve boxes, leakage collects in the valve box and drains back to the associated waste tank, diversion box or leak detection box. Valve boxes are generally located adjacent to the waste tanks they serve. [SRR-CWDA-2010-00128]

- **Valve Box 15/16** is located near Tank 16 and is shared by Tanks 15 and 16. It contains a transfer line connection to HDB-2 and allows this line to be lined up to receive waste from either Tank 14, 15 or 16. Any liquid accumulation can be drained through the HDB-2 encasement to the H-Catch Tank. The total volume for this valve box is approximately 60 gallons.
- **Tanks 21 and 22 Valve Boxes** contain isolation valves that connect with a transfer line to HDB-5. Both valve boxes drain to Tank 22. These valve boxes have an approximate volume of 400 gallons each.
- **Tank 40 Valve Box and Tank 40 Drain Valve Box -** The Tank 40 valve box is used mainly for transfers to DWPF. The Tank 40 drain valve box drains to a leak detection box. The Tank 40 drain valve box was installed because low points in the transfer piping were created that could not be drained. The transfer valve box and drain valve box have approximate volumes of 1,020 gallons and 350 gallons, respectively.

- **Tank 42 Valve Box** leakage drains to a leak detection box and then to the HDB-7 sump. This valve box has an approximate volume of 1,460 gallons.
- **Tank 49 Valve Box** leakage drains to the leak detection box drain cell. This valve box has an approximate volume of 1,300 gallons.
- **Tank 50 Valve Box** leakage drains back to Tank 50. This valve box has an approximate volume of 1,530 gallons.
- **Tank 51 Valve Box and Tank 51 Drain Valve Box -** The Tank 51 valve box is used for transfers in and out of Tank 51. The Tank 51 drain valve box drains to a leak detection box. The Tank 51 drain valve box was installed because low points in the transfer piping were created that could not be drained. The transfer valve box and drain valve box have approximate volumes of 1,030 gallons and 630 gallons, respectively.
- **241-96H Valve Box** allows transfers in and out of the building 241-96H monosodium titanate strike tanks. Its leakage drains to the leak detection box drain cell. This valve box has an approximate volume of 1,916 gallons.

[WHJISB03.STGD000100]

2.1.12.6 Other Ancillary Structures

The leak detection boxes provide for the collection and detection of leakage from a transfer line. Drain piping is run from a transfer line jacket to a leak detection box. The leak detection boxes typically have conductivity probe leak detection and drain and overflow plugs. Drain piping for the leak detection boxes is provided so that liquid from the leak sites is diverted to a diversion box or pump pit. No leakage into transfer line secondary containment (e.g., transfer line jacket and leak detection box) due to primary line failure has been detected. [SRR-CWDA-2010-00128]

The modified leak detection boxes serve the same purpose as the leak detection boxes but are larger and are installed at low points that cannot be gravity drained to a collection point. In addition to a conductivity probe, modified leak detection boxes also include a vent line to a diversion box or pump pit, an above-ground pressure gage to monitor for potential over-pressurization and a smear/cleanout pipe for measuring levels and manual pump-out of leakage into the box. [SRR-CWDA-2010-00128]

2.2 H-Tank Farm Wastes

As discussed in the following subsections, HTF has received waste from a number of different sources. Most of the waste managed in HTF originated in the H-Canyon Separations Facility, which primarily made use of the H-Modified (HM) chemical separations process. The HM process, which is similar to the PUREX process formerly utilized in the F-Canyon Separations Facility,[22] was developed to support processing of enriched uranium fuels beginning in 1959. Typically, in this process, uranium was extracted from fuel that was irradiated in the SRS nuclear production reactors. Subsequent modifications made possible the recovery of Np-237 and the efficient processing of moderately enriched uranium fuels from off-site reactors. From its startup in 1955 until introduction of the HM process in 1959, the H-Canyon Separations Facility was used for processing of natural uranium fuels utilizing the PUREX process.

Before transfer of the waste from the H-Canyon to the tank farms, sodium hydroxide was and continues to be added to adjust the waste to a high alkaline state to prevent corrosion of the carbon steel waste tanks. This chemical adjustment resulted in the precipitation of solids. These solids settled in the waste tanks forming a layer that is commonly referred to as “sludge.” These solids are comprised of fine particles of settled metal oxides including strontium, uranium and plutonium hydroxides. These solids are insoluble due to the chemical conditions of the solution. After settling of the solids occurred, the liquid salt waste solution (supernate) above this sludge layer was transferred out of the waste tanks. To maximize the space available in the waste tanks for storing additional waste, DOE’s practice at SRS has been to use the tank farm evaporator systems to reduce the volume of the decanted supernate by concentrating the waste. [HLW-2002-00025]

During the evaporation process, the liquid salt waste is concentrated. After the concentrated salt waste is returned to the waste tank, the concentrated salt waste forms two distinct phases (collectively called salt

[22] The final transfer of waste from F-Canyon to the FTF occurred in August 2005. Additional information on the separations facilities is provided in Appendix A of this Draft HTF 3116 Basis Document.

waste): 1) concentrated supernate solution and 2) solid saltcake. The predominant radionuclide present in the salt waste is Cs-137. Because of the high solubility of Cs-137, approximately 95 % of the Cs-137 is present in the concentrated supernate solution and the liquid found within the interstitial spaces in saltcake. The solid saltcake is composed predominantly of nitrate and nitrite salts and contains relatively small quantities of insoluble radioactive solids. When saltcake is dissolved and removed from the tank, these entrained sludge particles eventually settle on the waste tank bottom adding to the sludge inventory. [SRR-LWP-2010-00040]

The solids on the waste tank bottom collectively behave as a non-ideal fluid and generally have a consistency similar to peanut butter. Thus, a significant amount of mixing energy is required to suspend the sludge in solution to transfer it out of a waste tank.

The waste stored in HTF waste tanks is comprised of a combination of sludge, supernate and saltcake.

2.2.1 Sources of the Waste

This section describes the origin of the wastes managed in HTF and explains how these wastes are managed.

2.2.1.1 The H-Modified Process

This subsection briefly describes the HM process that generated most of the HTF waste. [DP-1500]

As discussed previously, most of the waste managed in HTF originated in the H-Canyon Separations Facility, which made use of the HM process. The first major step in the HM process involved dissolving the reactor fuels in nitric acid. This dissolver solution was processed to remove silica solids and the clarified solution was then fed to the first solvent extraction cycle. In this cycle, uranium, neptunium and plutonium were separated from the fission products by being extracted into the solvent. Approximately 95 % of the fission products remained in the aqueous phase, with the balance of the fission products being contained in the solvent along with the uranium, neptunium and plutonium.

The solvent product stream underwent additional processing cycles to separate the uranium, neptunium and plutonium and to purify these materials. The enriched uranium was recovered and transported off-site for further processing. Neptunium was concentrated for recovery from the solution. The relatively small quantities of plutonium were normally discarded in the aqueous waste, unless the content of Pu-238 was high enough to make its recovery desirable. The aqueous waste stream containing 95 % of the fission products, and the plutonium stream if not being recovered, was evaporated to reduce the waste volume and recover the nitric acid. The waste stream was then neutralized and transferred to one of the HTF waste tanks.

This neutralized waste stream was known as high-heat waste. Waste from the rest of the process and from other operations within the facility contain the remainder of the radionuclides and was categorized as low-heat waste. [DP-1500]

2.2.1.2 DWPF Recycle

As previously described in Section 2.1.9, the DWPF returns “DWPF recycle” to the HTF. The DWPF recycle stream is a generally very low-activity stream that consists of condensate from chemical processing and melter operations, waste from decontamination activities, and waste from miscellaneous drains and sumps in DWPF. Before the recycle stream is transferred to HTF, it is chemically adjusted to a high alkaline state to prevent corrosion of the carbon steel waste tanks. DWPF recycle is currently the largest influent stream received by HTF. Disposition of the DWPF recycle stream is handled through evaporation and through beneficial reuse (e.g., salt solution molarity adjustment, salt dissolution, heel removal). [SRR-LWP-2009-00001]

2.2.1.3 Evaporator Products

Figure 2.2-1: Saltcake at Bottom of Waste Tank

The three HTF evaporators concentrated the liquid waste generated in the PUREX and HM processes to remove excess water, a process which generated concentrated supernate and evaporator overheads. As discussed previously, the saltcake is precipitated salt waste from the concentrated supernate and is comprised principally of inert salts such as nitrites and nitrates. Figure 2.2-1 shows the saltcake at the bottom of a waste tank. The concentrated supernate is typically in an alkaline solution that is relatively high in radioactivity. Overheads are the excess water removed from the waste stream by the evaporation process. Overheads are sampled and, depending on the sample results, are sent to the ETF or, if cesium levels are high, returned to a waste tank to repeat the evaporation process. Additional cesium removal is also part of the process at ETF.

2.2.1.4 Zeolite Resin

Some waste tanks contain zeolite resin from ion exchange columns, which were also known as cesium removal columns. Tanks 24, 32 and 42 were equipped with these columns to remove cesium from the HTF evaporator overheads waste streams, with the spent zeolite containing captured Cs-137 being discharged into the waste tanks (zeolite is a natural mineral known for its ability to capture and retain cesium). The cesium removal columns were removed from service when FTF became operational. As discussed in the individual waste tank histories in Section 2.2.2.2, Tanks 24, 32, 38, 40, 42 and 51 contain zeolite resin. Tank 38, 40 and 51 zeolite content is a result of waste transfer receipts from Tanks 24, 42 and FTF. [CBU-PIT-2005-00099]

2.2.1.5 Miscellaneous Waste Streams

As described below, some HTF waste tanks have also received limited amounts of radioactive waste from other sources such as FTF, which received waste from the PUREX process in F-Canyon, Receiving Basin for Offsite Fuels (RBOF), Resin Regeneration Facility (RRF), In-Tank Precipitation (ITP) Project and Interim Salt Processing.[23]

2.2.2 Waste Management

This section addresses processes used for waste storage and volume reduction and provides a capsule history of each HTF waste tank.

2.2.2.1 Waste Storage and Volume Reduction

As discussed previously, the primary function of HTF has been to support the H-Canyon operation by storing waste produced primarily from the HM process. Management of waste stored in HTF has been complex due to the large volumes of waste produced by H-Canyon operations, efforts to reduce the volume of waste and waste removal from waste tanks. Because the HM process was based on a nitric acid flowsheet and because the waste tanks in HTF were constructed of carbon steel, the pH of the waste originating from H-Canyon must be chemically adjusted from an acidic solution to an alkaline solution through the addition of sodium hydroxide prior to transfer to HTF to protect the integrity of carbon steel waste tanks.

[23] As FTF waste tanks and ancillary structures are closed, waste currently stored in FTF, if not evaporated, will be transferred to HTF for additional processing through DWPF or salt processing (See Appendix A for additional discussion on DWPF and salt processing). The waste streams from the RBOF and RRF facilities are not wastes generated from the reprocessing of spent nuclear fuel and therefore are not, by themselves, subject to NDAA Section 3116. However, to the extent that these waste streams were added to waste tanks which did contain waste generated from the reprocessing of spent nuclear fuel and the waste streams became mixed, they are now subject to NDAA Section 3116 and therefore included in this Draft HTF 3116 Basis Document.

The volume of waste managed in HTF has been significantly reduced using the HTF Evaporator Systems. The 242-H Evaporator System operated from 1963 through 1994. The 242-16H Evaporator Facility entered service in 1982 and continues to operate. The 242-25H Evaporator Facility entered service in 2000 and continues to operate. Operation of an evaporator involves the use of a waste tank to feed the waste to the evaporator and other waste tanks to receive the concentrated salt waste from the evaporation process.

Waste removal from the waste tanks as a precursor to future closure activities results in waste being transferred to other waste tanks. The waste removal process includes adding large volumes of water to aid in dissolving saltcake and suspending sludge into slurry for transfer. These factors make it necessary to carefully manage waste tank space to prevent the tank farm from becoming “water logged.”

The waste tank histories in Section 2.2.2.2 describe how individual waste tanks have been used to receive waste directly from H-Canyon and in waste volume reduction and waste tank cleaning efforts.

2.2.2.2 Waste Tank History

The following waste tank histories are based on daily and monthly data report summaries, personal logs and tank-to-tank transfer data, unless otherwise specifically noted. [SRR-LWP-2012-00061] Sludge and saltcake volumes include the interstitial liquid (i.e., liquid within the sludge and saltcake matrix) associated with those phases. Leak site information is included for the Type I and Type IV waste tanks known to have a history of leakage. No primary waste tank leakage has been detected in Type III/IIIA secondary liners or concrete vaults.

Type I Tanks

Tank 9 was constructed between 1951 and 1953 and entered service in 1955 as the first H-Canyon waste receipt tank. This waste tank remained active and operational until 1973. The largest volume of waste stored in Tank 9 has been approximately 740,000 gallons. [DPSP 58-1-7-S_p27] As of April 2, 2012, Tank 9 contained approximately 13,000 gallons of supernate, 2,700 gallons of sludge and 534,000 gallons of saltcake. [SRR-LWP-2012-00029] In 1955, Tank 9 received high-heat waste from the H-Canyon PUREX process, prior to H-Canyon conversion to the HM process. In 1965 and 1966, the supernate and sludge were removed from Tank 9 to allow the waste tank to serve as a concentrate receipt tank for the 242-H evaporator. Tank 9 supported the 242-H evaporator until 1973. Since 1973, the waste tank has served as a salt waste storage tank. [DPSPU 79-11-1] Tank 9 is known to have leaked and approximately 8 to 10 inches of salt deposits has been observed on the annulus floor. However, the exact location of the leak sites has not been identified. The secondary containment system has worked as designed; the waste has been contained within the annular pan and has not reached the surrounding soils. [SRR-STI-2012-00346]

Tank 10 was constructed between 1951 and 1953 and entered service in 1955 as an H-Canyon waste receipt tank. The largest volume of waste stored in Tank 10 has been approximately 727,000 gallons. [DPSP 59-1-4-S_p42] As of April 2, 2012, Tank 10 contained approximately 2,700 gallons of sludge and 211,000 gallons of saltcake. [SRR-LWP-2012-00029] From 1955 through 1959, Tank 10 received high-heat waste from the H-Canyon PUREX process, prior to H-Canyon conversion to the HM process. In 1967, the supernate and majority of sludge were removed from Tank 10 to allow the waste tank to serve as a concentrate receipt tank for the 242-H evaporator. During the sludge removal operation, a spill of approximately 40 to 50 gallons occurred near Riser 5 on Tank 10 [DPSP 67-1-2-S_p39_p41]. From 1967 until 1974, Tank 10 served as a concentrate receipt tank for the 242-H evaporator and, during this time, underwent several salt removal campaigns. The remaining saltcake resulting from receipts of the evaporator bottoms was left in storage in Tank 10. [DPSPU 78-11-11] Additional salt removal campaigns were performed in Tank 10 beginning in 1979 and 1982. [DPSP 79-21-5_p8, DPSP 82-21-12_p14, DPSP 83-21-2_p13] In 1985, water additions to Tank 10 were made to support tank operations and, during the late 1980s, several transfers of supernate were made from Tank 10. Since that time, the waste tank has served as a salt waste storage tank. [SRR-LWP-2012-00061] Tank 10 is known to have leaked and approximately 2 to 3 inches of salt deposits has been observed on the annulus floor. However, the exact location of the leak sites has not been identified. The secondary containment system has worked as designed; the waste has been contained within the annular pan and has not reached the surrounding soils. [SRR-STI-2012-00346]

Tank 11 was constructed between 1951 and 1953 and entered service in 1955 as an H-Canyon waste receipt tank. The largest volume of waste stored in Tank 11 has been approximately 744,000 gallons. [DPSP 60-1-9-S_p38] As of April 2, 2012, Tank 11 contained approximately 30,300 gallons of supernate and 9,600 gallons of sludge. [SRR-LWP-2012-00029] From 1955 through 1956, Tank 11 received low-heat waste from the H-Canyon PUREX process, prior to H-Canyon conversion to the HM process. In 1961, supernate was transferred from Tank 11 and, from 1961 through 1968, the waste tank received high-heat waste from the HM process and Thorex. In 1968, a sludge removal campaign was performed in Tank 11 to allow the waste tank to serve as concentrate receipt tank for the 242-H evaporator. After a short period of time as the concentrate receipt tank, Tank 11 again became a receipt tank for high-heat waste from the HM process and served in that role until 1982. [DPSPU 78-11-12, DPSP 82-21-1_p8] In 2004, a sludge removal campaign was performed in Tank 11. [CBU-PIT-2004-00002] In 2008, aluminum rich supernate from a Low Temperature Aluminum Dissolution campaign conducted in Tank 51 was transferred into Tank 11 for short-term storage. [SRR-LWP-2010-00007] In 2012, a portion of the aluminum rich supernate was transferred from Tank 11 to Tank 8 to be staged for future processing. [SRR-LWP-2012-00061] Tank 11 is known to have leaked at two identified leak sites and trace amounts of waste are present on the walls near the leak sites and on the annulus floor. [C-ESR-G-00003] The secondary containment system has worked as designed; the waste has been contained within the annular pan and has not reached the surrounding soils.

Tank 12 was constructed between 1951 and 1953 and entered service in 1955 as an H-Canyon waste receipt tank. The largest volume of waste stored in Tank 12 has been approximately 736,000 gallons. [DPSPU 78-11-9] As of April 2, 2012, Tank 12 contained approximately 100,000 gallons of supernate and 13,700 gallons of sludge. [SRR-LWP-2012-00029] From 1956 through 1974, Tank 12 received high-heat waste from both the H-Canyon PUREX process, prior to H-Canyon conversion to the HM process, and the HM process. During this time period the supernate was removed five times, leaving the sludge. [DPSPU 78-11-9] From 1975 until 2004, Tank 12 was essentially idle with only several large transfers to remove portions of the Tank 12 supernate being performed. In 2004, water additions were made to Tank 12 in order to re-wet the dry sludge in preparation for waste removal. From 2009 through 2011, three sludge removal campaigns were conducted in Tank 12 to support sludge batch preparation for DWPF. [SRR-LWP-2012-00061] Tank 12 is known to have leaked at 15 identified leak sites and a small quantity of waste has been observed on the walls and on the annulus floor. [C-ESR-G-00003] The secondary containment system has worked as designed; the waste has been contained within the annular pan and has not reached the surrounding soils.

Type II Tanks

Tank 13 was constructed between 1955 and 1956 and entered service in 1956 as an H-Canyon waste receipt tank. The largest volume of waste stored in Tank 13 has been approximately 1,064,000 gallons. [SRR-CWDA-2012-00164] As of April 2, 2012, Tank 13 contained approximately 277,000 gallons of sludge and 424,000 gallons of supernate. [SRR-LWP-2011-00043] From 1956 until 1959, Tank 13 received low-heat waste from the H-Canyon PUREX process. In 1961, supernate was removed from Tank 13 and, until early 1976, Tank 13 served as a transfer tank for high-heat supernate waste being transferred to the 242-16H evaporator feed tank. In addition, from 1966 through 1969, Tank 13 received sludge from Tanks 9, 10, 11 and 14. [DPSPU 78-11-2] From 1976 through 1994, Tank 13 served as the feed tank for the 242-H evaporator. [SRR-CWDA-2012-00164, WSRC-RP-94-383-2] Tank 13 remained idle until 2012 when a waste removal campaign was initiated in Tank 12 to support sludge batch preparation for DWPF. [SRR-LWP-2012-00025, SRR-LWP-2012-00061] The Tank 13 waste removal campaign is currently ongoing. Tank 13 is known to have leaked at two identified leak sites and trace amounts of waste are present on the walls near the leak sites and on the annulus floor. [C-ESR-G-00003] The secondary containment system has worked as designed; the waste has been contained within the annular pan and has not reached the surrounding soils.

Tank 14 was constructed between 1955 and 1956 and entered service in 1957 as an H-Canyon waste receipt tank. The largest volume of waste stored in Tank 14 has been approximately 1,061,000 gallons. [DPSPU 77-11-19] As of April 2, 2012, Tank 14 contained approximately 28,000 gallons of sludge and 130,000 gallons of saltcake. [SRR-LWP-2012-00029] From 1957 through 1959, Tank 14 received high-heat waste from the H-Canyon PUREX process until waste leakage into the Tank 14 annulus was detected and fresh high-heat waste receipts were diverted to another waste tank. From 1959 through

1965, Tank 14 was used sparingly to receive high-heat waste from the HM process and high-heat waste that had leaked into the Tank 16 annulus. In 1968, supernate was removed from Tank 14 in preparation for a sludge removal campaign and, in 1969, a sludge removal campaign was initiated. From 1969 through 1970, Tank 14 received concentrated supernate from several waste tanks and, in 1972, 14,000 gallons were siphoned from the primary tank into the Tank 14 annulus via the annulus jet, the waste was immediately returned to the primary tank. [DPSPU 77-11-19] Tank 14 remained idle until 1977 when waste from the Tank 16 annulus was transferred into Tank 14. [SRR-CWDA-2011-00126] Since 1977, the waste tank has remained idle. Tank 14 is known to have leaked at 33 identified leak sites, and it is estimated that there are about 50 leak sites in this waste tank. Approximately 12 to 13 inches of salt deposits has been observed on the annulus floor. [SRR-STI-2012-00346, C-ESR-G-00003] The secondary containment system has worked as designed; the waste has been contained within the annular pan and has not reached the surrounding soils.

Tank 15 was constructed between 1955 and 1956 and entered service in 1960 as a receipt tank for supernate from Tank 16. The largest volume of waste stored in Tank 15 has been approximately 1,075,000 gallons. [SRR-CWDA-2012-00164] As of April 2, 2012, Tank 15 contained approximately 159,000 gallons of sludge and 76,200 gallons of saltcake. [SRR-LWP-2012-00029] In 1960, in response to leakage in Tank 16, Tank 15 was placed into service to initially receive supernate from Tank 16. From 1960 through 1978, Tank 15 received high-heat waste from the HM process and, during this time, supernate was periodically removed from Tank 15 to allow continued receipt of waste from H-Canyon. [DPSPU 77-11-26] From 1978 to 1980, Tank 15 received sludge slurry transfers from Tank 16. [SRR-CWDA-2011-00126] In 1982, a sludge removal campaign was performed in Tank 15. Since 1982, the waste tank has remained idle. [DPSP 82-21-3_p13] Tank 15 is known to have leaked at 15 identified leak sites and trace amounts of waste are present on the walls near the leak sites and on the annulus floor. In 1973, 12 new annulus risers were installed to provide nearly 100 % waste tank wall area surveillance capability. [DPSPU 77-11-26, C-ESR-G-00003] The secondary containment system has worked as designed; the waste has been contained within the annular pan and has not reached the surrounding soils.

Tank 16 was constructed between 1955 and 1956 and entered service in 1959 as an H-Canyon waste receipt tank. The largest volume of waste stored in Tank 16 has been approximately 1,061,000 gallons. [DPSPU 77-11-17] From 1959 through 1960, Tank 16 received high-heat waste from the HM process and, in 1960, due to leakage in the primary tank, approximately one-half of the contents of Tank 16 were transferred to Tanks 14 and 15. From 1967 through 1972, Tank 16 received low-heat waste from the HM process and concentrate from the 242-H evaporator, however, in 1972 leakage of the Tank 16 primary tank resumed and the supernate in Tank 16 was transferred to Tank 13. The sludge remained in the waste tank and the use of Tank 16 for any additional waste receipts was discontinued. [DPSPU 77-11-17] In 1978, an annulus cleaning campaign was performed for Tank 16. Waste removal from the Tank 16 primary tank was performed from 1978 through 1980. [SRR-CWDA-2011-00126] Tank 16 is known to have leaked at approximately 300 to 350 identified leak sites. Waste leakage into the annulus was first discovered in 1959, and in September 1960, liquid waste overflowed the annulus pan. A few tens of gallons of waste are estimated to have breached the waste tank concrete encasement and entered the surrounding soil. Leakage essentially stopped after the waste tank liquid level was lowered below the middle horizontal weld. In 1962 and 1974, sandblasting was used to support detailed inspections of the leak sites. Metallurgical examination indicated the cause of the cracks was nitrate-induced stress corrosion. [DPSPU 77-11-17, DP-1358] Currently, there are approximately 11 to 12 inches of waste on the annulus floor. [C-ESR-G-00003]

Type IV Tanks

Tank 21 was constructed in 1961 and entered service in 1961 as a receipt tank for supernate from Tank 13. The largest volume of waste stored in Tank 21 has been approximately 1,345,000 gallons. [DPSP 62-1-6-S_p42] As of April 2, 2012, Tank 21 contained approximately 53,500 gallons of sludge and 1,190,000 gallons of supernate. [SRR-LWP-2012-00029] In 1961, Tank 21 received low-heat waste transferred from Tank 13 and, subsequently, received additional low-heat waste from Tank 11. From 1963 through 1976, Tank 21 served as the feed tank for the 242-H evaporator and, during this time, stored both low-heat and high-heat waste. [DPSPU 78-11-10] From 1976 through 1986, Tank 21 received waste from the HM process and, in 1986, a sludge removal campaign was performed in the waste tank. [MO-RPT-86-SEP2_p20] In addition, from 1963 to 1994, Tank 21 received contaminated water from building 244-H, RBOF, and 245-H, RRF. From 2001 to 2005, Tank 21 served as a receipt tank for DWPF recycle. [CBU-SPT-2003-00181] Since 2005, Tank 21 has been utilized to assemble salt batches in preparation for treatment via ARP/MCU Interim Salt Processing.[24] Visual examinations of the steel liner have shown no evidence of failure, significant surface corrosion or other anomalies. [SRR-STI-2012-00346]

Tank 22 was constructed between 1961 and 1962 and entered service in 1965 as a receipt tank for supernate from Tank 21. The largest volume of waste stored in Tank 22 has been approximately 1,338,000 gallons. [DPSP 65-1-6-S_p53] As of April 2, 2012, Tank 22 contained approximately 71,500 gallons of sludge and 811,000 gallons of supernate. [SRR-LWP-2012-00029] In 1965, Tank 22 received high-heat waste transferred from Tank 21 and, subsequently, the material was transferred back to Tank 21, processed through the 242-H evaporator and returned to Tank 22. The recycled concentrate from Tank 21 and from other waste tanks was stored in the waste tank until 1971. From 1971 through 1974, supernate was removed from Tank 22 and a salt removal campaign was performed. [DPSPU 79-11-5] From 1974 until 1980, Tank 22 received low-heat waste from the HM process. In 1986, two sludge removal campaigns were completed in Tank 22 to provide feedstock for DWPF. In addition, from 1971 to 1989, Tank 22 received waste from building 244-H, RBOF, and 245-H, RRF via Tank 23. [SRR-LWP-2012-00061] Since 2000, Tank 22 has served as a receipt tank for DWPF recycle. [CBU-SPT-2003-00181] Visual examinations of the steel liner have shown no evidence of failure, significant surface corrosion or other anomalies. [SRR-STI-2012-00346]

Tank 23 was constructed between 1961 and 1962 and entered service in 1964 as a receipt tank for contaminated water from RBOF and RRF. The largest volume of waste stored in Tank 23 has been approximately 1,319,000 gallons. [MO-RPT-87-AUG3_p5] As of April 2, 2012, Tank 23 contained approximately 126,000 gallons of sludge and 548,000 gallons of supernate. [SRR-LWP-2012-00029] In 1964, Tank 23 began receiving contaminated water from building 244-H, RBOF, and 245-H, RRF. Waste from RBOF and RRF typically contained 1 to 2 % solids and 0.1 to 1.0 % of the amount of radioactivity contained in typical low-heat waste. [DPSPU 79-11-7] The waste tank remained in this service until 1995 when the RBOF facility was shutdown. The Tank 23 waste was processed initially by the 242-H evaporator; but beginning in 1966 the waste was processed through a zeolite bed to remove Cs-137 and small amounts of other radioisotopes, and discarded to seepage basins. [DPSPU 79-11-7] This practice was discontinued in 1988 when the Tank 23 material began being processed at ETF. In 2008, the material in Tank 23 was used to adjust salt solution from Tank 41 salt dissolution for processing at SDF as part of Deliquification, Dissolution and Adjustment (DDA) salt processing. [LWO-LWP-2008-00007] Since 2008, Tank 23 has been used to assemble salt batches in preparation for treatment via ARP/MCU Interim Salt Processing.[25] Visual examinations of the steel liner have revealed corrosion but no evidence of failure. [SRR-STI-2012-00346]

Tank 24 was constructed between 1961 and 1962 and entered service in 1963 as a concentrate receipt tank for the 242-H evaporator. The largest volume of waste stored in Tank 24 was approximately 1,326,000 gallons. [DPSP 68-1-5_p106] As of April 2, 2012, Tank 24 contained approximately 3,540 gallons of sludge and 1,280,000 gallons of supernate. [SRR-LWP-2012-00029] From 1963 through 1967, Tank 24 served as a concentrate receipt tank for the 242-H evaporator. Tank 24 remained mostly idle until 1981 when it began to receive waste, via Tank 23, from building 244-H, RBOF, and 245-H, RRF. The waste tank remained in this service until 1987. [SRR-LWP-2012-00061] In addition, in 1965, Tank 24 was equipped with a cesium removal column used to remove cesium from the evaporator overheads and the waste streams from RBOF/RRF. From 1966 through 1984, Tank 24 received approximately 44,000 gallons of zeolite. In 1982, a salt removal campaign was performed in Tank 24 and, in 1983, additional salt solution was removed from the waste tank. Also in 1983, a zeolite slurry transfer was sent from Tank 24 to Tank 38. In 1985, an oxalic acid demonstration for zeolite removal was performed in Tank 24 and it was estimated that approximately 5,500 gallons of zeolite remained in the waste tank. [CBU-PIT-2005-00099] In 2005, Tank 24 was used to assemble salt batches in preparation for treatment via ARP/MCU Interim Salt Processing. [CBU-PIT-2005-00269] Since 2010, Tank 24 has been used as a concentrated supernate storage tank. [SRR-LWP-2011-00001] Visual examinations of the steel liner

[24] A description of Interim Salt Processing is provided in Appendix A of this Draft HTF 3116 Basis Document.
[25] A description of Interim Salt Processing is provided in Appendix A of this Draft HTF 3116 Basis Document.

have shown no evidence of failure, significant surface corrosion or other anomalies. [SRR-STI-2012-00346]

Type III Tanks

No primary waste tank leakage has been detected in Type III secondary liners or concrete vaults. [SRR-STI-2012-00346]

Tank 29 was constructed between 1967 and 1970 and entered service in 1971 as a concentrate receipt tank for the 242-H evaporator. The largest volume of waste stored in Tank 29 has been approximately 1,295,000 gallons. [SRR-CWDA-2012-00164] As of April 2, 2012, Tank 29 contained approximately 219,000 gallons of supernate and 1,020,000 gallons of saltcake. [SRR-LWP-2012-00029] From 1971 through 1988, Tank 29 served as a concentrate receipt tank for the 242-H evaporator and, in 1980, also received concentrated supernate from Tank 10. [DPSP 80-21-5_p23] After 1988, three transfers were made from Tank 29 to Tank 32 and only one transfer, from Tank 42, was received. [SRR-LWP-2012-00061]

Tank 30 was constructed between 1967 and 1970 and entered service in 1974 as a concentrate receipt tank for the 242-H evaporator. The largest volume of waste stored in Tank 30 has been approximately 1,278,000 gallons. [SRR-LWP-2012-00025] As of April 2, 2012, Tank 30 contained approximately 872,000 gallons of supernate, 620 gallons of sludge and 298,000 gallons of saltcake. [SRR-LWP-2012-00029] From 1974 through 1995, Tank 30 served as a concentrate receipt tank for the 242-H evaporator. Tank 30 was converted to a concentrate receipt tank for the 242-25H evaporator in 2000. [SRR-LWP-2012-00061]

Tank 31 was constructed between 1967 and 1970 and entered service in 1973 as a concentrate receipt tank for the 242-H evaporator. The largest volume of waste stored in Tank 31 has been approximately 1,288,000 gallons. [SRR-CWDA-2012-00164] As of April 2, 2012, Tank 31 contained approximately 115,000 gallons of supernate and 1,150,000 gallons of saltcake. [SRR-LWP-2012-00029] From 1973 through 1983, Tank 31 served as a concentrate receipt tank for the 242-H evaporator. Since then, Tank 31 has not received a waste transfer. [SRR-LWP-2012-00061]

Tank 32 was constructed between 1967 and 1970 and entered service in 1971 as an H-Canyon waste receipt tank. The largest volume of waste stored in Tank 32 has been approximately 1,277,000 gallons. [SRR-CWDA-2012-00164] As of April 2, 2012, Tank 32 contained approximately 538,000 gallons of supernate, 104,000 gallons of sludge and 137,000 gallons of saltcake. [SRR-LWP-2012-00029] From 1971 through 1988, Tank 32 received high-heat waste from the HM process. In addition, Tank 32 was equipped with a cesium removal column used to remove cesium from the evaporator overheads and, from 1985 to 1988, received approximately 6,700 gallons of spent zeolite. [CBU-PIT-2005-00099] Tank 32 was converted to a feed tank for the 242-25H evaporator in 2000. [SRR-LWP-2012-00061]

Type IIIA Tanks

No primary waste tank leakage has been detected in Type IIIA secondary liners or concrete vaults. [SRR-STI-2012-00346]

Tank 35 was constructed between 1974 and 1977 and entered service in 1977 as an H-Canyon waste receipt tank. The largest volume of waste stored in Tank 35 has been approximately 1,274,000 gallons. [WSRC-RP-92-78-7B] As of April 2, 2012, Tank 35 contained approximately 1,080,000 gallons of supernate and 89,200 gallons of sludge. [SRR-LWP-2012-00029] From 1977 through 1990, Tank 35 received high-heat waste from the HM process. After 1990, Tank 35 received salt solution from Tank 37 saltcake removal campaigns in 2002, 2005 and 2010. [SRR-LWP-2012-00061]

Tank 36 was constructed between 1974 and 1977 and entered service in 1977 as concentrate receipt tank for the 242-H evaporator. The largest volume of waste stored in Tank 36 has been approximately 1,285,000 gallons. [SRR-LWP-2012-00061] As of April 2, 2012, Tank 36 contained approximately 237,000 gallons of supernate, 186 gallons of sludge and 1,040,000 gallons of saltcake. [SRR-LWP-2012-00029] From 1977 through 1988, Tank 36 served as a concentrate receipt tank for the 242-H evaporator. Since then, Tank 36 has not received a waste transfer. [SRR-LWP-2012-00061]

Tank 37 was constructed between 1974 and 1977 and entered service in 1978 as a concentrate receipt tank for the 242-H evaporator. The largest volume of waste stored in Tank 37 has been approximately

1,288,000 gallons. [SRR-LWP-2010-00007] As of April 2, 2012, Tank 37 contained approximately 217,000 gallons of supernate and 1,060,000 gallons of saltcake. [SRR-LWP-2012-00029] From 1978 through 1988, Tank 37 served as a concentrate receipt tank for the 242-H evaporator. In 2002, saltcake removal operations were performed in Tank 37 to allow the tank to serve as a concentrate receipt tank for the 242-25H evaporator. Additional saltcake removal campaigns were carried out in 2005 and 2010 allowing Tank 37 to continue serving as a concentrate receipt tank for the 242-25H evaporator. [SRR-LWP-2012-00061]

Tank 38 was constructed between 1976 and 1980 and entered service in 1981 as a receipt tank for a variety of waste streams in support of the H-Area Liquid Waste program. The largest volume of waste stored in Tank 38 has been approximately 1,263,000 gallons. [SRR-LWP-2012-00061] As of April 2, 2012, Tank 38 contained approximately 450,000 gallons of supernate and 802,000 gallons of saltcake. [SRR-LWP-2012-00029] From 1981 through 1986, Tank 36 received a variety of waste streams in support of the H-Area Liquid Waste program, including, in 1983 and 1984, zeolite slurry from Tank 24. Tank 38 received a total of approximately 38,000 gallons of zeolite from Tank 24. [CBU-PIT-2005-00099] Tank 38 was converted to a concentrate receipt tank for the 242-16H evaporator in 1986. [SRR-LWP-2012-00061]

Tank 39 was constructed between 1976 and 1980 and entered service in 1982 as an H-Canyon waste receipt tank. The largest volume of waste stored in Tank 39 has been approximately 1,280,000 gallons. [WSRC-RP-89-78-9B_p4] As of April 2, 2012, Tank 39 contained approximately 734,000 gallons of supernate and 163,000 gallons of sludge. [SRR-LWP-2012-00029] From 1982 through 1994, Tank 39 received high-heat waste from the HM process and, in 1987, served as a concentrate receipt tank for the 242-16H evaporator. After 1997, Tank 39 served as a receipt tank for H-Canyon waste, waste from the 299-H maintenance facility and waste from other Liquid Waste program initiatives. Transfers out of Tank 39 since 1996 have primarily been to the SRS FTF evaporator system. [SRR-LWP-2012-00061]

Tank 40 was constructed between 1976 and 1980 and entered service in 1986 as a receipt tank for sludge slurry transfers from Tanks 18 and 22. The largest volume of waste stored in Tank 40 has been approximately 1,252,000 gallons. [MO-RPT-87-MAR3_p4] As of April 2, 2012, Tank 40 contained approximately 647,000 gallons of sludge. [SRR-LWP-2012-00029] From 1986 through 2001, Tank 40 served as a receipt tank for sludge slurry transfers from Tanks 8, 18, 22 and 42 and, in 2001, the contents of Tank 40 were prepared as the second sludge batch for DWPF. Tank 40 began sending sludge to DWPF in 2002 and has been serving as the DWPF feed tank since that time. [SRR-LWP-2012-00061] Tank 40 has received zeolite material from both Tanks 42 and 51. [CBU-PIT-2005-00099]

Tank 41 was constructed between 1976 and 1980 and entered service in 1981 as a receipt tank for supernate from Tank 38. The largest volume of waste stored in Tank 41 has been approximately 1,281,000 gallons. [WSRC-RP-91-78-8B] As of April 2, 2012, Tank 41 contained approximately 516,000 gallons of supernate, 2,670 gallons of sludge and 488,000 gallons of saltcake. [SRR-LWP-2012-00029] In 1981, Tank 41 received concentrated supernate from Tank 38. From 1982 through 1987, Tank 41 served as a concentrate receipt tank for the 242-16H evaporator. In 2002, salt removal efforts in Tank 41 were initiated to prepare low-level waste feed for the Saltstone Production Facility (SPF). Tank 41 supernate was transferred to Tank 49 and, interstitial liquid was removed from Tank 41 and transferred to Tanks 49 and 39. Salt dissolution activities were performed in Tank 41 in 2005 and again in 2008. The salt solution from the Tank 41 saltcake removal campaigns was eventually transferred to the SPF as low-level waste having been treated by the DDA process. In 2008, Tank 41 began receiving salt solution from salt removal activities in Tank 25 in support of ARP/MCU Interim Salt Processing.[26] [SRR-LWP-2012-00061]

Tank 42 was constructed between 1976 and 1980 and entered service in 1982 primarily as a receipt tank for sludge slurry from sludge removal campaigns in Tanks 15, 24, 18 and 21. The largest volume of waste stored in Tank 42 has been approximately 1,278,000 gallons. [LWO-PIT-2006-00063] As of April 2, 2012, Tank 42 contained approximately 371,000 gallons of supernate and 17,600 gallons of sludge. [SRR-LWP-2012-00029] From 1982 through 1986, Tank 42 served as a receipt tank for sludge slurry from sludge removal campaigns in Tanks 15, 24, 18 and 21. In addition, Tank 42 was equipped with a cesium removal column used to remove cesium from the evaporator overheads and, from 1982 to 1990,

[26] A description of Interim Salt Processing is provided in Appendix A of this Draft HTF 3116 Basis Document.

received approximately 5,100 gallons of spent zeolite. [CBU-PIT-2005-00099] During this time period, and continuing until 1993, supernate was transferred out of Tank 42 to several waste tanks. From 1996 to 1999, Tank 42 supported the sludge batch preparation process by sending sludge slurry to Tank 51. Tank 42 was mostly idle until it was used to support various Liquid Waste program initiatives and the 242-25H evaporator from 2004 through 2006. In 2011, Tank 42 began to support sludge batch preparation and other waste removal initiatives. [SRR-LWP-2012-00061]

Tank 43 was constructed between 1976 and 1980 and entered service in 1982 as the 242-16H evaporator feed tank. The largest volume of waste stored in Tank 43 has been approximately 1,260,000 gallons. [CBU-SPT-2003-00181] As of April 2, 2012, Tank 43 contained approximately 690,000 gallons of supernate and 234,000 gallons of sludge. [SRR-LWP-2012-00029] Tank 43 entered service in 1982 as the 242-16H evaporator feed tank, and it continues to serve in that capacity today. From 1982 until the startup of DWPF in 1996, Tank 43 received material from various waste tanks, the 299-H maintenance facility and low-heat waste from the HM process. From 1996 until the present time, the 242-16H evaporator system (Tanks 43 and 38) has primarily supported the DWPF facility by volume reducing the DWPF recycle stream sent to HTF. Initially the DWPF recycle stream was sent directly to Tank 43; however, due to complications with processing this material in the 242-16H evaporator, the DWPF recycle stream was redirected to Tanks 21 and 22 beginning in 1999 to allow for solids settling to occur. Transfers from Tanks 21 and 22 to Tank 43 are periodically made to support the 242-16H evaporator and DWPF. [SRR-LWP-2012-00061]

Tank 48 was constructed between 1978 and 1981 and entered service in 1983 as part of the ITP project demonstration. The largest volume of waste stored in Tank 48 has been approximately 483,000 gallons. [WSRC-RP-95-841-6] As of April 2, 2012, Tank 48 contained approximately 251,000 gallons of supernate. [SRR-LWP-2012-00029] In 1983, cold chemicals were added to Tank 48 prior to receiving a transfer of salt solution from Tank 24. The initial batch of material in Tank 48 formed the base to conduct the ITP project demonstration. During the demonstration, a portion of the Tank 48 waste was treated via the ITP process and transferred to Tank 49. The ITP project ultimately was discontinued. Due to the residual organics that remained in Tank 48 after the demonstration project, Tank 48 has strict restrictions on what additions can be made to the waste tank. Tank 48 remains in this status at the present time while processes are being developed to disposition the contents of Tank 48. [SRR-LWP-2012-00061]

Tank 49 was constructed between 1978 and 1981 and entered service in 1983 as part of the ITP project demonstration. The largest volume of waste stored in Tank 49 has been approximately 1,236,000 gallons. [SRR-LWP-2011-00001] As of April 2, 2012, Tank 49 contained approximately 533,000 gallons of supernate and 300 gallons of saltcake. [SRR-LWP-2012-00029] In 1983, Tank 49 received two transfers of ITP washed precipitant during the ITP project demonstration. The ITP project ultimately was discontinued. Due to the residual organics that remained in Tank 49 after the demonstration project, Tank 49 had strict restrictions on what additions could be made to the waste tank. Tank 49 remained idle until 2001 when the residual waste from the ITP project demonstration was dispositioned. In 2005, Tank 49 received salt solution from salt dissolution activities performed in Tank 41. The salt solution from the Tank 41 saltcake removal campaigns was eventually adjusted with other tank farm material and transferred, via tank 50, to the SPF in 2007 and 2008 as low-level waste after having been treated by the DDA process. In 2009, Tank 49 became the batch feed tank for ARP/MCU Interim Salt Processing.[27] [SRR-LWP-2012-00061]

Tank 50 was constructed between 1978 and 1981 and entered service in 1983 as part of the ITP project demonstration. The largest volume of waste stored in Tank 50 has been approximately 1,232,000 gallons. [SRR-LWP-2012-00025] As of April 2, 2012, Tank 50 contained approximately 1,180,000 gallons of supernate. [SRR-LWP-2012-00029] In 1983, Tank 50 was placed into service as the feed tank for the SPF as part of the ITP project demonstration and, received approximately 518,000 gallons of ITP decontaminated salt solution during the demonstration. The ITP project ultimately was discontinued. In 1988, Tank 50 began receiving ETF evaporator bottoms for final disposition to the Saltstone Disposal Facility (SDF) and, continues to serve as the feed tank for low-level waste streams being transferred to the SPF for final disposition. In addition to the ETF low-level waste stream, Tank 50 has processed other low-level waste streams to SDF such as ITP project demonstration material from Tank 49, DDA material

[27] A description of Interim Salt Processing is provided in Appendix A of this Draft HTF 3116 Basis Document.

originating from Tank 41, low-level waste streams from H-Canyon and decontaminated salt solution from ARP/MCU Interim Salt Processing. [SRR-LWP-2012-00061]

Tank 51 was constructed between 1978 and 1981 and entered service in 1986 as a receipt tank for sludge slurry from sludge removal campaigns in Tanks 18, 21 and 22. The largest volume of waste stored in Tank 51 has been approximately 1,257,000 gallons. [MO-RPT-87-FEB2_p4] As of April 2, 2012, Tank 51 contained approximately 788,000 gallons of supernate and 24,700 gallons of sludge. [SRR-LWP-2012-00029] From 1986 through 1993, Tank 51 served as a receipt tank for sludge slurry from sludge removal campaigns in Tanks 18, 21 and 22 and, in addition, received transfers from Tanks 40 and 42. From 1996, when DWPF started up, until 2001, Tank 51 served as the feed tank for DWPF, the DWPF feed tank role was switched to Tank 40 in 2001. Tank 51 began to collect sludge slurry transfers from a variety of waste tanks to support future sludge batch preparation and remains in this role presently. [SRR-LWP-2012-00061] Tank 51 has received zeolite from Tank 42 and FTF Tank 7. [CBU-PIT-2005-00099]

2.3 Waste Removal Approach for Waste Tanks, Annuli and Ancillary Structures

The closure process for the tank systems begins with removing the waste using mechanical, chemical, and/or vacuum waste removal techniques, or other methods of comparable or greater effectiveness, discussed below.

Bulk waste removal is the first step toward waste tank closure and typically employs agitation/mixer pumps to suspend solids and potentially dissolve soluble material. If the tank contains saltcake, then well water, DWPF recycle or chemically treated water is added to dissolve the waste which results in a considerable impact to the tank farm waste storage space. In order to make the salt mobile for transferring and to adjust the salt concentrations (molarity) for processing and disposal, significant quantities of dissolution liquid must be added. [DOE-WD-2005-001] Bulk sludge and/or salt waste is transferred from the tank, leaving behind a heel.

Mechanical heel removal employs techniques such as agitation, spraying, lancing, pulse jet mixing, vacuum retrieval, mechanical manipulators, robotic devices or recycle systems to augment existing waste removal equipment to reduce the heel volume. These technologies are described in Section 2.3.2.

Chemical heel removal employs oxalic acid or other specialized chemical treatment of the heel to dissolve solids. The oxalic acid may be sprayed into the tank to clean contaminants from the internal tank surfaces (e.g., walls, cooling coils, support columns, equipment), as practical.

If necessary, at the conclusion of chemical heel removal, the interior of the waste tank may be washed with water to rinse oxalic acid from internal surfaces and dislodge loose contamination. The wash water will then be removed.

For waste tanks that have leaked waste from primary to secondary containment, waste may be removed as applicable from the annulus as described in Section 2.3.6.

Waste tank, annulus and ancillary structure cleaning is subject to a variety of operating constraints including:

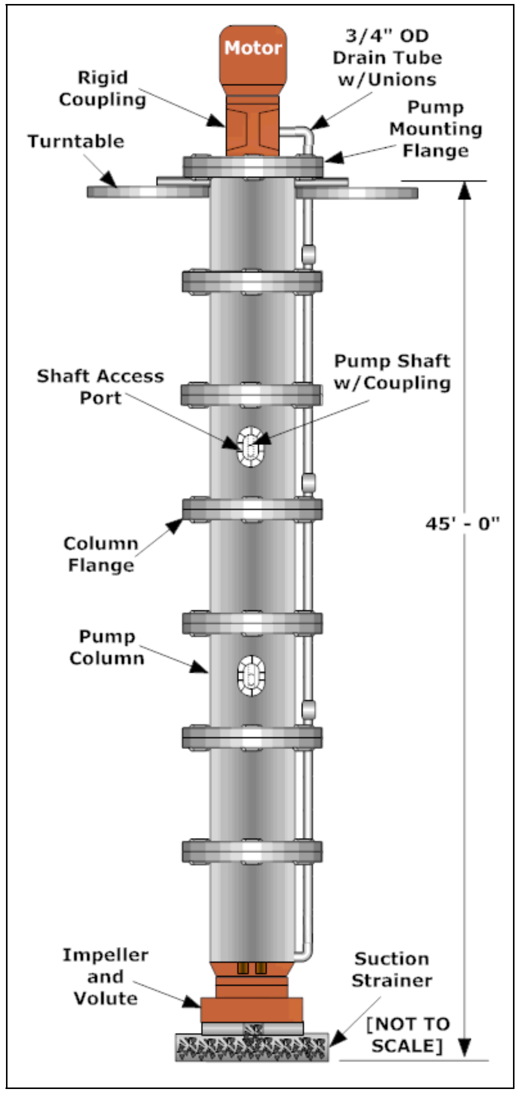
- maintaining emergency tank space,
- meeting safety basis requirements,
- controlling tank chemistry and radionuclide inventory,
- requirements to remove waste from tanks with a leakage history and tanks that do not meet secondary containment and leak detection requirements, and
- preparing waste for downstream waste treatment facilities.

The complex interdependency of safety and process requirements of the various Liquid Waste facilities drive the sequencing of the tanks undergoing waste removal and tank cleaning. Plans for bulk waste removal, mechanical, chemical and vacuum cleaning and tank closure are summarized in the *Liquid Waste System Plan*. [SRR-LWP-2009-00001] See Section 1.3 for discussion on the closure schedule.

2.3.1 Tank Waste Removal History

Early waste removal efforts at SRS (1960s) employed hydraulic mining and sluicing techniques using once-through water at high pressure. The practice was discontinued because insufficient tank storage space was available to accommodate the large volume of water added to the tank farm system. The technique was modified to use existing waste supernate as the slurry liquid media and slurry pumps for breaking up and suspending the sludge. Using this technique, several slurry pumps are installed in the waste tank being cleaned in lieu of the external pumps formerly used. This change allows the slurrying operation to be repeated as often as necessary to suspend the sludge without adding significant new waste volume to the tank farm. Figure 2.3-1 presents a typical standard slurry pump design. A slurry pump is a vertical shafted centrifugal pump with the drive motor mounted topside. A coupled shaft connects the motor and pump. Suction is drawn into the pump and discharged from two nozzles (aimed in opposite directions from each side of the pump). The nozzles are shaped such that high velocity jets are ejected into the liquid. The pump rotates on a turntable, thereby allowing the jets to spin in the horizontal plane if desired. The pumps are typically installed in available risers such that the circular pattern of suspended solids, or effective cleaning radius, of each individual pump overlaps with the adjacent pump to maximize effectiveness. The initial elevation of the pump suction is typically positioned just above the sludge layer. Water may be added to the tank if there is not enough supernate to use as the slurry media. The pumps typically suspend sludge that can be suspended (at that slurry pump elevation setting) within a few days. The slurry pumps are then lowered typically in 10- to 17-inch increments, more water is added, if needed, and the next layer of sludge is suspended. This process is repeated until the slurry pumps are at the lowest elevation practical, typically 10 inches above the waste tank floor. The transfer pump is then lowered to the desired elevation, typically 6 inches above the tank floor. Interferences in the waste tanks such as "field to fit" horizontal cooling coils may limit the depth to which individual pumps may be lowered.[28] The sludge slurry is then transferred out of the tank. To obtain the proper weight percent of suspended solids in the resulting sludge batch, more than one transfer may be required. Examples of HTF tanks in which this technique has been successfully used for bulk sludge removal include Tanks 11, 12, 13, 15, 16, 21, 22 and 42. [HLW-2002-00025]

Figure 2.3-1: Typical Standard Slurry Pump



[WSRC-TR-2001-00313]

Slurry pumps have also been used for bulk waste removal in tanks containing saltcake. To remove saltcake, the pumps are positioned just above the saltcake and water is added to the tank. The water is stirred by the pumps to dissolve the top layer of saltcake. Once the resulting solution becomes nearly saturated with dissolved salt it is transferred out of the tank. The slurry pumps are then lowered, water is added and the process is repeated. In HTF, this technique has been successfully used for bulk salt removal in Tank 24. [HLW-2002-00025]

Saltcake can also be dissolved without agitation. To dissolve the saltcake and create salt solution batches, the waste tank

[28] Location and spacing of vertical and horizontal cooling coil loops are specified on waste tank drawings. However, the location and routing of supply and return piping for the cooling coil loops was left to the discretion of the construction crews during installation.

is filled with dissolution liquid, which, if necessary, is water chemically treated to prevent corrosion of the carbon steel waste tanks, until the saltcake surface is flooded. The dissolution liquid dissolves a portion of the saltcake forming a salt solution. The salt solution is then transferred out of the tank. In HTF, this process has been used for saltcake removal in Tanks 10, 22, 37 and 41. [HLW-2002-00025]

Processing the salt waste requires significant available waste tank space. To make the salt mobile for transferring and to adjust the salt concentrations (molarity) for processing and disposal, significant quantities of dissolution liquid must be added. Type III/IIIA tank space must be available for receiving and adjusting these solutions.

2.3.2 Waste Removal Technologies

Slurry pumps previously installed in HTF waste tanks may continue to be used in waste removal activities. For example, HTF Tank 12 underwent bulk waste removal efforts utilizing standard slurry pumps. The slurry pumps installed in Tank 12 continue to be used to support heel removal activities being performed within the waste tank. [SRR-LWE-2012-00059] In addition, a new generation of waste removal equipment has been developed and are available as described in the following subsections.

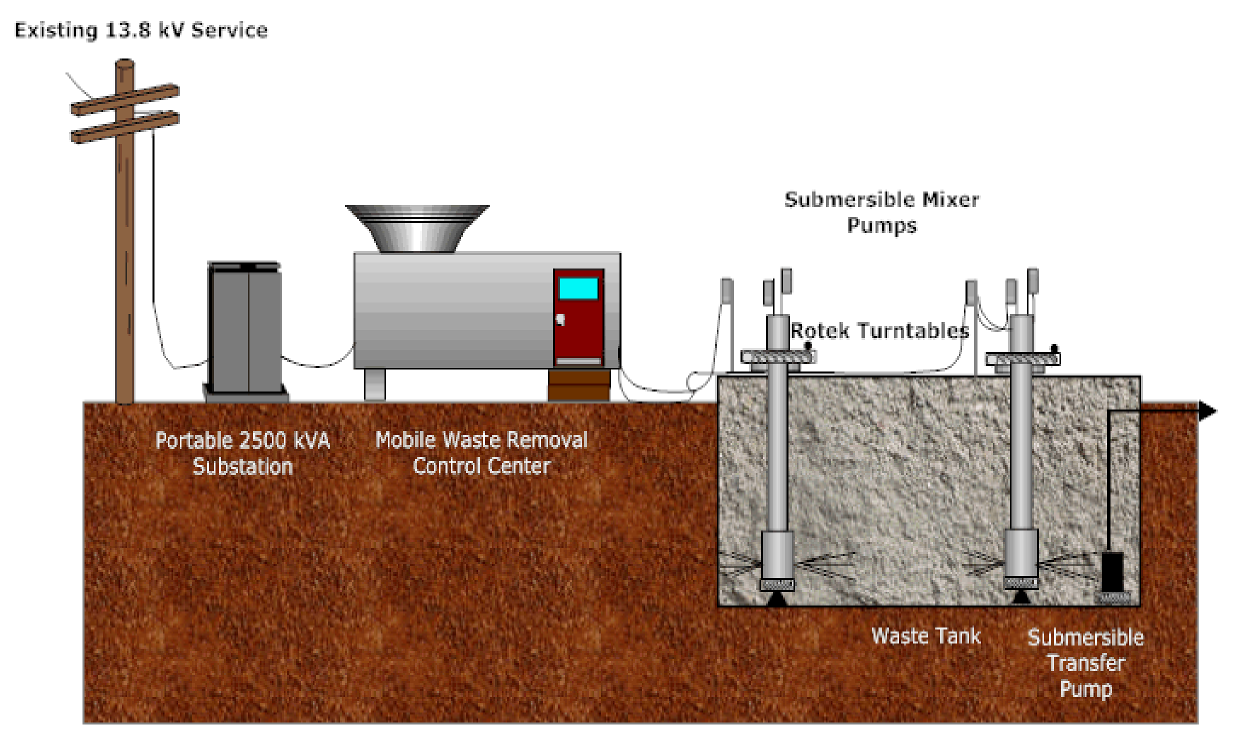
2.3.2.1 Submersible Mixer Pumps - Type I, II and III and IIIA Tanks

In 2003, SRS used a systematic process to identify, evaluate and select equipment for waste removal tasks to accelerate clean up. This process is documented in a Systems Engineering Evaluation. [G-ESR-G-00051] The study investigated options for bulk waste mixing, waste transfer and heel removal. The study graded the options on weighted selection criteria such as technical maturity, effectiveness, reliability, reusability, radiological control requirements, integration with the tank farm system and cost. Knowledgeable tank farm operations, engineering, plant support and maintenance personnel identified potential technology candidates based on experience, literature, world wide web research and contacts with other knowledgeable personnel in the DOE complex and commercial industry.

The team recommended using floor-mounted canned Submersible Mixer Pumps (SMPs) for bulk waste mixing, a mast-mounted Submersible Transfer Pump (STP) for waste transfer, chemical cleaning using oxalic acid for final heel removal and an air-driven submersible pump to enhance final heel removal if centrifugal STPs are insufficient to remove the final residual material. The technology consists of a mobile substation that provides power, a Mobile Waste Removal Control Center that provides local control and monitoring capabilities, SMPs for mixing and suspending waste solids and an STP for waste transfer. These mobile units have the capability of being co-located near any tank or tanks scheduled for waste removal. This concept efficiently performs waste removal using mobile and reusable equipment (Figure 2.3-2).[29] [G-ESR-G-00051]

[29] Figure 2.3-2 depicts two SMPs located in the waste tank, however, during actual cleaning operations DOE may deploy from one to four SMPs within a waste tank based upon the particular waste tank configuration and waste characteristics.

Figure 2.3-2: Submersible Mixer Pump Waste Removal Diagram



To date, the SMPs have been used to support bulk waste removal efforts on HTF Tank 13 and FTF Tanks 4, 5 and 6[30] and support mechanical and chemical cleaning of residual heels in Tanks 5 and 6. The SMPs are variable speed, single-stage centrifugal pumps with a 305-horsepower motor that can operate up to 1,600 revolutions per minute. The SMPs utilize the tank liquid waste to cool the motor and lubricate the upper and lower bearings. Two discharge nozzles give the SMPs the capability to produce an effective cleaning radius of up to 50 feet. The SMPs are rotated by a turntable assembly that provides the motive force for oscillation, or allows for stationary indexing operation. The SMPs have a rotating foot attached to the lower end of the pump, which allows the SMP to rest on the tank floor and oscillate. [M-CLC-G-00349]

Waste transfers during HTF Tanks 11 and 12, and FTF Tanks 4, 5 and 6 bulk waste removal, as well as Tanks 5 and 6 mechanical cleaning were achieved by using a STP. In addition, current bulk waste removal efforts in HTF Tank 13 and heel removal activities in HTF Tank 12 are utilizing STPs. The STP is a 15 horsepower, 3,450 revolutions per minute, 250 gallons per minute centrifugal pump that has the capability of being located at any elevation within the waste tank. The pump is typically located inside a 22-inch diameter sleeve pipe (caisson) that rests on the tank floor. The caisson protects the STP from direct discharge from the SMPs. Pump configurations are shown in Figure 2.3-3 and Figure 2.3-4.

[30] Discussion on Tanks 4, 5 and 6 cleaning is included for information; however, Tanks 4, 5 and 6 are located in the FTF at SRS and are not within the scope of this Draft HTF 3116 Basis Document.

During waste removal supported by SMPs, supernate may be used as the slurry media to minimize the amount of water added to the tank farm system. Minimization of water additions to the tank farm is important because water introduced into a waste tank becomes additional waste that occupies the limited available waste storage space and must be ultimately treated and disposed of. The SMPs are operated using various strategies depending on the configuration of the waste in that particular tank. To keep the solids suspended in the slurry, mixing continues as long as possible while the slurry is transferred out of the tank. The SMPs are required to be shut down as the liquid level approaches the elevation of the discharge nozzles to prevent waste spraying, which may cause filters in the tank ventilation system to become inoperable and cause potentially high exposure to workers. Typically, the STP continues to operate until it loses the ability to pump out any additional waste. After the transfer, the residual solids configuration and volume are assessed based on the condition of the waste remaining in the tank. Liquid may be transferred back into the waste tank for additional mixing and transfer cycles.

Figure 2.3-3: Submersible Mixing Pump and Submersible Transfer Pump

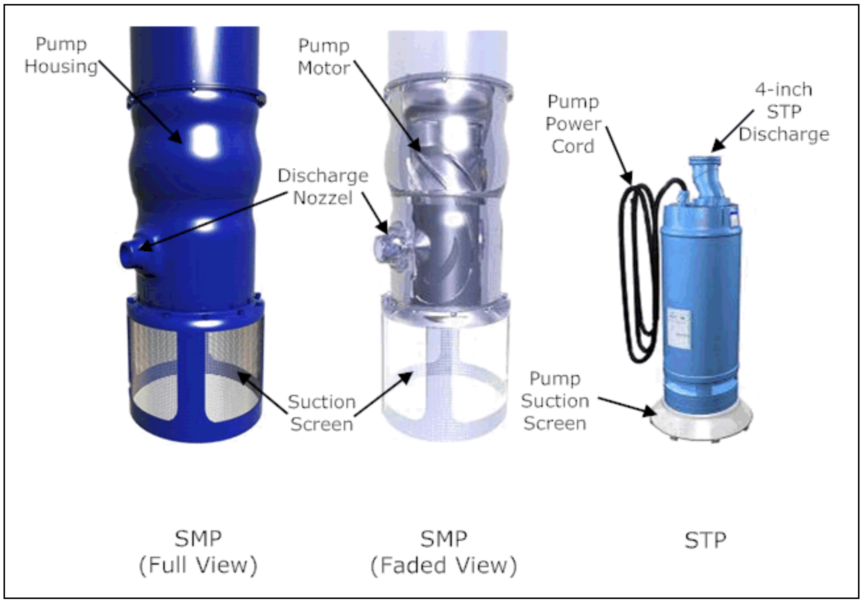


Figure 2.3-4: Submersible Mixing Pump in a Test Tank

2.3.3 Chemical Cleaning

Chemically-aided cleaning techniques have been evaluated for additional levels of waste removal following mechanical heel removal. A team of knowledgeable and experienced engineers and scientists assessed the current knowledge base and collected and evaluated information available on chemical-based methods for removing residual solids from the waste tanks. [WSRC-TR-2003-00401] As part of this study, the team developed recommendations for chemical treatments to remove residual solids. The cleaning agents identified included:

- oxalic acid,
- a mixture of oxalic acid and citric acid,
- a combination of oxalic acid with hydrogen peroxide,
- nitric acid,
- formic acid, and
- organics.

The results of the evaluation support oxalic acid as the optimal chemical cleaning agent. Nitric acid, formic acid and oxalic acid with hydrogen peroxide were all closely grouped for the next best choice. The mixture of oxalic acid and citric acid rated poorly (primarily due to the fact that it performed less well than oxalic acid and the presence of citrate could adversely impact downstream operations, such as the SWPF and the DWPF). Organics rated even more poorly due to large uncertainties in performance and downstream impacts.

The use of oxalic acid was recommended for a number of reasons. First, oxalic acid has been widely studied and used several times to clean waste tanks at SRS and at other sites within the DOE Complex. Second, the oxalic acid has been shown to be effective for a wide variety of sludge types and out-performed nitric acid and other chemical cleaning agents in head-to-head tests. Lastly, oxalic acid is less corrosive to the carbon steel tank than nitric acid or a combination of oxalic acid and hydrogen peroxide. [WSRC-TR-2003-00401]

Chemical cleaning using bulk oxalic acid is the method currently being considered for heel removal in HTF waste tanks, as appropriate. However, other cleaning solutions or methods may be used if they have comparable or greater effectiveness. The contemplated chemical cleaning methods are similar to bulk oxalic acid cleaning methods used in HTF Tank 16 and FTF Tanks 5 and 6, consisting of several oxalic acid strikes, use of agitation to facilitate particle-acid contact and a final clean water mixing operation. As appropriate, oxalic acid could be sprayed into the tank to clean contaminants from internal tank surfaces (e.g., walls, cooling coils, support columns, equipment, etc.).

Oxalic acid cleaning produces sodium oxalates in the solids slurry that will be added to sludge batches that feed the DWPF. Because of sodium limits and oxalate restrictions on the DWPF feed, preparation of the feed results in a significant amount of additional material being generated that eventually must be processed through SWPF and disposed of in the SDF.[31] Therefore, the oxalic acid flowsheet evaluations have considered the effects of oxalates on DWPF and salt processing to optimize the quantities of oxalic acid introduced into the Liquid Waste System. [WSRC-TR-2004-00317] Due to the downstream effect of oxalic acid on DWPF and salt processing, the selection of a chemical cleaning method will be considered on each individual application basis. Environmental conditions to which the waste has been exposed also affect its dissolution characteristics; therefore, in future chemical cleaning planning, each waste tank (or groups of tanks with similar waste and similar historical conditioning) will be considered individually.

Another example of a chemical cleaning method is Low Temperature Aluminum Dissolution which DOE has deployed at HTF to help remove residual solids. This methodology was utilized to help reduce the solids volume in Tank 12. [X-CLC-H-00921] Under this process, aluminum is dissolved from sludge waste into the supernate by treatment with caustic, followed by decantation and water washing to subsequently remove aluminum. Aluminum solids in the sludge are believed to be present in primarily three compounds – aluminum trihydrate or gibbsite, alumina monohydrate or boehmite, and aluminosilicate. With caustic treatment, the gibbsite form dissolves readily at the relatively low dissolving temperatures possible in the waste tanks. The boehmite form dissolves much more slowly and is somewhat less soluble than gibbsite, but can still be dissolved at relatively low temperatures, given enough time. The aluminosilicate has such a low solubility in waste slurries that it is generally considered insoluble. [SRNS-STI-2008-00021]

2.3.4 Vacuum Heel Removal Cleaning

As the result of a March 2006 DOE-sponsored Tank Cleaning Technical Exchange, a new vacuum technology was identified. The DOE has adapted and successfully used this new technology in the unobstructed Type IV tanks, Tanks 18 and 19,[32] located at SRS FTF. To deploy this technology in Tank 18 and Tank 19, DOE utilized a cleaning device, called a Mantis, which consists of a mechanical crawler and an eductor assembly that made up a retrieval system utilizing an ultra-high-pressure water eductor to vacuum residual solids and transport the slurry to a receipt tank (Figure 2.3-5). The process system consists of a remotely controlled, in-tank Mantis, an umbilical hose containing hydraulic supply lines and the high-pressure water hoses, in-tank waste retrieval hose, a diesel-driven ultra-high-pressure water pump, a motor-driven high pressure water pump, hydraulic pump skid, a diesel generator, above-ground hose-in-hose transfer lines, Waste Mixing Chamber (WMC) and support equipment. The device was inserted into the tank through a 24-inch riser in a folded position. Once inside the tank, the device was unfolded into its operational configuration.

[31] See Appendix A for a brief description of DWPF, SWPF and SDF operations.
[32] Discussion of Tanks 18 and 19 is included for information regarding the use of the Mantis technology; however, Tanks 18 and 19 are located in FTF at SRS and are not within the scope of this Draft HTF 3116 Basis Document.

Figure 2.3-5: Mantis

The Mantis was remotely driven around the waste tank bottom by an operator located in the Control Center. A high pressure hydro-lance at its front was used to break up waste mounds and an eductor was used to vacuum waste from the floor of the waste tanks. The waste traveled through the eductor in-tank waste retrieval hose up into a tee spool piece located on top of the tank riser and then through an above-ground transfer line that terminated inside a WMC installed inside a riser on the receipt tank. An immersion mill, located near the bottom of the WMC, size-reduced solid waste particles so that the particles can be more easily re-suspended in future waste removal activities. [WSRC-TR-2007-00327]

The cooling coils in Type I, Type II, Type III and Type IIIA tanks precludes the use of large tethered mechanical crawlers such as the Mantis platform. However, DOE recognizes the potential for future use of vacuum technology deployed on other platforms specifically tailored for applications in tanks with obstructions.

2.3.5 Removal of Residual Waste from Failed Cooling Coils

DOE recognizes that some waste tank cooling coils have failed and that additional failures during waste removal are likely. Potential failure mechanisms include:

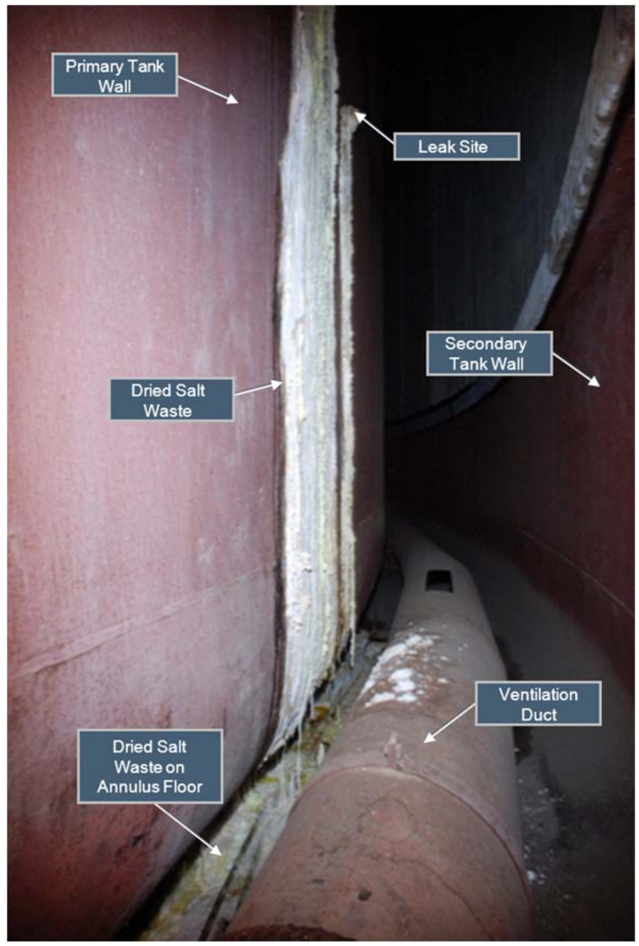
- pitting and cracking due to corrosion,
- cracking due to thermal expansion and contraction, and
- breaks due to forces imposed on the coils from mixer operation during bulk waste removal and heel removal.

Once a coil has failed, the coil may become internally contaminated with waste. Cooling coils with the potential for residual waste holdup will be flushed, as appropriate.

2.3.6 Annulus Cleaning

Currently, eight waste tanks in HTF have leak sites on the primary tank walls. The waste tanks include all of the Type I tanks (i.e., Tanks 9, 10, 11 and 12) and all of the Type II tanks (i.e., Tanks 13, 14, 15 and 16). [SRR-STI-2012-00346] To date, waste escaped to the surrounding soils once due to a leak site in a primary tank wall. This event occurred in 1960 and was associated with Tank 16. [DPSOX-5954] Details on the number of leak sites and volume of waste on the annulus floor for all of the HTF waste tanks is provided in the individual waste tank histories contained in Section 2.2.2.2 of this Draft HTF 3116 Basis Document. Figure 2.3-6 provides an example of an HTF waste tank with waste deposits on the exterior primary tank wall and Figure 2.3-7 provides an example of waste deposits on the annulus floor.

Figure 2.3-6: Waste Deposits on Exterior Primary Tank Wall Before Cleaning (Tank 12)



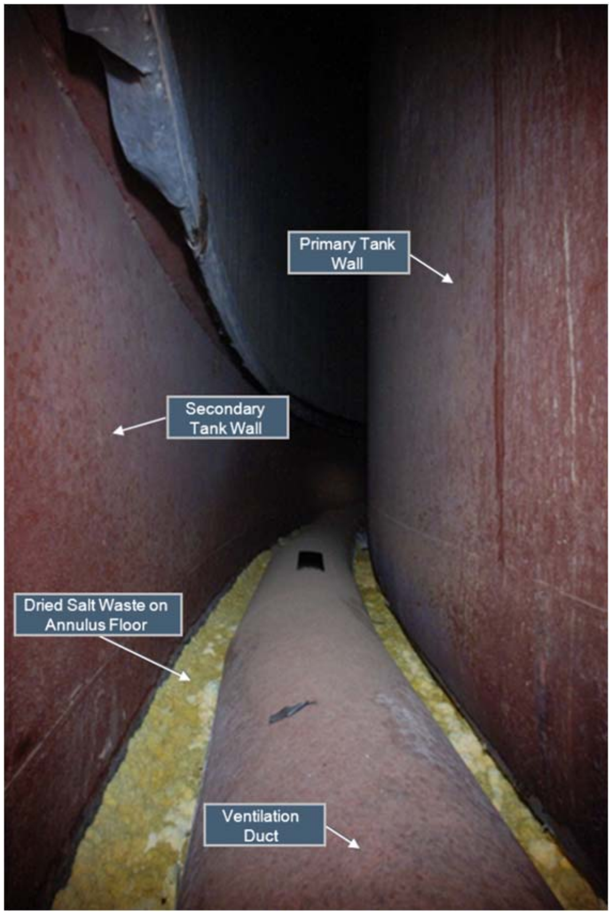
To date in HTF, waste removal activities on Tank 16 have included steps to remove material from the floor of the waste tank annulus. Annulus cleaning activities in Tank 16 were undertaken in the 1970's. The annulus historical maximum volume was 25,680 gallons. After liquids removal, approximately 6,000 gallons of solids remained in the annulus. The outside of the primary tank wall was sandblasted to facilitate leak site inspection and sand was introduced into the annulus. In 1976, vacuum operations removed some of the sand from the annulus. Water was introduced in the annulus to dissolve remaining solids and steam jets were used to increase the temperature and promote circulation. Approximately 1,400 gallons of additional material were estimated to have been removed from the annulus. [SRR-CWDA-2011-00126] In 2007, DOE investigated the potential use of vendor supplied robotic equipment to remove additional material from the Tank 16 annulus. [LWO-LWE-2007-00204] DOE is currently evaluating this technology and other alternate technologies to determine the practicality of additional waste removal from the Tank 16 annulus. For all HTF waste tanks, the annular regions of the waste tank will be inspected prior to ceasing waste removal activities to verify previously documented annulus conditions and determine if any additional leakage from the primary waste tank has occurred during the waste removal process. For those waste tanks with residual salt waste present in the annulus, the annulus of applicable HTF waste tanks will be cleaned to the extent practical.

2.3.7 Potential Future Waste Tank Cleaning Technology

DOE will continue to review and consider technological developments relevant to waste tank cleaning and will evaluate technologies of comparable, or greater, effectiveness than those discussed above.[33] A range of potential technologies for evaluation will potentially include proven technologies developed and/or used at other DOE sites, in domestic commercial industry and in international applications. Waste tank cleaning technologies that will potentially be evaluated include, but are not necessarily limited to, sluicing, mixing, chemical cleaning, vacuum retrieval techniques, mechanical manipulators, robotic

[33] Future technology selection and optimization will be informed by the results of the HTF PA and DOE will take into consideration specific technologies, with emphasis on HRRs, as described in Appendix B of this Draft HTF 3116 Basis Document.

Figure 2.3-7: Waste Deposits on Annulus Floor Before Cleaning (Tank 9)



devices and processes that remove (chemically extract) the radionuclides from the residual material that may remain in the tank.[34]

2.3.8 Ancillary Structures Cleaning

Ancillary structures are described in Section 2.1.12.

Flushing the transfer lines after use has long been practiced for waste transfers to prevent material build up within the systems. Transfer line core pipe flushing has been part of operations of the tank farms from at least the mid-1970s, and there is also indication that some level of flushing has always been a part of transfer system operations. The rigor to which flushing has been applied has increased over the years.

The SRS Tank Farm Transfer Control Program requires transfer line flushing based on two factors: 1) the radioactivity of the potential residual waste in the core pipe as indicated by the inhalation dose potential and 2) the potential for salt solids formation to cause pluggage in the core pipe. The inhalation dose potential criteria for flushing have recently been reduced from 9.8E+07 rem/gallon to 3.5E+07 rem/gallon. [WSRC-TR-2002-00403] Typically,[35] transfer line core pipe flushing based on potential residual material radioactivity is required within thirty days after completing a waste transfer. At least three line volumes of water are required to be flushed through the core pipe following a transfer identified to be a "sludge slurry transfer." Sludge slurry transfers are those transfers that may result in a one weight percent or greater, concentration of sludge during the transfer. Three line volumes at a normal flush water system rate is expected to dilute the sludge slurry by 99 %. At least one line volume of water is required following other types of transfers and for flushes required by potential salt solids formation. In addition to transfer line flushing based on the potential residual waste radioactivity and salt solids formation potential, transfer lines are also typically[36] flushed if there is a section of the transfer line that may not be self-draining (low point). [WSRC-TR-2002-00403]

Transfer lines may be cut and capped during the isolation and closure process for an associated waste tank. Typically,[37] the transfer lines will be flushed to remove contamination prior to cutting and capping as an as low as reasonably achievable (ALARA) practice to reduce the potential for worker dose. In summary, transfer line flushing is always performed when the transferred material meets the criteria for

[34] NRC has recommended that DOE continue to participate in technology exchanges and consider how to better assess and optimize the effectiveness of selected technologies. [ML112371715] DOE agrees with these recommendations and will continue to evaluate these areas under DOE Manual 435.1-1, pursuant to DOE's responsibilities under the Atomic Energy Act of 1954, as amended.
[35] Flushing will normally be carried out as described, however, there may be some instances in which flushing is not, or cannot, be performed. For example, if the time between multiple transfers is less than thirty days, flushing may not be performed until after the last transfer. Also, equipment issues could impact the ability to perform routine flushing following transfers. Similarly, although transfer lines would normally be flushed prior to cutting and capping, there may be instances where lines cannot be flushed due to such things as the condition of the transfer line or the transfer line configuration (e.g., no route for flushing liquid, no access to transfer line).
[36] See footnote 35.
[37] See footnote 35.

residual radioactivity or the criteria for salt solids formation. Additionally, transfer lines are typically[38] flushed if there is a low point in the transfer route and at other times to reduce potential worker dose.

In addition to operational practices of flushing, specific design practices have contributed to removing the waste from waste transfer line piping systems. The installation of stainless steel for the waste transfer core piping, the transfer piping sloping toward a waste tank with minimal valves and the layout of turn radii are specific design features that prevent waste accumulation in the piping systems.

Secondary containment (e.g., transfer line jackets, leak detection box encasements) is provided for transfer line core pipes. No leakage of waste from primary core pipes into secondary containment has been identified. Transfer lines currently in service are tested, or evaluated, as part of the Structural Integrity Program. [S-TSR-G-00001]. The structural integrity air or helium testing of transfer lines procedurally requires radiological surveys to check for indications of contamination. [SW10.6-SVP-5] This testing has not identified any significant contamination in HTF transfer line secondary containment. Therefore, no residual waste is expected in these structures at the time of closure.

As described in Section 2.1.12, there are three evaporator systems in HTF, the 242-H Evaporator System, the 242-16H Evaporator System and the 242-25H Evaporator System. The 242-H evaporator and associated concentrate transfer system were shutdown in 1994. [HLW-2002-00025] The 242-16H and 242-25H Evaporator Systems remain operational.

The final residual levels in the three HTF Evaporator Systems are expected to be comparable to the residual levels achieved in the 242-F Evaporator System due to similar design, operational histories, and comparable cleaning techniques. The SRS FTF 242-F evaporator and associated concentrate transfer system were shut down in 1988. Various waste removal campaigns were completed in 1991, 1992 and again in 2004. During the 2004 waste removal campaign, various mixing and transfer cycles were performed in the evaporator vessel and concentrate transfer system waste tank. Following the 2004 waste removal campaign, the evaporator vessel and the concentrate transfer system tank were inspected and the contents were sampled and characterized. [CBU-LTS-2004-00078]

There are nine stainless steel pump tanks in HTF: HPT-2 through HPT-10. There is a single catch tank in HTF designed to collect drainage from HDB-1 and the Type I tank transfer line encasements. These stainless steel tanks are accessible for waste removal. [SRR-CWDA-2010-00023]

Prior to closure, secondary containment structures (e.g., pump pits, diversion boxes, leak detection boxes, modified leak detection boxes and valve boxes) will be inspected and exposure to waste over their service life determined. The pump pits are shielded reinforced concrete structures located below grade at the low points of transfer lines and are lined with stainless steel. These structures are secondary containments that house the pump tanks. The diversion boxes are shielded reinforced concrete structures containing transfer line nozzles to which jumpers are connected to direct waste transfers to the desired location. The majority of the diversion boxes are located below ground and are either stainless steel-lined or sealed with waterproofing compounds. Valve boxes provide secondary containment for valves and transfer line jumpers to facilitate specific waste transfers. The valves are generally manual ball valves in removable jumpers with flush water connections on the transfer piping. Since these structures do not provide primary containment, they are expected to contain only incidental radionuclide contamination at the time of closure. [SRR-CWDA-2010-00128]

2.4 Radionuclide Inventory in H-Tank Farm Facility Systems, Structures and Components

Minimal quantities of residual material are expected to remain in HTF at the time of closure following waste tank and ancillary structures cleaning activities. Data developed for the HTF PA, Revision 1,[39] provided the estimated HTF residual radionuclide inventory used in this Draft HTF 3116 Basis Document. [SRR-CWDA-2010-00128] Estimated radionuclide concentrations used to develop the HTF PA, Revision 1, residual radionuclide inventory were determined by three methods:

[38] See footnote 35.

[39] Unless otherwise noted, the information in Section 2.4 and subsequent Sections 2.5 and 2.6 is based on information developed in support of the HTF PA, Revision 1. As required by DOE Manual 435.1-1, maintenance of the HTF PA will include future updates to incorporate new information, updated model codes, analysis of actual residual inventories, and other information as appropriate. [SRR-CWDA-2010-00128]

- sample analysis
- process knowledge data maintained in a controlled database (WCS)
- special analysis

The inventory of each waste tank was used to establish the characterization of the estimated residual material in the ancillary structures and was decayed to year 2032.[40] These estimates should not be considered limits associated with future cleaning activities nor should they be considered binding estimates. The following subsections describe the process for estimating residual material inventory at closure for the HTF waste tanks and ancillary structures, as provided in the HTF PA, Revision 1. [SRR-CWDA-2010-00128]

2.4.1 Residual Inventory for Waste Tank Primary Tanks

A methodical approach was used to construct reasonably conservative estimates of HTF waste tank closure inventories to be used in performance assessment modeling. Independent steps were developed to systematically construct the estimated HTF tank inventories, with each step adjusting inventory either by tank or by radionuclide. The steps used in inventory development were as follows.[41] [SRR-CWDA-2010-00023]

1. The initial list of radionuclides to be included in the HTF tank inventories was established. This list was developed beginning with an initial listing of 849 radionuclides compiled from a variety of published resources including those from Tables 1 and 2 of 10 CFR 61.55. [CBU-PIT-2005-00228]

2. The contaminant screening process consisted of several steps to arrive at an appropriate list of 54 isotopes to be included in the HTF waste tank closure inventory estimates to be used in the HTF PA modeling. This initial screening process considered the following information:
   - Physical properties of each radionuclide such as half-life and decay mechanism,
   - Waste source and handling based on radionuclide production mechanisms and time since the radionuclide was produced, and
   - Screening factors for radionuclide ground disposal developed in NCRP-123 which convert a quantity of each radionuclide to a dose.

   This initial screening reduced the radionuclide list from 849 down to 159 radionuclides. [CBU-PIT-2005-00228]

   Additional screening of the 159 radionuclides was performed to identify the radionuclides, from this list of 159, to be considered in the initial HTF PA inventory. The screening criteria included the following:

   - Radionuclides were screened out if there were no ancestors present from the specific decay chain or no decay source for the radionuclide.
   - Evaluation of HTF waste production history information for the potential for a specific radionuclide. This criterion screened out radionuclides not present within the HTF waste.
   - In general, radionuclides present only due to ingrowth from a decay series were screened out, however, production history was used to retain those radionuclides present at a greater proportion than from the decay series. This criterion eliminated radionuclides that are present only due to the decay of their parent radionuclide. The inventory of these radionuclides can be controlled by removing the parent radionuclide(s).
   - Radionuclides with less than a five year half-life were screened out. This criterion reflects that active institutional control will be maintained over the site for 100 years after facility closure. The inventories of these radionuclides will be significantly diminished due to the amount of radioactive decay that will occur during the 100-year institutional control period.

[40] The year 2032 corresponds to the year the HTF PA assumes, for the purposes of analysis, that a 100-year period of institutional control will begin.
[41] Removal experience in Tanks 5, 6, 18 and 19 was used to support development of the HTF PA residual inventory estimates; however, Tanks 5, 6, 18 and 19 are located in the FTF at SRS and are not within the scope of this Draft HTF 3116 Basis Document.

Based on these screening criteria, an additional 105 radionuclides were screened out, thus reducing the HTF PA modeling initial inventory radionuclide number to 54. [SRR-CWDA-2010-00128]

3. The concentrations for each of the 54 radionuclides were estimated by using the WCS database [DOE-WD-2005-001] or physical relationships. The WCS is an electronic information system that tracks waste tank data, including projected radionuclide inventories based on sample analyses, process histories, composition studies and theoretical relationships. The WCS, initially developed in 1995, and populated with historical information, tracks, among other things, the dry sludge concentrations of radionuclides in each of the SRS waste tanks. The primary purpose for developing WCS was to provide reasonable estimates on which to base safety analysis evaluations such as criticality issues in the tanks farms. Safety analysis evaluations, in general, build in a degree of conservatism, consequently, a level of conservatism for some materials is reflected in the data. The radionuclides tracked in the WCS were selected primarily based on their impact on waste tank safety basis source term, inhalation dose potential or on the E-Area Vault waste acceptance criteria (WAC). For the radionuclides with information available in WCS, the concentration was calculated by dividing the dry sludge activity by the corresponding settled sludge volume extracted from WCS.

   In the WCS, a subset of the HTF waste tanks required additional estimating where no input was available for various radionuclides. In addition, alternate methods provided estimates for additional radionuclides generated as activation products. Certain HTF waste tanks contain zeolite in addition to the sludge material. The estimated radionuclide concentration in Tanks 24, 32, 38, 40, 42 and 51 were adjusted to account for zeolite and corresponding captured cesium. Affected radionuclides and the methods used to estimate their concentrations are detailed in SRR-CWDA-2010-00023.

4. The estimated residual volume for the HTF waste tanks, for the purpose of developing the HTF PA inventory, was based on waste removal experience in Tanks 5, 6, 16, 18 and 19. Based on this experience, the projection for residual material volume remaining in the primary tank was conservatively estimated to be 4,000 gallons for each HTF waste tank with the exception of Tank 16. To provide a reasonably conservative estimate for Tank 16, 1,000 gallons was used as an estimate of residual volume in the primary tank.

5. To determine the initial radionuclide inventory estimates for each of the HTF waste tanks, the concentrations, discussed in Step 3 above, were multiplied by the residual volume estimates, discussed in Step 4 above, to determine the waste tank inventory for each of the radionuclides. The radionuclide inventories of residual liquid were assumed to be included in the final closure solids inventory as the residual liquid has typically evaporated by the time samples are taken from the waste tank.

6. Following the development of the initial inventory estimates, adjustments were made to add a reasonable conservatism to the inventory estimates. The steps outlined below summarize the adjustments made to the initial inventory estimates.

7. Allowing for a more efficient and cost effective means of confirming concentrations for radionuclides with a limited potential impact to dose, the inventories for these radionuclides were adjusted to either one curie or used an analytical detection limit. If the radionuclide initial estimated inventory was less than the detection limit, then it was adjusted up to the detection limit. However, if the radionuclide initial estimated inventory was at least at the detection limit, then it was adjusted up to one curie. Recent sample analyses from Tanks 5, 18 and 19 were reviewed for appropriate detection limits. [SRNL-STI-2012-00034, SRNL-STI-2010-00386, SRNL-STI-2010-00439] The adjustments to either the detection limit or to one curie exclusively increased residual inventory estimates. Inventory estimates were not adjusted lower, only higher, from the initial estimated inventory. Those radionuclides with initial estimated inventories of greater than one curie were not adjusted in this step.

   For those radionuclides that have been observed (through previous analyses or scoping studies) to have greater potential impact on the overall dose, if the initial estimated inventory was less than the detection limit the inventory was adjusted to the analytical detection limit. However, if the radionuclide initial estimated inventory was at least at the detection limit, then it was not adjusted further.

8. Based on the differences in concentrations observed due to the waste removal process in Tank 5, decreases in concentrations are anticipated for cesium, strontium and zirconium. [WSRC-STI-2007-00192, SRNL-STI-2009-00492] Based on this observation, all the waste tank inventories of these radionuclides were adjusted one order of magnitude lower to reflect the effect of the waste removal process.

9. Based on results from the Tank 5 inventory determination and FTF PA (SRS-REG-2007-00002), inventory estimates required adjustment for Tc-99 and Zr-93. For Tc-99, the initial estimated inventories were believed to be overly conservative. The FTF PA estimated inventory for Tc-99 was close to three orders of magnitude higher than the final inventory. To reduce the overestimate while maintaining a reasonably conservative inventory estimate for Tc-99, each waste tank's initial estimated inventory was reduced by one order of magnitude. In previous versions of HTF PA inventory estimates, Zr-93 inventory estimates were based on a detection limit value. In Tanks 5, 18 and 19, Zr-93 was measured. Therefore, a method to estimate Zr-93 inventories was needed. Using these sample results, Zr-93 was estimated by using a ratio to the Sr-90 concentrations due to similar fission yields.

10. The waste tanks were binned according to waste tank use and design. The tank type generally had an effect on the type of waste received and therefore guided the group selection. In general, each waste tank was built at approximately the same time as others of the same type. The bins for the waste tanks are presented in Table 2.4-1.

    Table 2.4-1: Waste Tank Groupings

Type I & II	Type III/IIIA	Type IV
9, 10, 11, 12, 13, 14, 15	29, 30, 31, 32, 35, 36, 37, 38, 39, 40 ,41 ,42, 43, 48, 49, 50, 51	21, 22, 23, 24

    Note: Tank 16 is a special case with its own grouping

    As each waste tank is cleaned, the waste removed from within the tank during waste removal will be transferred to other tanks. Due to transfer line configuration, the material in one tank will typically pass through other tanks of the same type prior to exiting the HTF. Due to the uncertain order of tank waste removal and closure activities, the maximum inventory concentrations associated with an individual tank within a tank group were applied to the other tanks within the bin. The maximum adjusted inventory, to this point, was used as the estimated inventory for all tanks within each waste tank group.

11. Within each waste tank group, for each of the radiounuclides, after adjusting the initial estimated inventories, as described above, the maximum radionuclide inventory for any one waste tank was used to estimate that radionuclides' inventory for the other waste tanks within the grouping. The one exception to this was that for adjustments to Pu-238 inventories within the Type III/IIIA tank group, the waste tanks were further grouped by salt and sludge tanks prior to making this adjustment.

    Based on experience with previous performance assessments, overestimating the Pu-238 inventories can ultimately exaggerate the projected overall dose due to the associated ingrowth of Ra-226. To reduce this exaggeration for the purpose of estimating Pu-238 inventories in the Type III/IIIA tanks, the grouping was split based on the two different waste types (salt and sludge).

At the completion of waste removal for each of the tanks, the estimated residual inventory identified for that tank in the HTF PA will be compared and evaluated against the actual residual inventory determined during final residual characterization after the tank has been cleaned. [SRR-CWDA-2010-00128] The actual residual inventory will be developed from a determination of the residual material volume combined with analytical data from a statistically based sampling program of the residual material. Additional information regarding the comparison and subsequent evaluation between estimated and actual residual inventories is provided in Appendix B.[42]

2.4.2 Residual Inventory for Tank Annuli

Wall inspections of the waste tanks have found cracks where material has seeped into the secondary containment or annulus. The amount of material contained in the waste tank's annulus has been estimated. Based on these estimates, inventories within the appropriate annuli were estimated.

To estimate each tank's annulus inventory, estimates of the residual volume and constituent concentrations were prepared.

Current estimates of the amount of material within the tank annuli were used to estimate the residual volumes at closure. [C-ESR-G-00003] The Type I and Type II tanks are known to have leak sites and material in their annuli. Type IV tanks do not have annuli and the Type III/IIIA tanks have no residual material within their annuli.

The amount of material currently in the Tank 16 annulus has been most recently estimated to be 3,300 gallons. [SRR-LWE-2012-00039] For other annuli with significant volume, this volume was also used. Except for Tank 16, the material in the annuli is expected to be highly soluble. This is due to the material originally being supernate that leaked into each annulus and dried. Therefore, the 3,300-gallon estimate for all other waste tanks is believed to be reasonably conservative. Tank 16 is expected to be an exception due to the mixture of silicon from sand blasting activities carried out in the Tank 16 annulus. This material is expected to limit the quantity of material removed or limit the practicality of waste removal from the annulus and, is therefore the reason to use the current volume estimate as the reasonably conservative estimate for the appropriate annuli volume.

For those waste tank annuli with a trace amount of material, a reasonably conservative volume of 100 gallons was used.

Characterization of the material within the various annuli is based on available samples taken from annulus material. Recently, samples were collected from the Tank 16 annulus. Four samples were taken at various locations within the annulus and numerous constituents analyzed. These sample results were used to inform the inventory estimates for the HTF waste tanks with annulus material. [SRNL-STI-2012-00178] For those constituents analyzed, the concentration reported provided the estimate of that constituent's concentration. Since the sample analysis did not include all constituents of concern, the remaining constituents were estimated, as explained below. The type of adjustment made to each radionuclide in the primary tank residual inventory estimate (see Section 2.4.1) determined the method to estimate each radionuclide's concentration for the associated annulus.

Those constituents, whose Tank 16 primary tank inventory was estimated by using detection limits (see Section 2.4.1), concentrations were estimated by taking a ratio of the primary tank residual volume estimate to the annulus residual volume estimate. For example, Cl-36 was estimated in the Tank 16 primary tank residual material via a detection limit; a ratio of the Tank 16 primary tank residual volume estimate (1,000 gallons) to the annulus residual volume estimate (3,300 gallons) multiplied by the primary tank residual inventory estimate was used to estimate the Cl-36 concentration in the annulus material.

For those constituents estimated in the Tank 16 primary tank via the unit curie adjustment methodology (see Section 2.4.1), a unit curie was also assigned to the annulus inventory. For example, Ac-227 was estimated in the Tank 16 primary tank inventory estimate at one curie. Therefore, the Tank 16 annulus inventory estimate of Ac-227 was also one curie.

For those constituents with sample analysis results or considered significant to dose analysis, concentrations were based on a ratio of a chemically similar element, within the analysis, and the applicable primary tank residual estimate. A ratio to the Pu-238 analysis was used for the radionuclides that would tend to be insoluble, while a ratio to the Tc-99 analysis was used for the more soluble

[42] DOE will continue to incorporate actual residual waste characterization information in special analyses to update the HTF PA, and explore appropriate methods to reduce uncertainty in the HTF PA, as part of the HTF PA maintenance process under DOE Manual 435.1-1, pursuant to DOE's responsibilities under the Atomic Energy Act of 1954, as amended.

components. For example, Am-241 was not analyzed in the Tank 16 annulus samples. Considering Am-241 can be significant to dose analysis, its annulus concentration was estimated by using the Pu-238 sample concentration and a ratio of the Am-241 to Pu-238 primary inventories. The Am-241 concentration in the Tank 16 annulus material was estimated by multiplying the Pu-238 annulus samples concentration by a ratio of the Am-241 Tank 16 primary tank inventory to the Pu-238 Tank 16 primary tank inventory.

The annulus inventories were estimated by multiplying the volume and concentration estimates. The decay date for these inventories is 2032.[43]

2.4.3 Residual Inventory for Type II Sand Layers

All Type II tanks have both a primary and secondary sand layer. The one-inch thick primary sand layer is between the primary tank and secondary liner and the one-inch thick secondary sand layer is between the secondary liner (annular pan) and the basemat. Due to the material that leaked from the Type II primary tanks into each tank's annulus, residual material has been assumed to be present within the respective sand layers. The sand layer inventories were estimated by multiplying the residual concentrations by the estimated residual quantity, as explained further below.

The residual material within the sand layer was assumed to have the same concentrations as determined for the annulus material (see Section 2.4.2).

The quantity estimate within the Type II tank sand layers was based on the operational history of each waste tank. For Tanks 14 and 16, a significant quantity of material leaked from the primary tank into the secondary containment and was sufficient to deposit material at a depth of several inches. For Tanks 13 and 15, a minimal quantity of material has leaked from the primary tank. This is based on the inspections of the annulus floor where negligible quantities of material have been observed. [SRR-CWDA-2010-00023]

The Type II tanks have a grout pad that surrounds the primary sand layers. This grout pad would limit the flow of material into the sand layer. The top part of the grout pad meets the bottom of the primary tank liner. For material to reach the primary sand layer, the liquid level in the annulus would need to be higher than the top part of the grout pad. In Tanks 13 and 15, since the quantity of material that leaked from the primary tank is limited, the amount of material that moved into the sand layer is considered negligible. Following the reasonably conservative approach, 100 gallons was assumed to be present within the primary sand layer for Tanks 13 and 15. For Tanks 14 and 16, the depth of material in the annulus suggests the possibility of material movement into the sand layer. It is thought that little liquid material moved into the sand layer due to the tight, although not sealed, fit between the grout pad and primary tank liner. However, to be reasonably conservative, the void space within these sand layers was estimated to be completely saturated with residual material. [SRR-CWDA-2010-00023]

The Type II tanks also have a secondary sand layer that is beneath the secondary liner or annulus. Tank 16 experienced the largest quantity of material leaving the primary tank and gathering in the annulus. In 1960, the level in the annulus was above the top of the 5 foot high annular pan, liquid was in direct contact with the concrete vault wall. Based on detailed analysis, it is estimated that tens of gallons escaped from the Tank 16 system and reached the surrounding soils. [DPSPU 77-11-17] For the purpose of this inventory evaluation, it is assumed that all of the material (26 gallons) that is estimated to have escaped the Tank 16 system entered the secondary sand layer below Tank 16. For Tanks 13 through 15, no material has leaked beyond the secondary containment; therefore, it is assumed that the secondary sand layers below these waste tanks contain no inventory. [SRR-CWDA-2010-00023]

The sand layer inventories were estimated by multiplying the volume and concentration estimates. The decay date for these inventories is 2032.[44] [SRR-CWDA-2010-00023]

[43] The year 2032 corresponds to the year the HTF PA assumes, for the purposes of analysis, that a 100-year period of institutional control will begin.

[44] The year 2032 corresponds to the year the HTF PA assumes, for the purposes of analysis, that a 100-year period of institutional control will begin.

2.4.4 Residual Inventory for Failed Cooling Coils and Internal Waste Tank Surfaces

When a solution is in contact with a solid phase, the constituents may partition between the liquid and solid. In the waste tank, liquid waste is in contact with corrosion products on the tank interior wall, so small quantities of radioactive material could be held on the corrosion products (i.e., iron oxides). [SRT-WPT-2005-00049]

The inventories for inside failed cooling coils and on the surface of the waste tank walls, cooling coils and columns are encompassed by the estimated total tank inventories. Cooling coils with the potential for residual waste holdup will be evaluated and flushed with water as appropriate. Flushing is expected to remove residual waste that may have entered damaged coils. The volume of cooling coils represents less than 1 % of the entire waste tank volume. [SRR-CWDA-2010-00023]

2.4.5 Residual Waste Inventory for Transfer Lines, Pump Tanks and Catch Tanks and Evaporator Systems

Ancillary structures include transfer lines, transfer line secondary containment, pump tanks, pump pits, the HTF catch tank, diversion boxes, valve boxes, concentrate transfer system tanks and the evaporator systems. Over the operating life of the facility, radioactive waste comes into physical contact with some of these components, contaminating them and hence, leaves contamination on the components. The degree of contamination depends on many factors, which include, but are not limited to, the service life of the component, the material of construction and the type of waste in contact with the component. Some of the listed equipment serves only as secondary containment and may not have contacted the waste. [SRR-CWDA-2010-00023]

Ancillary structures inventories are estimated for the following categories:

- transfer lines,
- pump tanks,
- concentrate transfer system tanks, and
- evaporator vessels.

To estimate the inventory associated with the transfer lines, pump tanks and concentrate transfer system tanks, the inventory of each waste tank is used to establish the characterization of the residual material in the ancillary structures. The results of a review of waste transfers within HTF and between FTF and HTF have been sorted to determine the percentage of the volume of all waste transfers that can be attributed to each HTF waste tank. The representative tank's concentration was then determined by applying a weighted average to each isotopic distribution in the HTF waste tanks. The characterization of dry sludge was used for each waste tank for conservatism. It is important to note that while the sludge concentrations were used, dry sludge is only a small portion of the total waste that passes through the transfer lines that are routinely flushed with a high volume of supernate. Using the dry sludge concentrations provides a conservative representation of the actinides and long-lived isotopes. The short-lived isotopes, which are more concentrated in the supernate than the sludge, will have decayed significantly during the 100-year active institutional control period and are not expected to be a significant portion of the residual material in the ancillary structures. [SRR-CWDA-2010-00023]

To estimate the residual inventory associated with the HTF evaporators, sample characterization from the FTF 242-F Evaporator System was used. At this time, no residual sample characterization (i.e., after waste removal) exists for any of the HTF evaporators but, based on the similarities of evaporator designs and the anticipated similarities between evaporator flushing and cleaning techniques, the final residual source term is not expected to differ significantly from the 242-F system.

2.5 Residual Waste Stabilization

In May 2002, DOE issued an EIS on waste tank cleaning and stabilization alternatives. DOE studied five alternatives:

- empty, clean and fill tank with grout,
- empty, clean and fill tank with sand,
- empty, clean and fill tank with saltstone,

- clean and remove tanks, and
- no action.

The EIS concluded the Fill with Grout option was preferred. DOE also issued a ROD selecting the Fill with Grout alternative for SRS waste tank closure. [DOE/EIS-0303 ROD, SRR-CWDA-2010-00128]

Evaluations described in the EIS showed the Fill with Grout alternative to be the best approach to minimize human health and safety risks associated with closure of the waste tanks. This alternative offers several advantages over the other alternatives evaluated such as the following:

- provides greater long-term stability of the tanks and their stabilized contaminants than the sand-fill approach,
- provides for retaining radionuclide within the tanks by use of reducing agents in a fashion that the sand-fill would not,
- avoids the technical complexities and additional worker radiation exposure that the fill-with-saltstone approach would entail,
- produces smaller impacts due to radiological contaminant transport than the sand- and saltstone-fill alternatives, and
- avoids the excessive personnel radiation exposure and greater occupational safety impact that would be associated with the clean and remove alternative.

Cementitious materials are often used to stabilize radioactive wastes. Grout has been one of the most commonly used materials for solidifying and stabilizing radioactive wastes and the technology is at a mature stage of development. Grout is a mixture of primarily cement and water proportioned to produce a pourable consistency. Stabilization is needed to maintain the waste tank structure and minimize water infiltration over an extended period of time, thereby impeding release of stabilized contaminants into the environment.

The waste tank fill grout will likely be reducing grout, which has low Eh minimizing the mobility of certain radionuclides after closure. All grout formulas are alkaline because grout is a cement-based material that naturally has a high pH, which is compatible with the tank carbon steel. The tank fill grout will have a relatively high compressive strength and low permeability, which enhances its ability to limit the migration of contaminants after closure. The grout formulas must be fluid to allow a near-level placement. [SRR-CWDA-2010-00128]

The grout properties studied consisted of two major states, cured and fresh. [WSRC-STI-2007-00369] The major requirements for cured properties of grout include compressive strength, saturated hydraulic conductivity, porosity and dry bulk density. The fresh grout properties include flow, bleed water, set time, air content and wet unit weight (density). [SRNL-STI-2011-00551, WSRC-STI-2007-00641]

The fluidity of the mixtures is one of the main requirements. Grout requirements consist of both mechanical and chemical properties. The mechanical requirements of the grout consist of adequate compressive strength to withstand the overburden load and provide a physical barrier to discourage future intruders. The chemical requirements of grout include a high pH and a low Eh to create an environment that makes contaminants less soluble and less mobile. Grout with a high pH can accept protons to lower the pH of contaminants to make them less soluble. Grout with low Eh has the tendency to donate electrons and thereby reduce contaminants to make them less mobile.

Reducing grout will likely be used to fill the Type I, II, III and IIIA tanks. In the Type IV tanks, reducing grout will likely be used to fill the waste tank volume and the tank dome will be filled with a strong grout (i.e., a grout with compressive strength properties in excess of 2,000 psi) to deter intrusion. However, if the final reducing grout recipe provides equivalent compressive strength (2,000 psi minimum) as the strong grout, then only reducing grout will be used for the Type IV waste tanks. Type I, II, III and IIIA tanks have sufficient thickness of reinforced concrete roofs to deter such intrusion.

For waste tank types with cooling coils and annuli, the cooling coils and annuli will be grouted to minimize void spaces, to minimize fast flow pathways and for stability. Annulus risers and ductwork will be filled with grout up to grade level and closed and capped.

Various pieces of equipment will remain in the waste tanks at the time of closure. This equipment consists of items such as transfer jets, thermowells, level instrumentation, a leak detection system, transfer piping out of the waste tank and equipment directly used in tank closure operations (such as submersible mixers and pumps, cables, temporary transfer hoses). These various pieces of equipment, in both the primary tanks and the annuli, will be grouted to the extent practical. In addition, steel tapes and other miscellaneous debris will remain in the waste tank after closure. These components will be entombed in the grout as part of the closure process.

The intent of the in-tank equipment grouting process using highly flowable grout is to minimize fast flow paths that would potentially be present due to void spaces in equipment that extend vertically from the waste tank top down through the grout to close proximity to the residual waste at the bottom of the grouted waste tank. The configuration of the grouted waste tank, annulus and equipment is intended to eliminate fast flow paths (i.e., significant vertical voids that provide a pathway for infiltrating water to bypass the grout layer and impact the contaminant zone), consistent with the Base Case (Case A) presented in the HTF PA. [SRR-CWDA-2010-00128] During grout planning, equipment to be entombed in the grouted waste tank will be identified and documented. This identification will take into consideration the location of the equipment in the waste tank, the state of the equipment in question (e.g., is the equipment failed) and the practicality of removing the equipment (e.g., potential worker dose considerations). Waste tank top modifications to equipment will be performed to provide access to deliver grout to the void spaces of equipment that will be entombed in the grouted waste tank. For example, the motor at the top of abandoned standard slurry pumps (Figure 2.3-1) may be removed to provide access to deliver grout into the pump column. Efforts will be made to assess the completeness of filling equipment void spaces. For example, as practical, grout may continue to be pumped into the supply pipe of a transfer jet until grout is observed exiting the discharge pipe of the jet to demonstrate the void space has been filled with grout. Small equipment such as sample crawlers have minimal void spaces and grout will generally flow into horizontal spaces.

The DOE has successfully developed and tested highly flowable grout in preparation for filling void space in equipment that will be entombed inside of waste tanks at closure. In full scale tests, simulated horizontal and vertical cooling coils were filled with a grout formulation consisting of slag and cable grout. Examination of grouted simulated cooling coil test samples indicated that air entrainment and resulting void space was minimal (much less than 4 %). The use of this type of grout will maximize the ability to fill voids in equipment in the waste tanks at closure. [WSRC-STI-2008-00172, WSRC-STI-2008-00298]

In general, equipment that extends to the tank top will have its void spaces filled with grout directly, while equipment that does not extend to the tank top will have its voids grouted indirectly through encapsulation. The void space of some equipment inside the waste tanks, that do not extend to the top of the waste tank, cannot be fully grouted. For example, the void space in transfer pumps located at various elevations within FTF Tanks 18 and 19 were not fully grouted because of limited or inadequate grout delivery access.[45] However, void spaces of equipment, such as these transfer pumps, entombed inside the waste tanks do not extend to the top of the waste tank and therefore do not provide a vertical void space of significant length to create a fast flow path through the grouted tank. For example, the Pitbull pump in FTF Tank 19 is approximately 25 feet below the northeast riser; and the transfer pump in FTF Tank 18 (used for Tank 18 to Tank 19 transfers) is approximately 29 feet below the west riser. The other transfer pumps and dewatering pumps in the northeast risers of both Tanks 18 and 19 are positioned in very close approximation to the waste tank floor. As described above, because this equipment does not extend to the top of the waste tank and does not provide a vertical void space of significant length, these void spaces would not provide a fast flow path to the residual inventory.

With the exception of the transfer lines, ancillary structures (e.g., diversion boxes, pump tanks, pump pits) associated with HTF will be filled, as necessary, at final closure to prevent subsidence. Since any residual radioactive waste would be on the interior wall of the transfer lines and the leach rate would not be significantly influenced by grout, there is no environmental or human health and safety benefit to grouting these small diameter transfer lines. [SRR-CWDA-2010-00128]

[45] Discussion on Tanks 18 and 19 equipment is included for examples of DOE plans for grouting of in-tank equipment; however, Tanks 18 and 19 are located in the FTF at SRS and are not within the scope of this Draft HTF 3116 Basis Document.

2.6 Closure Cap

An engineered closure cap will be installed over the HTF following the closure of the waste tanks and ancillary equipment. The HTF conceptual closure cap design is presented in SRNL-ESB-2008-00023. Because of the similar characteristics of the HTF design to the FTF design presented in the WSRC-STI-2007-00184, the FTF infiltration rates are considered applicable. The design information being provided is for planning purposes sufficient to support evaluation of the closure cap as part of the integrated site conceptual model being evaluated in the HTF PA and is adopted from the detailed FTF closure cap report WSRC-STI-2007-00184 for HTF. The closure cap design will be finalized closer to the time of HTF closure, to take advantage of possible advances in materials and closure cap technology that could be used to improve the design.

A detailed discussion on closure cap design is provided in Section 3.0 of the HTF PA. An overview of the general design features and figures from the HTF PA are provided below. [SRR-CWDA-2010-00128]

Figure 2.6-1 presents the general design of the closure cap above a closed waste tank. Figure 2.6-2 presents the closure cap footprint and the elevations of the closure cap surfaces and the grading plan. Figure 2.6-3 through Figure 2.6-5 present cross sections of the closure cap conceptual design.

Figure 2.6-1: HTF Closure Cap General Concept

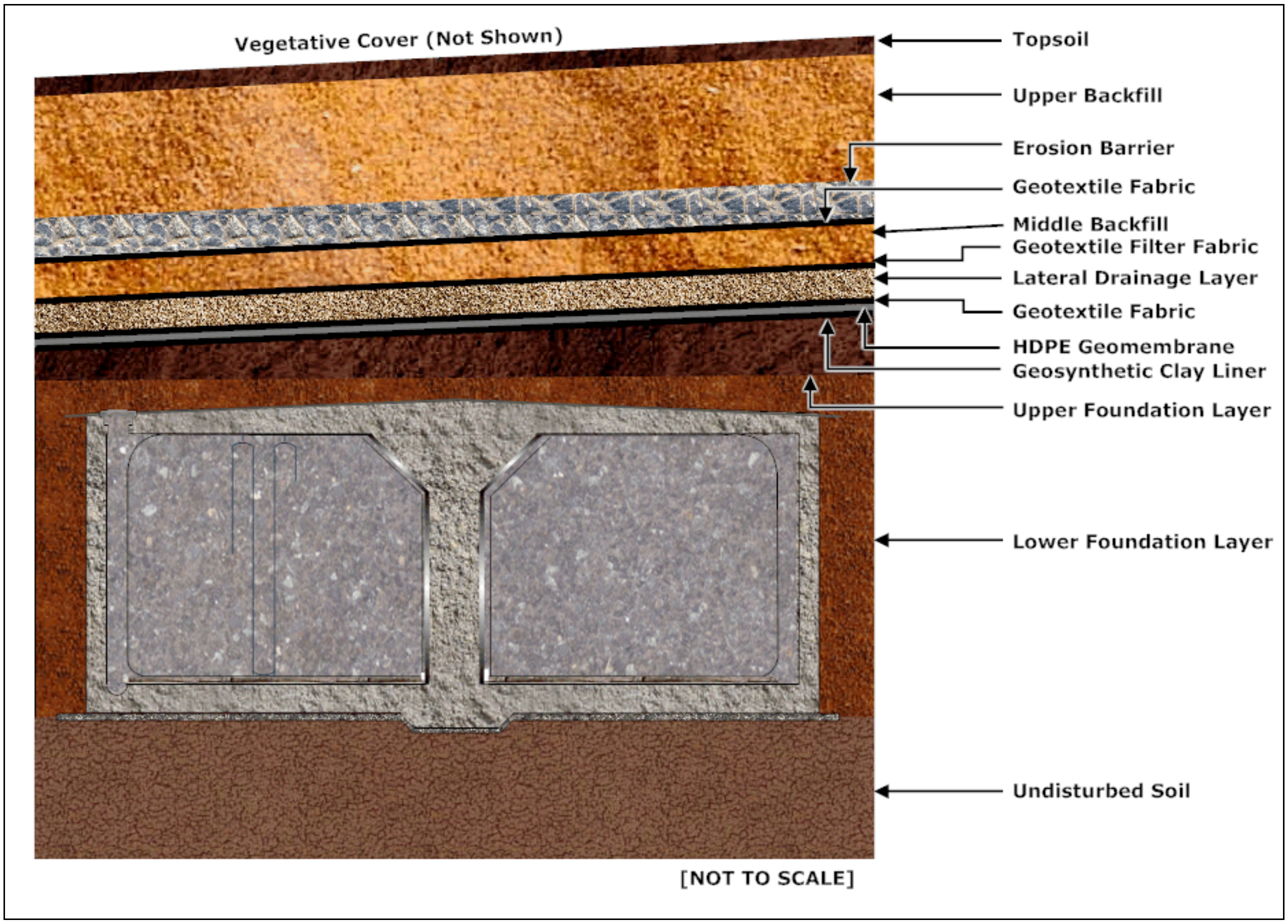
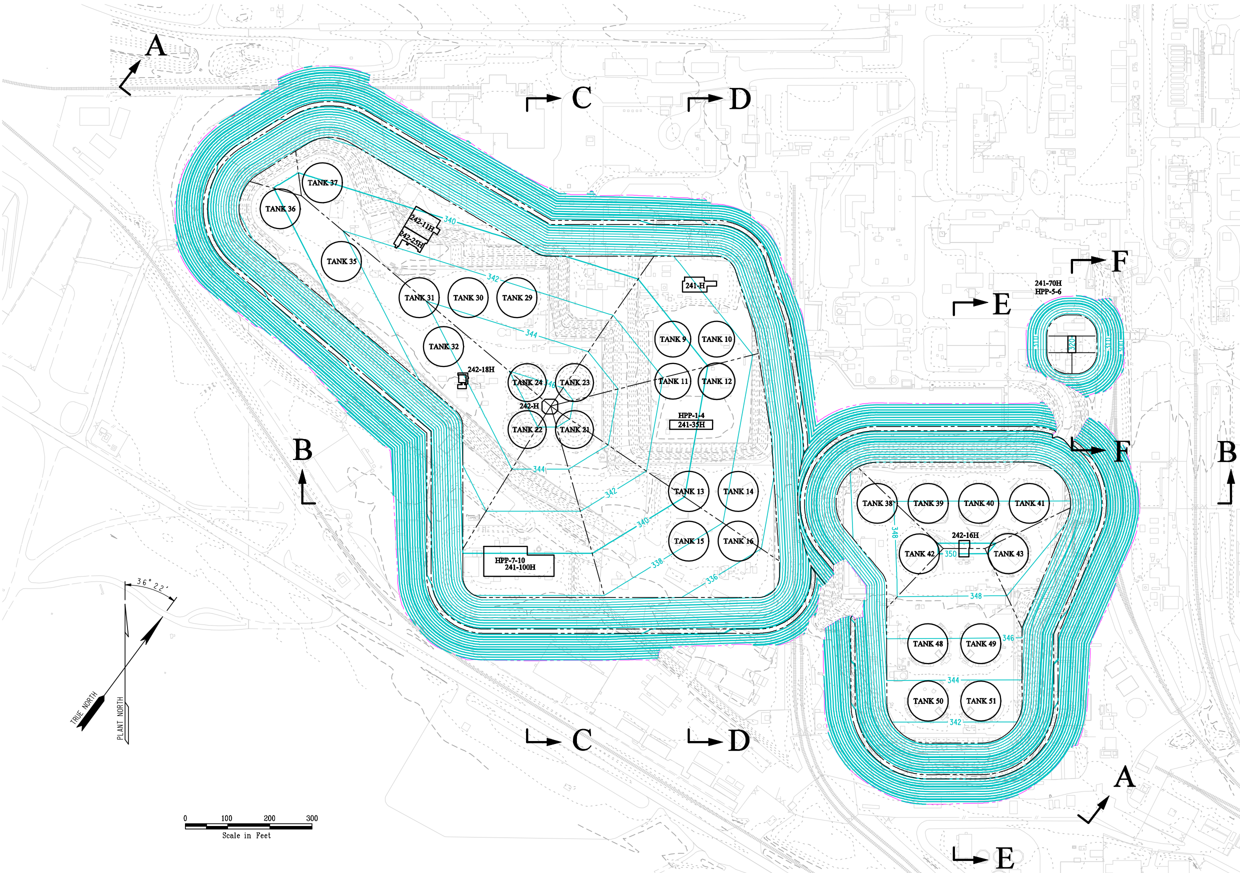
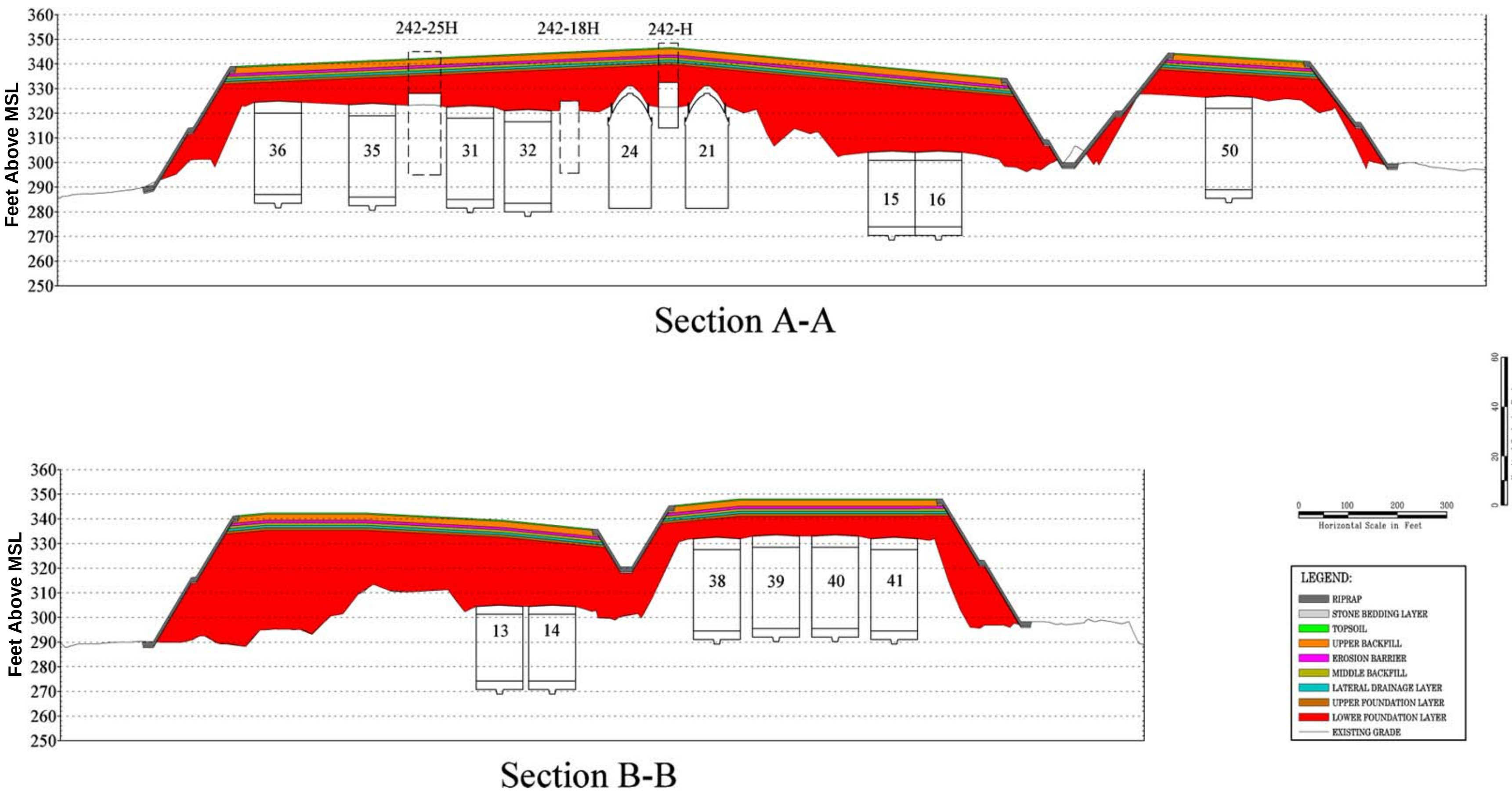


Figure 2.6-2: HTF Closure Cap Conceptual Design, Cap Footprint and Grading Cap



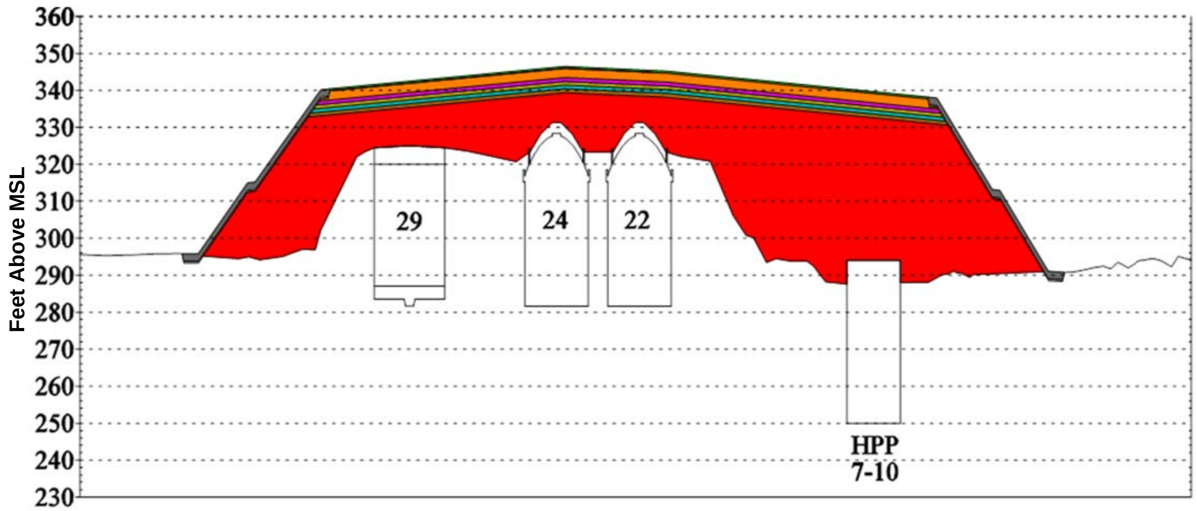
[SRNL-ESB-2008-00023, Figure 1]

Figure 2.6-3: HTF Closure Cap Conceptual Design, Sections A-A and B-B

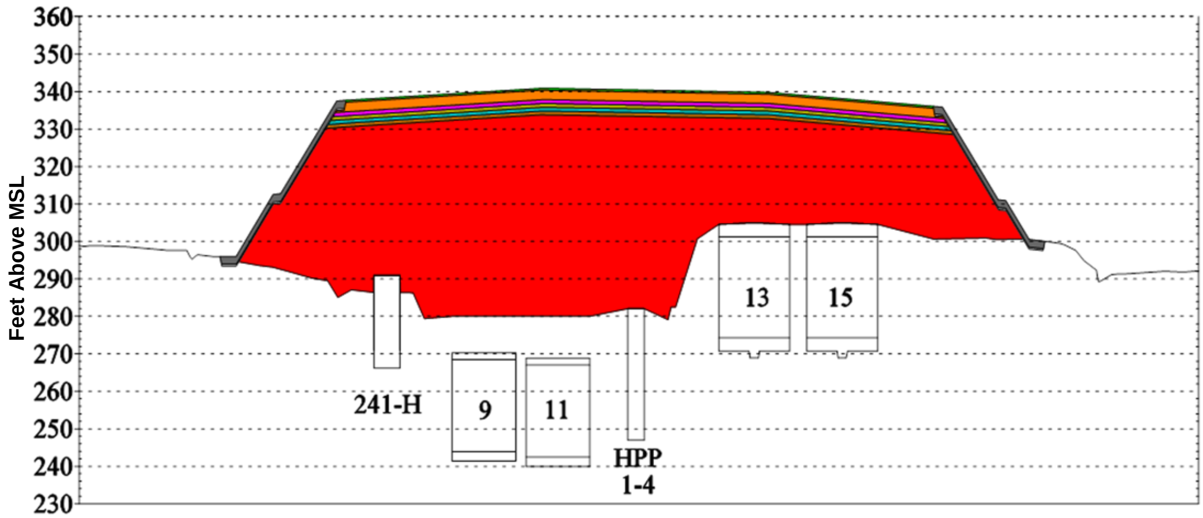


NOTE: Vertical scale of sections has been exaggerated five times in order to show all closure cap layers.
[SRNL-ESB-2008-00023, Figure 2]

Figure 2.6-4: HTF Closure Cap Conceptual Design, Sections C-C and D-D



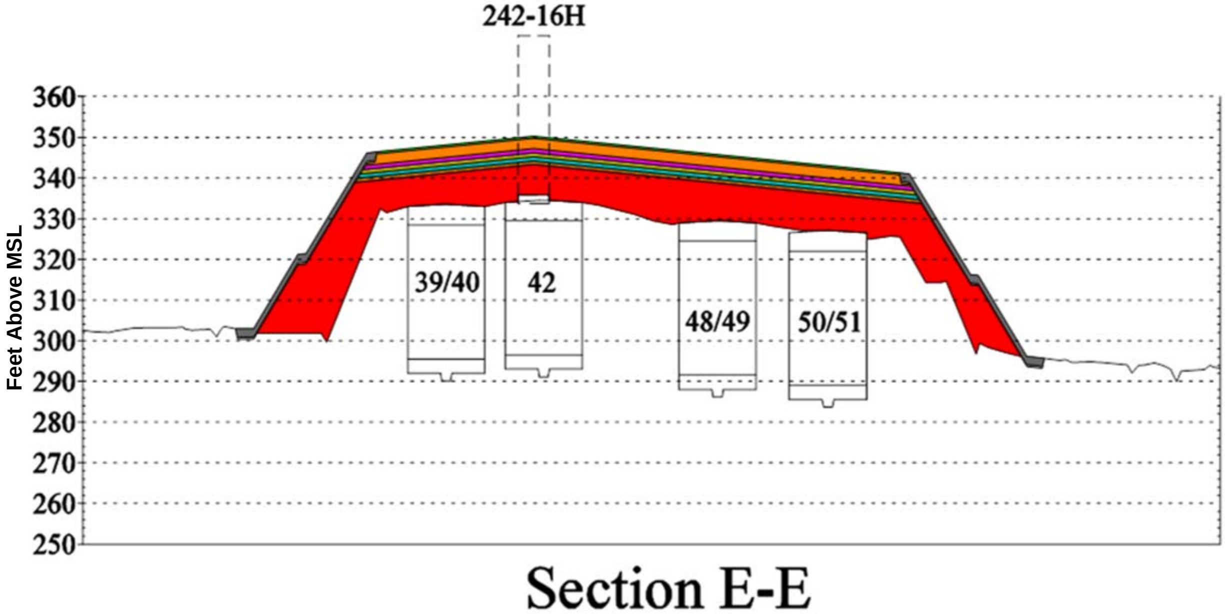
Section C-C

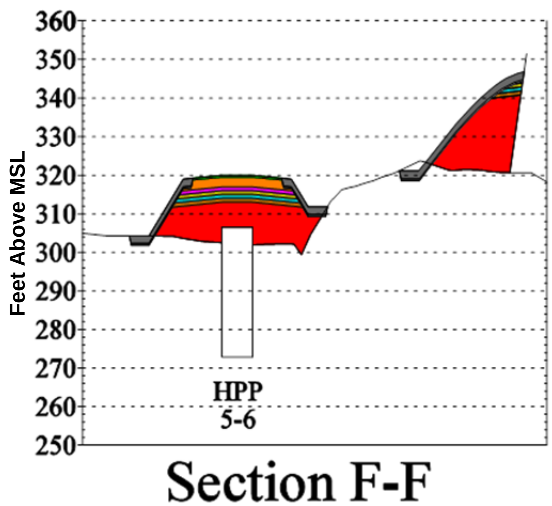


Section D-D

NOTE: Vertical scale of sections has been exaggerated five times in order to show all closure cap layers. See legend on Figure 2.6-3.
[SRNL-ESB-2008-00023, Figure 3]

Figure 2.6-5: HTF Closure Cap Conceptual Design, Sections E-E and F-F





NOTE: Vertical scale of sections has been exaggerated five times in order to show all closure cap layers. See legend on Figure 2.6-3.
[SRNL-ESB-2008-00023, Figure 3]

2.6.1 Function of Closure Cap Layers

The HTF conceptual closure cap design has a 2 % maximum surface slope that is less than 585 feet in length. Therefore, the calculations for the FTF conceptual closure cap design documented in WSRC-STI-2007-00184 are applicable for the HTF.

Using the 585 feet maximum slope length and 2 % maximum slope, initial infiltration estimates through the conceptual closure cap case were made utilizing the Hydrologic Evaluation of Landfill Performance (HELP) Model. Based upon the initial estimates, detailed water balances were produced. Table 2.6-1 presents the pertinent closure cap layers for HTF modeling and the resulting average initial infiltration rate. Table 2.6-2 summarizes the function of each of these layers.

Details on the input development required for the HELP modeling are provided in WSRC-STI-2007-00184. For the purposes of this modeling, synthetic daily weather data for precipitation, temperature, and solar radiation over 100 years were generated based upon the HELP data for Augusta, Georgia, and modified with SRS-specific average monthly precipitation and temperature data reported in WSRC-STI-2007-00184.

Table 2.6-1: HTF Closure Cap Layers

Parameter	Configuration
Layer (depth)	Vegetative Cover (NA)
Layer (depth)	Topsoil (6 inches)
Layer (depth)	Upper Backfill (30 inches)
Layer (depth)	Erosion Barrier (12 inches) [soil infill]
Layer (depth)	Geotextile Fabric (NA)
Layer (depth)	Middle Backfill (12 inches)
Layer (depth)	Geotextile Filter Fabric (NA)
Layer (depth)	Lateral Drainage Layer (12 inches) [soil infill]
Layer (depth)	Geotextile Fabric (NA)
Layer (depth)	High Density Polyethylene (HDPE) Geomembrane (0.06 inch)
Layer (depth)	Geosynthetic Clay Liner (GCL) (0.2 inch)
Layer (depth)	Upper Foundation Layer (12 inches)
Layer (depth)	Lower Foundation Layer (72 inches minimum)
Average Infiltration Rate	0.00088 in/yr (through the GCL)
Average Change in Water Storage	0.06 in/yr

\- Negligible
NA - Not Applicable
[WSRC-STI-2007-00184, Table 11]

Table 2.6-2: Function of the HTF Closure Cap Layers

Layer	Function
Vegetative Cover	The vegetative cover will promote runoff, minimize erosion, and promote evapotranspiration. The initial vegetative cover will be a persistent grass such as Bahia. If it is determined that bamboo is a climax species that prevents or greatly slows the intrusion of pine trees, bamboo will be planted as the final vegetative cover at the end of the 100-year institutional control period. Bamboo is not assumed in present design calculations and modeling.
Topsoil	The topsoil is designed to support a vegetative cover, promote runoff, prevent the initiation of gullying, and provide water storage for the promotion of evapotranspiration.
Upper Backfill	The upper backfill is designed to increase the elevation of the closure cap to that necessary for placement of the topsoil and to provide water storage for the promotion of evapotranspiration.
Erosion Barrier	The erosion barrier is designed to prevent riprap movement during a probable maximum precipitation event and therefore form a barrier to further erosion and gully formation (i.e., provide closure cap physical stability). It is used to maintain a minimum 10 feet of clean material above the tanks and significant ancillary equipment to act as an intruder deterrent. It also provides minimal water storage for the promotion of evapotranspiration.
Geotextile Fabric	This geotextile fabric is designed to prevent the penetration of erosion barrier stone into the underlying middle backfill and to prevent piping of the middle backfill through the erosion barrier voids.
Middle Backfill	The middle backfill provides water storage for the promotion of evapotranspiration in the event that the topsoil and upper backfill are eroded away since the overlying erosion barrier provides only minimal water storage.
Geotextile Filter Fabric	This geotextile fabric is designed to provide filtration between the overlying middle backfill layer and the underlying lateral drainage layer. This filtration allows water to freely flow from the middle backfill to the lateral drainage layer while preventing the migration of soil from the middle backfill to the lateral drainage layer.
Lateral Drainage Layer	The lateral drainage layer is a coarse sand layer designed to: • divert infiltrating water away from the underlying tanks and ancillary equipment and transport the water to the perimeter drainage system, in conjunction with the underlying composite hydraulic barrier (i.e., HDPE geomembrane and GCL) and • provide the necessary confining pressures to allow the underlying GCL to hydrate properly.
Geotextile Fabric	This geotextile fabric is a nonwoven geotextile fabric designed to protect the underlying HDPE geomembrane from puncture or tear during placement of the overlying lateral drainage layer.
HDPE Geomembrane	The HDPE geomembrane forms a composite hydraulic barrier in conjunction with the GCL. The composite hydraulic barrier is designed to promote lateral drainage through the overlying lateral drainage layer and minimize infiltration to the tanks and ancillary equipment.
GCL	The GCL forms a composite hydraulic barrier described above in conjunction with the HDPE geomembrane. As part of the composite hydraulic barrier the GCL is designed to hydraulically plug any holes that may develop in the HDPE geomembrane.
Upper Foundation Layer Lower Foundation Layer	The foundation layers are designed to: • provide structural support for the rest of the overlying closure cap, • produce the required contours and produce a slope of 2 % for the overlying layers, • produce the maximum 3:1 side slopes of the closure cap, • provide a suitable surface for installation of the GCL (i.e., a soil with a moderately low permeability and a smooth surface, free from deleterious materials), • promote drainage of infiltrating water away from and around the tanks and ancillary equipment, and • contain utilities, equipment, facilities, etc., that are not removed from above current grade prior to installation of the closure cap.

[WSRC-STI-2007-00184, Table 12]

3.0 SECTION 3116 OF THE RONALD W. REAGAN NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 2005

The NDAA Section 3116(a) provides that radioactive waste that results from reprocessing is not “high-level radioactive waste” if the Secretary of Energy determines, in consultation with the NRC, that the waste meets certain specified criteria.

The NDAA Section 3116(a) provides in pertinent part:

In General – Notwithstanding the provisions of the Nuclear Waste Policy Act of 1982, the requirements of section 202 of the Energy Reorganization Act of 1974, and other laws that define classes of radioactive waste, with respect to material stored at a Department of Energy site at which activities are regulated by a covered State pursuant to approved closure plans or permits issued by the State, the term “high-level radioactive waste” does not include radioactive waste resulting from the reprocessing of spent nuclear fuel that the Secretary of Energy (in this section referred to as the “Secretary”), in consultation with the Nuclear Regulatory Commission (in this section referred to as the “Commission”), determines –

(1) does not require permanent isolation in a deep geologic repository for spent fuel or high-level radioactive waste;

(2) has had highly radioactive radionuclides removed to the maximum extent practical; and

(3) (A) does not exceed concentration limits for Class C low-level waste as set out in section 61.55 of title 10, Code of Federal Regulations, and will be disposed of –

(i) in compliance with the performance objectives set out in subpart C of part 61 of title 10, Code of Federal Regulations; and

(ii) pursuant to a State-approved closure plan or State-issued permit, authority for the approval or issuance of which is conferred on the State outside of this section; or

(B) exceeds concentration limits for Class C low-level waste as set out in section 61.55 of title 10, Code of Federal Regulations, but will be disposed of –

(i) in compliance with the performance objectives set out in subpart C of part 61 of title 10, Code of Federal Regulations;

(ii) pursuant to a State-approved closure plan or State-issued permit, authority for the approval or issuance of which is conferred on the State outside of this section; and

(iii) pursuant to plans developed by the Secretary in consultation with the Commission.

4.0 WASTE DOES NOT REQUIRE PERMANENT ISOLATION IN A DEEP GEOLOGIC REPOSITORY FOR SPENT FUEL OR HIGH-LEVEL RADIOACTIVE WASTE

The NDAA Section 3116(a) provides in pertinent part:

> *[T]he term "high-level radioactive waste" does not include radioactive waste resulting from the reprocessing of spent nuclear fuel that the Secretary of Energy…, in consultation with the Nuclear Regulatory Commission…, determines –*
>
> *(1) does not require permanent isolation in a deep geologic repository for spent fuel or high-level radioactive waste.*

Under NDAA Section 3116(a), certain wastes from reprocessing are not "high-level radioactive waste" if the Secretary of Energy, in consultation with the NRC, determines that certain criteria are met. The NDAA Section 3116(a) sets out three criteria. Criterion (2), which is set forth in NDAA Section 3116(a)(2), requires removal of highly radioactive radionuclides to the maximum extent practical. Criterion (3) generally mirrors the regulatory criteria that the NRC has established for determining whether waste qualifies for land disposal as low-level waste. That criterion provides that disposal of the waste must meet the NRC performance objectives at 10 CFR Part 61, Subpart C, that the waste must not exceed concentration limits for Class C waste in 10 CFR 61.55 or must be disposed of pursuant to plans developed by the Secretary in consultation with NRC, and that disposal must be pursuant to a State-approved closure plan or permit. Criteria (2) and (3) will be discussed in subsequent sections of this Draft HTF 3116 Basis Document, which demonstrate that those criteria are satisfied.

Criterion (1), quoted above, is a broader criterion that allows the Secretary of Energy, in consultation with the NRC, to consider whether there are other considerations that, in the Secretary of Energy's judgment, warrant permanent isolation of the radioactive waste in a deep geologic repository. Generally, such considerations would be an unusual case because waste that meets the third criterion would be waste that will be disposed of in a manner that meets the 10 CFR 61, Subpart C performance objectives and either falls within one of the classes set out in 10 CFR 61.55 that the NRC has specified are considered "generally acceptable for near-surface disposal" or for which the Secretary of Energy has consulted with NRC concerning DOE's disposal plans.[46] Normally, it follows that if disposal of a waste stream in a facility that is not a deep geologic repository will meet these objectives, in the ordinary case, that waste does not "require permanent isolation in a deep geologic repository" because non-repository disposal will be protective of public health and safety.

However, it is possible that in rare circumstances a waste stream that meets the third criterion might have some other unique radiological characteristic or may raise unique policy considerations that warrant its disposal in a deep geologic repository. Clause (1) of NDAA Section 3116(a) is an acknowledgment by Congress of that possibility. For example, the waste stream could contain material that, while not presenting a health and safety danger if disposed of at the near- or intermediate-surface, nevertheless presents non-proliferation risks that the Secretary concludes cannot be adequately guarded against absent deep geologic disposal.[47] Criterion (1) allows the Secretary of Energy, in consultation with the NRC, to consider such factors in determining whether waste that meets the other two criteria may need permanent isolation in a deep geologic repository in light of these considerations.

This is not the case here. As demonstrated later in this document, the stabilized residuals within the waste tanks and ancillary structures, the waste tanks, and the ancillary structures (including integral

[46] As the NRC explained in *In the Matter of Louisiana Energy Services, L.P. (National Enrichment Services),* [CLI-05-05], the 10 CFR 61, Subpart C performance objectives in turn "set forth the ultimate standards and radiation limits for (1) protection of the general population from releases of radioactivity; (2) protection of individuals from inadvertent intrusion; (3) protection of individuals during operations; and (4) stability of the disposal site after closure."

[47] In NUREG-1854, *NRC Staff Guidance for Activities Related to U.S. Department of Energy Waste Determinations*, the NRC similarly explains: "In general, there is reasonable assurance that this criterion can be met if the two other NDAA criteria can be met. In other words, if highly radioactive radionuclides have been removed to the maximum extent practical and the waste will be disposed of in compliance with the performance objectives in 10 CFR Part 61, Subpart C (which are the same performance objectives NRC uses for disposal of low-level waste), then this supports a conclusion that the waste does not require disposal in a deep geologic repository. However, this criterion allows for the consideration that waste may require disposal in a geologic repository even though the two other NDAA criteria may be met. Those circumstances under which geologic disposal is warranted to protect public health and safety and the environment could be considered; for example, unique radiological characteristics of waste or nonproliferation concerns for particular types of material."

equipment) located at HTF at the time of closure will meet the performance objectives of 10 CFR 61, Subpart C so as to provide for the protection of the public health and the environment. Accordingly, the waste does not require disposal in a deep geologic repository due to the risk to public health and safety. Furthermore, the stabilized residuals within the waste tanks and ancillary structures, the waste tanks, and the ancillary structures (including integral equipment) do not raise any unique considerations that, notwithstanding these demonstrations, require permanent isolation in a deep geologic repository. Accordingly, the stabilized residuals within the waste tanks and ancillary structures, the waste tanks, and the ancillary structures (including integral equipment), meet the criterion of Clause (1) of NDAA Section 3116(a).

5.0 WASTE HAS HAD HIGHLY RADIOACTIVE RADIONUCLIDES REMOVED TO THE MAXIMUM EXTENT PRACTICAL

Section Purpose

The NDAA Section 3116(a) provides that certain waste resulting from reprocessing is not high-level waste if the Secretary of Energy, in consultation with the NRC, determines, among other things, that the waste has had HRRs removed "to the maximum extent practical". This section demonstrates that the HTF residual waste, tanks and ancillary structures, upon completion of waste removal activities at closure, will have had HRRs removed to the MEP and meet this criterion.

Section Contents

Section 5.1 identifies the HRRs for the purpose of this Draft HTF 3116 Basis Document. Section 5.2 describes the removal processes used to remove HRRs to the MEP. Section 5.3 demonstrates that, at closure, the HRRs will have been removed to the MEP.

Key Points

- The list of HRRs for HTF describes the radionuclides that could reasonably be expected to exist in the HTF waste tanks and ancillary structures and that, using a risk-informed approach, contribute significantly to the radiological risk to workers, the public and the environment, taking into account scientific principles, knowledge and expertise.
- The list of HRRs for HTF includes all radionuclides important to meeting the performance objectives in 10 CFR Part 61, Subpart C, and all radionuclides in Tables 1 and 2 of 10 CFR 61.55 were considered.
- Cleaning methodologies are expected to collectively remove approximately 99 % of HRRs, based on a starting point of the maximum historical radionuclide inventory in the overall HTF, although individual waste tanks or ancillary structures may not achieve this level of HRR removal on an individual basis.

The NDAA Section 3116(a) provides in pertinent part:

> *[T]he term "high-level radioactive waste" does not include radioactive waste resulting from the reprocessing of spent nuclear fuel that the Secretary of Energy …, in consultation with the Nuclear Regulatory Commission …, determines — …*
>
> (2) *has had highly radioactive radionuclides removed to the maximum extent practical.*

5.1 Highly Radioactive Radionuclides

5.1.1 Methodology

Based on consultation with the NRC, DOE views "highly radioactive radionuclides" to be those radionuclides that, using a risk-informed approach, contribute most significantly to radiological risk to workers, the public and the environment. Strontium-90, Tc-99, I-129, Cs-137, U-233, U-234, U-235, Np-237, Pu-238, Pu-239, Pu-240, Am-241 and Am-243 are the HRRs in the HTF stabilized residuals, HTF waste tanks and HTF ancillary structures at the closure of HTF that DOE has determined contribute significantly to radiological risk to workers, the public and the environment, taking into account scientific principles, knowledge and expertise.[48]

The list of HRRs, Table 5.1-1, was developed beginning with an initial listing of 849 radionuclides compiled from a variety of published resources (e.g., NCRP information), and included radionuclides not necessarily present in the projected HTF inventory at closure. [CBU-PIT-2005-00228] The initial listing of

[48] Some of the radionuclides listed as HRRs in this Draft HTF 3116 Basis Document may not be listed in other NDAA Section 3116 basis documents if such radionuclides are not present in the waste or do not contribute significantly to dose to the worker, the public or the inadvertent intruder.

849 radionuclides included those radionuclides from Tables 1 and 2 of 10 CFR 61.55.[49] DOE reviewed this initial list and identified those radionuclides that were present in the waste and may be important in meeting performance objectives in 10 CFR Part 61, Subpart C because they contribute to the dose to the workers, the public and/or the inadvertent intruder (for one or more reasonable intruder scenarios) in the HTF PA Base Case and sensitivity and uncertainty analyses. In DOE's view, this approach results in a risk-informed list of HRRs that includes: those short-lived radionuclides that may present risk because they produce radiation emissions that, without shielding or controls, may harm humans simply by proximity to humans without inhalation or ingestion; and those long-lived radionuclides that persist well into the future, may be mobile in the environment or may pose a risk to humans if inhaled or ingested.[50]

Table 5.1-1: HTF Highly Radioactive Radionuclides

Radionuclide	Radionuclide Half-Life (yr)	Potential Long-Term Radiological Hazards	Potential Short-Term Radiological Hazards
Sr-90 [b, c, d, f]	2.89E+01		X
Tc-99 [a, b, c, e]	2.11E+05	X	
I-129 [a, b]	1.57E+07	X	
Cs-137 [c, d, f]	3.00E+01		X
U-233 [b]	1.59E+05	X	
U-234 [a, b, c]	2.46E+05	X	
U-235 [a]	7.04E+08	X	
Np-237 [a, c, e]	2.14E+06	X	
Pu-238 [a, b, e]	8.77E+01	X	
Pu-239 [b, c, e]	2.41E+04	X	
Pu-240 [b, c, e]	6.56E+03	X	
Am-241 [a, b, c, e]	4.32E+02	X	
Am-243 [b, e]	7.37E+03	X	

[a] HRRs based on groundwater analyses results from the HTF PA. [SRR-CWDA-2010-00128]
[b] HRRs based on intruder analysis results from the HTF PA. [SRR-CWDA-2010-00128]
[c] HRRs based on uncertainty and sensitivity run results from the HTF PA. [SRR-CWDA-2010-00128]
[d] HRRs based on potential contribution to worker dose.
[e] Included in Table 1 of 10 CFR 61.55.
[f] Included in Table 2 of 10 CFR 61.55.

The list of HTF HRRs in Table 5.1-1 account for approximately 99 % of the current radioactivity in the HTF waste. The short-lived fission products Cs-137 and Sr-90 and their equilibrium daughter products, Ba-137m and Y-90, are by far the predominant sources of radioactivity present in the HTF waste today. Cs-137, and its daughter Ba-137m, are typically considered as a single radionuclide for human health protection purposes because the half-life of Ba-137m is so short that it only exists when Cs-137 is present. The same is true for Sr-90 and its daughter Y-90. Accordingly, the discussions that follow in this Draft HTF 3116 Basis Document focus on Cs-137 or Sr-90 since approaches that are effective in removing Cs-137 and Sr-90 also remove Ba-137m and Y-90, respectively. Approximately 97 % of the current radioactivity in the HTF waste is associated with these two radionuclides and their short-lived daughters. [SRR-LWP-2012-00031] Moreover, Cs-137, Sr-90 and their daughters are present in sufficient concentrations in the HTF waste that, without shielding and controls, they produce radiation emissions that would present risk to humans simply due to their proximity without direct inhalation or ingestion. Accordingly, they are of potential acute hazard to occupational workers, the public and the environment.

The remainder of the radionuclides listed are the long-lived isotopes that may pose the greatest risk in the future to human health because of their long life and because they present human health risk if directly inhaled or ingested. These long-lived isotopes combined account for less than 1 % of the current radioactivity in the HTF waste today.[51] [SRR-LWP-2012-00031]

[49] Although Tables 1 and 2 in 10 CFR 61.55 specify concentration limits for certain radionuclides in the form of activated metal, DOE includes such radionuclides without regard to whether such radionuclides are in the form of activated metal.
[50] The methodology described in this Draft HTF 3116 Basis Document is the same as the methodology utilized in FTF. Although not required by Section 3116, DOE will nevertheless continue to characterize and confirm the actual residuals after cleaning, with an emphasis on HRRs, for the waste tanks and ancillary structures, as described in this Draft HTF 3116 Basis Document (including Appendix B) and supporting references. DOE also will continue to incorporate actual residual waste characterization information, and explore associated refinement of assumptions, in special analyses and future revisions of the HTF PA as part of the HTF PA maintenance and monitoring processes under DOE Manual 435.1-1, pursuant to DOE responsibilities under the Atomic Energy Act of 1954, as amended.
[51] The remaining radionuclides in the HTF waste in combination contribute approximately 2% of the current radioactivity.

5.1.2 Performance Assessment Radionuclides

As explained above, DOE has included in the list of HRRs those radionuclides that may be important to meeting the performance objectives of 10 CFR 61, Subpart C because they contribute to the dose to workers, the public and/or the inadvertent intruder based on the HTF PA, which includes sensitivity and uncertainty analyses. The HTF PA applied a rigorous, documented, multi-step, multi-factor screening methodology (including consideration of NCRP information) to 849 radionuclides compiled from radionuclides present in the HTF (based on the SRS Waste Characterization System, process knowledge and available sampling data) as well as radionuclides reported in a variety of published resources. Specifically, DOE used the following approach in the HTF PA to focus on those radionuclides that contribute to the dose for various pathways. [SRR-CWDA-2010-00128]

For the purpose of determining which radionuclides should be evaluated in the HTF PA, an initial radionuclide screening process was developed and performed, evaluating an initial list of 849 radionuclides compiled from a variety of published resources including the following:

- *Screening Models for Releases of Radionuclides to Atmosphere, Surface Water and Ground*, Volumes I and II, National Council on Radiation Protection and Measurements, which identifies 826 nuclides of interest in determining radiation exposure due to releases to the air, water and ground. [NCRP-123]
- The EPA Risk Assessment Web Site, which provides conversion factors for 824 nuclides which are of interest in determining human health cancer risk from radionuclides in the air, soil and water. [CBU-PIT-2005-00228]
- *Fission-Product Yields from Neutron-Induced Fission*, Nucleonic - Reference Data Manual, which details 148 radionuclides produced from thermal neutron induced fission of U-235. [Nucleonics_1960]
- *Integrated Data Base Report-1996: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections and Characteristics*, DOE, which identified 168 nuclides of issue in making material disposition decisions. [DOE/RW-0006]
- *Derivation of Initial Radionuclide Inventories for the Safety Assessment of the Disposal of Used CANDU Fuel*, Atomic Energy of Canada Limited, which lists 211 nuclides of interest in making decisions about disposal of spent fuel from heavy water reactors (note that the five reactors operated at SRS were also heavy water reactors). [AECL-9881]

This initial screening process considered the following information:

- physical properties of each radionuclide such as half-life and decay mechanism,
- waste source and handling based on radionuclide production mechanisms and time since the radionuclide was produced, and
- screening factors for radionuclide ground disposal developed in *Screening Models for Releases of Radionuclides to Atmosphere, Surface Water and Ground* [NCRP-123] which convert a quantity of each radionuclide to a dose.

This initial screening reduced the radionuclide list from 849 down to 159 radionuclides. [CBU-PIT-2005-00228]

Additional screening of the 159 radionuclides was performed to identify the radionuclides to be considered in the initial HTF PA inventory. The screening and adjustment included the following:

- Radionuclides were screened out if there were no ancestors present from the specific decay chain or no decay source for the radionuclide.
- The HTF waste production history information was evaluated for the potential for a specific radionuclide to be present in HTF. This step screened out radionuclides not present within the HTF waste.
- In general, radionuclides present due to ingrowth from a decay series were screened out, however, production history was used to retain those radionuclides present at a greater proportion than from the decay series (i.e., Np-237). This screening step eliminated radionuclides that are present only due to the decay of their parent radionuclide (i.e., Ba-137m, Y-90, Ra-226

and Th-229). The inventory of these radionuclides can be controlled by removing the parent radionuclide(s) to the "maximum extent practical."

- Radionuclides with less than a five-year half-life were screened out. This screening reflects that active institutional control will be maintained over the site for 100 years after facility closure. The inventories of these radionuclides will be significantly diminished due to the amount of radioactive decay that will occur during the assumed 100-year institutional control period.

Based on the above screening and adjustment, an additional 105 radionuclides were screened out, thus reducing the HTF PA modeling initial inventory radionuclide number to 54. For the waste tanks and ancillary structures, an initial inventory value for these 54 radionuclides was developed and was used as input into the HTF PA modeling. The results of the HTF PA analyses were then evaluated using the methodology described below to determine which of the 54 radionuclides would be considered HRRs for HTF. [SRR-CWDA-2010-00023, SRR-CWDA-2010-00128]

5.1.3 Highly Radioactive Radionuclides Based on 100-Meter Groundwater Analysis (For Member of the Public Following Closure)

To determine which radionuclides are HRRs, DOE considered the doses estimated in the HTF PA, as well as the NRC guidance in NUREG-1854, the NRC guidance in Volume 2 of NUREG-1757 (referenced in NUREG-1854), and recommendations by the NRC during previous consultation.[52] The approach followed by DOE in this Draft HTF 3116 Basis Document is identical to the approach followed in the FTF 3116 Basis Document. It is a thorough and methodical approach that reflects NRC guidance and recommendations and results in the identification of those radionuclides that may provide more than an insignificant contribution to dose. [DOE/SRS-WD-2012-001]

Several radionuclides have been included on the HRR list based on an evaluation of the HTF 100-meter groundwater dose, using the groundwater dose results calculated in the HTF PA. For the HTF PA, the 100-meter point is the point of maximum exposure at, or outside of, the HTF 100-meter buffer zone. The pathways for release to a member of the public considered in the HTF PA analyses are discussed in Section 7.1.2. The groundwater analysis in the HTF PA utilized the initial inventory of 54 radionuclides resulting from the screening analysis described in the previous section as input for the HTF PA model. The model used to perform the groundwater analysis accounted for radioactive decay and ingrowth throughout the assessment period. [SRR-CWDA-2010-00128] The results of the groundwater analysis were then evaluated to determine the HRRs.

DOE examined the resulting dose contributions to the groundwater analysis, shown in the HTF PA, from all individual radionuclides in the HTF PA initial inventory at the time of closure. Those radionuclides which, in aggregate, would not contribute greater than 1.25 mrem/yr were not considered HRRs. The first step in this groundwater evaluation was to review the resulting doses from the HTF PA groundwater analysis at any time within 20,000 years.[53] The individual doses from each radionuclide were then listed in order of contribution. DOE conducted a quantitative analysis to determine those radionuclides with an aggregate contribution to dose of less than or equal to 1.25 mrem/yr.[54] These radionuclides were screened from the HRR list. Based on this evaluation, the remaining radionuclides – Ni-59, Tc-99, I-129, Ra-226, Pa-231 and Np-237 - were initially identified for consideration. For those radionuclides, the projected inventories (as shown in the HTF PA) at the time of HTF closure were reviewed. For those radionuclides with a relatively insignificant initial inventory (i.e., Ra-226 and Pa-231) the associated decay chains were examined. Reduction of these radionuclides is accomplished through the removal of the

[52] NRC suggested during a public Draft FTF 3116 Basis Document scoping meeting held on July 13-14, 2010 that DOE consider the guidance in NUREG-1757 in establishing these evaluation thresholds. [SRR-CWDA-2010-00091]

[53] To ensure that a conservative approach is taken in selection of the HRRs, the calculation of groundwater dose for 20,000 years was used to account for waste tank degradation for Type I, Type II and Type III/IIIA tanks. DOE is using a 20,000-year evaluation period for determination of HRRs due to the expected timing of tank liner failures and resultant peak doses. This tank liner failure analysis is specific to the SRS HTF Type I, Type II and Type III/IIIA tanks.

[54] This approach is consistent with the guidance and general approach in Volume 2 of NUREG-1757, *Consolidated Decommissioning Guidance* (NUREG-1757), which explains that "NRC staff considers radionuclides and exposure pathways that contribute no greater than 10% of the dose criteria to be insignificant contributors." The above-referenced NUREG, which applies to NRC licensees, is being used only as general guidance, and DOE's use of this NUREG as guidance should not be construed to suggest that it is a requirement under NDAA Section 3116 or that the NUREG is applicable in the 3116 context. To ensure that selection of the HRRs is sufficiently conservative, DOE has used 5 percent (i.e., 1.25 mrem/yr) of the 25 mrem/yr all-pathways dose limit.

respective parent radionuclides, i.e., U-234 (for Ra-226), U-235 (for Pa-231), Pu-238 (for Ra-226), Pu-239 (for Pa-231). An additional parent radionuclide, Am-241, was included based on progeny ingrowth of Np-237.

Nickel-59 is one of the radionuclides identified in the initial screening described above. When listing the individual doses from each radionuclide in order of contribution, Ni-59 is the radionuclide which causes the aggregate dose to exceed 1.25 mrem/yr, Ni-59 causes the aggregate dose in this screening step to increase from 1.1 mrem/yr to 1.83 mrem/yr. The dose contribution from Ni-59 is attributed to the estimated Ni-59 residual inventory in the annuli of the Type I waste tanks. The estimated Ni-59 inventory in the Type I tank annuli was estimated by setting the annulus residual inventory equal to the primary tank residual inventory. The actual annulus inventories for Ni-59 in the Type I tanks is expected to be considerably lower than the inventory used in the HTF PA modeling. Based on this consideration, the associated dose from Ni-59, in aggregate with the previously screened radionuclides, are not expected to contribute greater than 1.25 mrem/yr to the groundwater dose. Additional conservatism for Ni-59 dose is also provided by the fact that the HTF PA PORFLOW model does not account for isotope dilution on solubility. In addition to the Ni-59 present in the tank waste, stable nickel is also present. The amount of stable nickel significantly surpasses the amount of Ni-59. The PORFLOW model treats each constituent individually, which ignores other constituents of the same element and their impact on solubility. There is more than two orders of magnitude more stable nickel than Ni-59. There would be a proportional decrease in the dose associated with Ni-59.

A review of the decay chain for Pa-231 provides that both U-235 and Pu-239 could be potential contributors to progeny ingrowth of Pa-231. A review of the dose results shows that decay from the initial inventory of U-235 contributes greater than 85 % of the future Pa-231 inventory. Therefore, Pu-239, although a contributor to the future Pa-231 inventory, is not considered an HRR based on the groundwater pathway.

DOE believes that the screening of radionuclides whose dose contribution in aggregate is less than or equal to 1.25 mrem/yr is sufficiently low, compared to the 25 mrem/yr all-pathways dose limit, to capture all risk-significant radionuclides in those that remain. For the purpose of this Draft HTF 3116 Basis Document, Tc-99, I-129, U-234, U-235, Np-237, Pu-238 and Am-241 were included in the HRR list based on the groundwater pathway.

5.1.4 Highly Radioactive Radionuclides Based on Air Pathway Analysis (For Member of the Public Following Closure)

In a similar manner, radionuclides were evaluated for inclusion on the HRR list based on the HTF 100-meter dose from airborne radionuclides, using the air pathway dose results calculated in the HTF PA. The pathways for release to a member of the public considered in the HTF PA analyses are discussed in Section 7.1.2 of this Draft HTF 3116 Basis Document. In the HTF PA, radionuclides contained in the initial inventory that are susceptible to volatilization were considered in the air pathways analysis. These radionuclides included H-3, C-14, Cl-36, Se-79, Tc-99, Sb-125, Sn-126 and I-129. For the HTF PA, the 100-meter point is the point of maximum exposure at or outside of the HTF 100-meter buffer zone. The HTF PA shows that the air pathway is not a significant contributor to dose, and contributes, in aggregate less than 0.1 mrem/yr peak dose. [SRR-CWDA-2010-00128] Therefore, for the purpose of this Draft HTF 3116 Basis Document, no radionuclides were included in the HRR list based on the air pathway.

5.1.5 Highly Radioactive Radionuclides Based on Intruder Pathway Analysis

Several radionuclides have been included on the HRR list based on an evaluation of the HTF inadvertent intruder dose, using the intruder dose results calculated in the HTF PA. The intruder scenarios and associated exposure pathways used for this evaluation are discussed in Section 7.2.2 of this Draft HTF 3116 Basis Document. The intruder analysis in the HTF PA utilized the initial inventory of 54 radionuclides resulting from the screening analysis described previously as input for the HTF PA model. The model used to perform the intruder analysis did account for radioactive decay and ingrowth throughout the assessment period. [SRR-CWDA-2010-00128] The results of the intruder analysis were then evaluated to determine the HRRs.

DOE examined the resulting dose contributions to the inadvertent intruder analysis, shown in the HTF PA, from all individual radionuclides in the HTF PA initial inventory at the time of closure. Those radionuclides which, in aggregate, would not contribute greater than 25 mrem/yr were not considered HRRs. The first step in this intruder evaluation was to review the resulting doses from the HTF PA intruder analysis at any time within 20,000 years.[55] The individual doses from each radionuclide were then listed in order of contribution. DOE conducted a quantitative analysis to determine those radionuclides with an aggregate contribution to dose of less than or equal to 25 mrem/yr.[56] These radionuclides were screened from the HRR list. Based on this evaluation the remaining radionuclides - Sr-90, Y-90, Tc-99, I-129, Ra-226, Th-229, U-233, U-234, Pu-239, Pu-240, Pu-244, Am-241, Am-243, Cm-245, Cm-247, Cm-248 and Pb-210 - were initially identified for consideration. For those radionuclides, the projected inventories (as shown in the HTF PA) at the time of HTF closure were reviewed. For radionuclides with a relatively insignificant initial inventory (i.e., Ra-226, Th-229, Pb-210), the associated decay chain was examined. Reduction of these radionuclides is accomplished through the removal (during the cleaning and waste removal process) of the respective parent radionuclides, i.e., U-233 (for Th-229), U-234 (for Ra-226), Pu-238 (for Ra-226), Ra-226 (for Pb-210).

For a number of radionuclides in the projected inventory with limited potential impact to dose, inventories were adjusted to either one curie or the analytical detection limit. If the radionuclide inventory was less than the detection limit, then it was adjusted to the detection limit. However, if the radionuclide inventory estimated was at least at the detection limit, then it was adjusted up to one curie. For the list of radionuclides identified in the initial screening of the HTF PA intruder doses described above Pu-244, Cm-245, Cm-247 and Cm-248 all had their projected HTF PA inventory set to one curie, at least one order of magnitude higher than the inventory based on estimates utilizing Tanks 5, 6, 18 and 19 sample analyses and WCS estimates (i.e., Pu-244 greater than two orders of magnitude, Cm-245 greater than one order of magnitude, Cm-247 greater than five orders of magnitude, Cm-248 greater than three orders of magnitude). [SRR-CWDA-2010-00023] Based on the HTF PA projected inventory for Pu-244, Cm-245, Cm-247 and Cm-248, the associated dose from these radionuclides, in aggregate with the previously screened radionuclides, are not expected to contribute greater than 25 mrem/yr to the inadvertent intruder dose.

Strontium-90, and its daughter Y-90, are typically considered as a single radionuclide for human health protection purposes because the half-life of Y-90 is so short that it only exists when Sr-90 is present. Removal of Y-90 is accomplished through removal of the parent radionuclide Sr-90 during the waste removal process. Therefore, Y-90 is not considered an HRR based on contribution to the inadvertent intruder dose.

DOE believes the screening of radionuclides whose dose contribution, in aggregate, is less than or equal to 25 mrem/yr is sufficiently low, compared to the 500 mrem/yr peak intruder dose recommended in NRC guidance (NUREG-0945 and NUREG-1854), to capture all risk significant radionuclides in those that remain. For the purpose of this Draft HTF 3116 Basis Document, Sr-90, Tc-99, I-129, U-233, U-234, Pu-239, Pu-240, Am-241 and Am-243 were included in the HRR list based on the intruder pathway.

5.1.6 Highly Radioactive Radionuclides Based on Uncertainty and Sensitivity Analyses

Some radionuclides have been included on the HRR list based on an evaluation of the uncertainty and sensitivity analyses included in the HTF PA. [SRR-CWDA-2010-00128] The HTF PA uncertainty and sensitivity analyses were reviewed to identify those radionuclides shown to have the most influence on the model results.

The purpose of the uncertainty and sensitivity analyses was to consider the effects of uncertainties in the conceptual models used and sensitivities in the parameters used in the mathematical models. While the

[55] To ensure that a conservative approach is taken in selection of the HRRs, the calculation of inadvertent intruder dose for 20,000 years was used to account for waste tank degradation for Type I, Type II and Type III/IIIA tanks. DOE is using a 20,000-year evaluation period for determination of HRRs due to the expected timing of tank liner failures and resultant peak doses. This tank liner failure analysis is specific to the SRS HTF Type I, Type II and Type III/IIIA tanks.

[56] This approach is consistent with the guidance and general approach in Volume 2 of NUREG-1757, *Consolidated Decommissioning Guidance* (NUREG-1757), which explains that "NRC staff considers radionuclides and exposure pathways that contribute no greater than 10% of the dose criteria to be insignificant contributors." The above-referenced NUREG, which applies to NRC licensees, is being used only as general guidance, and DOE's use of this NUREG as guidance should not be construed to suggest that it is a requirement under NDAA Section 3116 or that the NUREG is applicable in the 3116 context. To ensure that selection of the HRRs is sufficiently conservative, DOE has used 5 percent (25 mrem/yr) of the 500 mrem/yr all-pathways dose recommended in NRC guidance. [NUREG-0945 and NUREG-1854]

uncertainty and sensitivity analyses were primarily performed using a probabilistic model, some additional single parameter sensitivity analyses were performed through deterministic modeling. The probabilistic model allows for variability of multiple parameters simultaneously, so concurrent effect of changes in the model can be analyzed. The deterministic model single parameter analysis provides a method to evaluate the importance of the uncertainty around a single parameter of concern. Using both probabilistic and deterministic models for sensitivity analysis versus a single approach provides additional information concerning which parameters are of most importance to the HTF PA model. In addition, as part of the sensitivity analyses, modeling was performed for a period of 100,000 years. [SRR-CWDA-2010-00128]

The HTF PA considers the uncertainties and sensitivities associated with the projected dose results to a member of the public through uncertainty analysis of the HTF probabilistic model, through sensitivity analysis using the HTF probabilistic model and through sensitivity analysis using the HTF deterministic model. A review of the uncertainty analysis realizations with the highest peak doses show Sr-90 and Tc-99 to be significant to dose. A review of the sensitivity analysis performed using the HTF probabilistic model shows Tc-99 and Ra-226 to be significant. A review of the sensitivity analysis performed using the HTF deterministic model, including a barrier analysis, show Tc-99, I-129, Ra-226 and Np-237 to be significant to dose. For Ra-226, which has a relatively insignificant initial inventory, the associated decay chain was examined. Reduction of Ra-226 is accomplished through the removal of its parent radionuclides U-234 and Pu-238 during the waste removal process. An additional parent radionuclide, Am-241, was included for progeny ingrowth of Np-237. Based on an evaluation of the HTF PA results for these different analyses, Sr-90, Tc-99, I-129, U-234, Np-237, Pu-238 and Am-241 were included in the HRR list.

The HTF PA also considered the effects on the Intruder Analysis of uncertainties in the conceptual models used and sensitivities in the parameters used in the mathematical models. Deterministic intruder sensitivity analyses performed identified Ra-226 and U-234 as potentially significant to the inadvertent intruder results. For Ra-226, which has a relatively insignificant initial inventory, the associated decay chain was examined. Reduction of Ra-226 is accomplished through the removal of its parent radionuclides U-234 and Pu-238 during the waste removal process. A review of the HTF intruder sensitivity analyses identified Sr-90, Y-90, Tc-99, Cs-137 and Ba-137m as potentially significant to the inadvertent intruder results. Cesium-137, and its daughter Ba-137m, are typically considered as a single radionuclide for human health protection purposes because the half-life of Ba-137m is so short that it only exists when Cs-137 is present. The same is true for Sr-90 and its daughter Y-90. Removal of Ba-137m and Y-90 is accomplished through removal of the parent radionuclides Cs-137 and Sr-90, respectively, during the waste removal process. Therefore, Ba-137m and Y-90 are not considered HRRs based on an evaluation of the uncertainty and sensitivity analyses. Strontium-90, Tc-99, Cs-137, U-234 and Pu-238 were included in the HRR list based on an evaluation of the results for the HTF PA inadvertent intruder uncertainty and sensitivity analyses.

Based on the HTF PA uncertainty and sensitivity analyses, Sr-90, Tc-99, I-129, Cs-137, U-234, Np-237, Pu-238 and Am-241 were included in the HRR list.

5.1.7 Highly Radioactive Radionuclides Summary

The results of the HRR evaluation are summarized in Table 5.1-2. The table provides the results of the evaluation for each of the 54 radionuclides contained in the initial HTF PA inventory. Radionuclides were considered HRRs based on the evaluations and considerations discussed above. Based on these evaluations and considerations, Sr-90, Tc-99, I-129, Cs-137, U-233, U-234, U-235, Np-237, Pu-238, Pu-239, Pu-240, Am-241 and Am-243 are considered the HRRs in the HTF stabilized residuals, HTF waste tanks and HTF ancillary structures at the closure of HTF.

Table 5.1-2: Radionuclides Contained in HTF PA Initial Inventory

Radionuclide with Initial Inventory	Half-Life (yr)	Evaluation Results[a]							
		Groundwater Analysis		Air Pathway Analysis		Intruder Analysis			
		Dose > 1.25 mrem/yr	Impact on Progeny > 1.25 mrem/yr	Dose > 1.25 mrem/yr	Impact on Progeny > 1.25 mrem/yr	Dose > 25.0 mrem/yr	Impact on Progeny > 25.0 mrem/yr	Uncertainty & Sensitivity Analysis	Contribution to Worker Dose
H-3[c]	1.23E+01	x	x	x	x	x	x	x	x
C-14[b]	5.70E+03	x	x	x	x	x	x	x	x
Al-26	7.17E+05	x	x	x	x	x	x	x	x
Cl-36	3.01E+05	x	x	x	x	x	x	x	x
K-40	1.25E+09	x	x	x	x	x	x	x	x
Ni-59[b]	7.60E+04	x	x	x	x	x	x	x	x
Ni-63[c]	1.00E+02	x	x	x	x	x	x	x	x
Co-60[c]	5.30E+00	x	x	x	x	x	x	x	x
Se-79	2.95E+05	x	x	x	x	x	x	x	x
Sr-90[c]	**2.89E+01**	x	x	x	x	✓	x	✓	✓
Y-90	7.31E-03	x	x	x	x	x	x	x	x
Zr-93	1.53E+06	x	x	x	x	x	x	x	x
Nb-93m	1.61E+01	x	x	x	x	x	x	x	x
Nb-94[b]	2.03E+04	x	x	x	x	x	x	x	x
Tc-99[b]	**2.11E+05**	✓	x	x	x	✓	x	✓	x
Pd-107	6.50E+06	x	x	x	x	x	x	x	x
Sn-126	2.30E+05	x	x	x	x	x	x	x	x
Sb-126	1.24E+01	x	x	x	x	x	x	x	x
Sb-126m	1.92E+01	x	x	x	x	x	x	x	x
I-129[b]	**1.57E+07**	✓	x	x	x	✓	x	✓	x
Cs-135	2.36E+06	x	x	x	x	x	x	x	x
Cs-137[c]	**3.00E+01**	x	x	x	x	x	x	✓	✓
Ba-137m	4.85E-06	x	x	x	x	x	x	x	x
Sm-151	9.00E+01	x	x	x	x	x	x	x	x
Eu-152	1.35E+01	x	x	x	x	x	x	x	x
Eu-154	8.59E+00	x	x	x	x	x	x	x	x

✓ Included on the HRR list based on specific evaluation threshold.
x Does not meet specific evaluation threshold.
a Radionuclides considered HRRs if one or more evaluation thresholds are met.
b Included in Table 1 of 10 CFR 61.55.
c Included in Table 2 of 10 CFR 61.55.
Note: HRRs for this Draft HTF 3116 Basis Document are highlighted.
[SRR-CWDA-2010-00128]

Table 5.1-2: Radionuclides Contained in HTF PA Initial Inventory (Continued)

		Evaluation Results[a]							
		Groundwater Analysis		Air Pathway Analysis		Intruder Analysis			
Radionuclide with Initial Inventory	Half-Life (yr)	Dose > 1.25 mrem/yr	Impact on Progeny > 1.25 mrem/yr	Dose > 1.25 mrem/yr	Impact on Progeny > 1.25 mrem/yr	Dose > 25.0 mrem/yr	Impact on Progeny > 25.0 mrem/yr	Uncertainty & Sensitivity Analysis	Contribution to Worker Dose
Pt-193	5.00E+01	x	x	x	x	x	x	x	x
Ra-226	1.60E+03	x	x	x	x	x	x	x	x
Ac-227	2.17E+01	x	x	x	x	x	x	x	x
Th-229	7.88E+03	x	x	x	x	x	x	x	x
Th-230	7.54E+04	x	x	x	x	x	x	x	x
Pa-231	3.27E+04	x	x	x	x	x	x	x	x
U-232	6.89E+01	x	x	x	x	x	x	x	x
U-233	**1.59E+05**	x	x	x	x	✓	✓	x	x
U-234	**2.46E+05**	✓	✓	x	x	✓	✓	✓	x
U-235	**7.04E+08**	x	✓	x	x	x	x	x	x
U-236	2.34E+07	x	x	x	x	x	x	x	x
U-238	4.47E+09	x	x	x	x	x	x	x	x
Np-237[b]	**2.14E+06**	✓	x	x	x	x	x	✓	x
Pu-238[b]	**8.77E+01**	x	✓	x	x	x	✓	✓	x
Pu-239[b]	**2.41E+04**	x	x	x	x	✓	x	x	x
Pu-240[b]	**6.56E+03**	x	x	x	x	✓	x	x	x
Pu-241[b]	1.43E+01	x	x	x	x	x	x	x	x
Pu-242[b]	3.75E+05	x	x	x	x	x	x	x	x
Pu-244[b]	8.00E+07	x	x	x	x	x	x	x	x
Am-241[b]	**4.32E+02**	x	✓	x	x	✓	x	✓	x
Am-242m[b]	1.41E+02	x	x	x	x	x	x	x	x
Am-243[b]	**7.37E+03**	x	x	x	x	✓	x	x	x
Cm-243[b]	2.91E+01	x	x	x	x	x	x	x	x
Cm-244[b]	1.81E+01	x	x	x	x	x	x	x	x
Cm-245[b]	8.50E+03	x	x	x	x	x	x	x	x
Cm-247[b]	1.56E+07	x	x	x	x	x	x	x	x
Cm-248[b]	3.48E+05	x	x	x	x	x	x	x	x
Cf-249[b]	3.51E+02	x	x	x	x	x	x	x	x

✓ Included on the HRR list based on specific evaluation threshold.
x Does not meet specific evaluation threshold.
a Radionuclides considered HRRs if one or more evaluation thresholds are met.
b Included in Table 1 of 10 CFR 61.55.
c Included in Table 2 of 10 CFR 61.55.
Note: HRRs for this Draft HTF 3116 Basis Document are highlighted.
[SRR-CWDA-2010-00128]

5.2 Removal of Highly Radioactive Radionuclides to the Maximum Extent Practical

The NDAA Section 3116(a) provides that certain waste resulting from reprocessing is not high-level waste if the Secretary of Energy, in consultation with the NRC, determines, among other things, that the waste has had HRRs removed "to the maximum extent practical".[57] Section 5.2 and 5.3 demonstrates that the HTF residual waste, tanks and ancillary structures will have had HRRs removed to the MEP upon cessation of waste removal activities. Removal to the maximum extent "practical" is not removal to the extent theoretically "possible." Rather, a "practical" approach to removal is one that is "adapted to actual conditions" (*A Dictionary of Modern English Usage*); "adapted or designed for actual use" (http://infoplease.com/ipd/A0598638.html); "useful" (http://infoplease.com/ipd/A0598638.html); selected "mindful of the results, usefulness, advantages or disadvantages, etc., of [the] action or procedure" (http://infoplease.com/ipd/A0598638.html); fitted to "the needs of a particular situation in a helpful way" (http://dictionary.cambridge.org/define.asp?key=practical*2+0&dict=A); "effective or suitable" (http://dictionary.cambridge.org/define.asp?key=practical*2+0&dict=A). Therefore, the determination as to whether a particular HRR will be removed to the MEP will vary from situation to situation, based not only on the available technologies but also on the overall costs and benefits[58] of deploying a technology with respect to the conditions in a specific HTF waste tank or ancillary structure. The MEP standard contemplates room for exercising expert judgment in weighing several factors. Such factors may include, but are not limited to, environmental, health, timing or other exigencies; the risks and benefits to public health, safety and the environment arising from further HRR removal as compared with countervailing considerations that may ensue from not removing or delaying removal; the reasonable availability of proven technologies; the usefulness of such technologies; and the sensibleness of using such technologies. What may be removal to MEP in a particular situation or at one point in time may not be that which, on balance, is practical, feasible or sensible in another situation or at a prior or later point in time.

Moreover, it may not be practical to undertake further removal of certain radionuclides because further removal is not sensible or useful in light of the overall benefit to human health and the environment. As a general matter, such a situation may arise if certain radionuclides are present in such extremely low quantities that they make an insignificant contribution[59] to potential doses to workers, the public, and the hypothetical human intruder.

The HRRs have been and, for tanks and equipment to be cleaned in the future, will be removed from HTF waste tanks and ancillary structures to the MEP for the purpose of removal from service[60] and eventual closure of the waste tanks and ancillary structures. Removal of HRRs to the MEP in HTF waste tanks and ancillary structures occurs through a systematic progression of waste removal and cleaning activities using proven technologies to a point where further removal of HRRs is not sensible or useful in light of the overall benefit to human health, safety and the environment.

[57] The NDAA Section 3116 does not specify "remedial goals" or other numerical objectives, and does not require DOE to develop any such removal goals or objectives.

[58] While prior NRC and DOE requirements for waste determinations called for removal "to the maximum extent *technically* and *economically* practical" [NRC_03-02-93; DOE M 435.1-1], NDAA Section 3116 omits these adverbs, thereby suggesting that a broad range of considerations, including but not limited to technical and economic practicalities, may appropriately be taken into account in determining the extent of removal that is practical.

[59] The DOE normally would view radionuclides as making a clearly insignificant contribution if the contribution to dose from those radionuclides, in both the expected case and considering sensitivity analyses, does not exceed any of the following: (1) 10% of the 25-mrem/yr all-pathways annual dose to the public, (2) 10% of the DOE 100-mrem annual dose limit to the intruder (under all reasonable intruder scenarios), (3) 10% of the DOE 500-mrem acute dose limit to the intruder (under all intruder scenarios), and (4) 10% of the annual worker dose in the relevant provisions of 10 CFR 20. This methodology is based on NRC consultation and is intended to be consistent with the guidance and general approach in Volume 2 of NUREG-1757, *Consolidated Decommissioning Guidance* (NUREG-1757), which explains that "NRC staff considers radionuclides and exposure pathways that contribute no greater than 10% of the dose criteria to be insignificant contributors." The above-reference NUREG, which applies to NRC licensees, is being used only as general guidance, and DOE's use of this NUREG as guidance should not be construed to suggest that it is a requirement under NDAA Section 3116 or that either the NUREG or 10 CFR 20, Subpart E is applicable in the 3116 context.

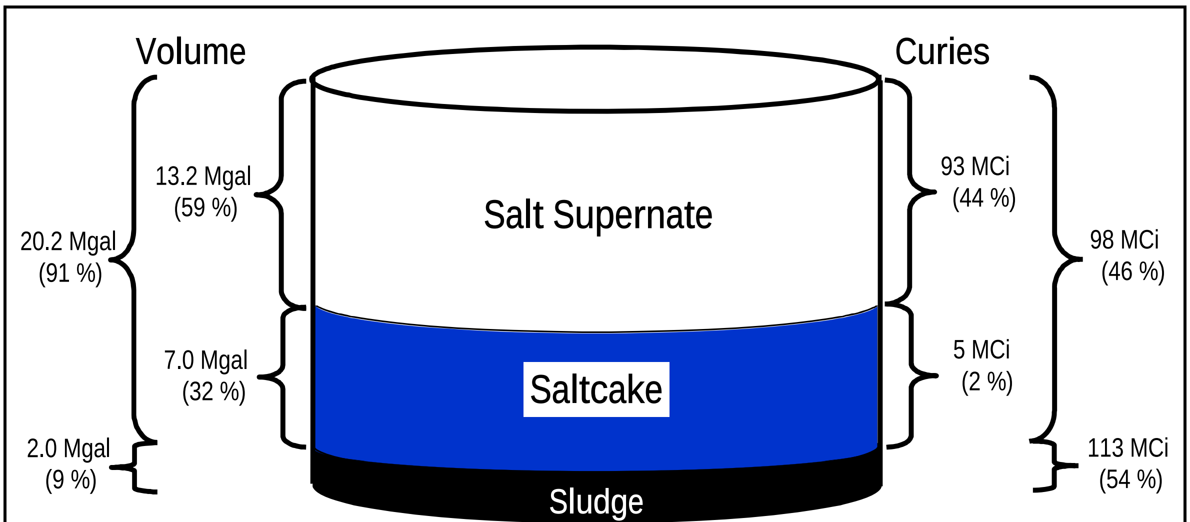
[60] The term "removal from service" refers to the protocols set forth in the State-approved GCP, as described in Section 8.0 of this Draft HTF 3116 Basis Document, to stabilize the waste tank or ancillary structure.

5.2.1 Current Status of H-Tank Farm Waste Removal Activities

The HTF includes 29 waste storage tanks. The Type I, Type II and Type IV waste tanks in HTF are no longer actively receiving fresh canyon waste and the Type I and Type II tanks are currently undergoing waste removal activities. Tank 16 has undergone an extensive waste removal campaign. [SRR-CWDA-2011-00126] Bulk waste removal efforts have been completed for Tanks 11 and 12, and are currently underway in Tank 13; preparation for bulk waste removal efforts in Tank 10 are in-progress. Heel removal activities have been initiated in Tank 12. Waste removal activities, for the purposes of final waste tank closure, have not been initiated in any of the 17 Type III/IIIA tanks or four Type IV tanks located in HTF. However, DOE has previously performed additional waste removal activities in various HTF waste tanks to support efficient management of ongoing tank farm operations and preparation of feed batches for DWPF. Bulk sludge removal activities have been performed in HTF Tanks 9, 10, 11, 14, 15, 21, 22 and 42. Bulk saltcake removal has been performed in HTF Tanks 22, 24, 37 and 41. After completion of the waste removal activities in these tanks, the available storage space created within these tanks was subsequently re-used to support ongoing tank farm operations.

As of April 2, 2012, HTF stored approximately 211,000,000 curies in approximately 22,200,000 gallons of waste. The sludge portion of this waste represents approximately 9 % of the volume but contains approximately 54 % of the radioactivity. Of the approximately 20,200,000 gallons of salt waste, approximately 7,000,000 gallons is in the form of saltcake with the remaining approximately 13,200,000 gallons being concentrated supernate. The concentrated supernate accounts for approximately 44 % of the total radioactivity in the HTF. Figure 5.2-1 graphically presents the approximate breakdown of the waste in HTF in terms of both volume and curies for each of the three primary waste types. [SRR-LWP-2012-00031, SRR-LWP-2012-00029]

Figure 5.2-1: HTF Waste Tank Composite Inventory



HTF Inventory values as of April 2, 2012

5.2.2 Waste Removal Technologies

The DOE has considered a large number of different technologies in recent years in its efforts to identify the best available technologies to remove waste from the SRS tanks, and a new generation of waste removal equipment has been selected for use at SRS. DOE has over 40 years of experience in successfully removing waste from the SRS waste tanks. This experience encompasses removal of all waste types (supernate, sludge and saltcake).

In 2003, DOE used a systematic process to identify, evaluate and select equipment for waste removal tasks to accelerate waste removal and the removal of waste tanks from service. This process is formally documented in a Systems Engineering Evaluation. The evaluation investigated options for bulk waste mixing, waste transfer and residual waste heel removal. The evaluation graded the options on weighted selection criteria such as technical maturity, effectiveness, reliability, reusability, radiological control requirements, integration with the tank farm system and cost. Knowledgeable tank farm operations, engineering, plant support and maintenance personnel identified potential technology candidates based on experience, literature, worldwide web research and contacts with other knowledgeable personnel in the DOE Complex and commercial industry. The team recommended using a combination of mechanical removal technologies and chemical removal technologies, if necessary, to perform waste removal in the tanks. [G-ESR-G-00051]

In addition to the mechanical and chemical waste removal technologies, as the result of a March 2006 DOE-sponsored Tank Cleaning Technical Exchange, DOE identified a new vacuum removal technology for heel removal applications. [CBU-PIT-2006-00067]

DOE also conducted a new Systems Engineering Evaluation in 2012, which evaluated potential new technologies and technology enhancements, as documented in the appendix accompanying the *Cost-Benefit Analysis for Removal of Additional Highly Radioactive Radionuclides from Tank 18*. [SRR-CWDA-2012-00026] This 2012 Systems Engineering Evaluation examined over 50 potential technologies and chemical cleaning methods, with four analyzed in detail, to identify any new or enhanced technologies to remove HRRs, as discussed further in Section 5.3 of this Draft HTF 3116 Basis Document.

The DOE is utilizing mechanical, chemical and vacuum heel removal technologies at SRS in various combinations and sequences depending on the unique characteristics of the waste and conditions in each tank. The DOE will continue to consider new technological developments relevant to waste tank cleaning, and has a detailed process in place to evaluate potential new technologies and technology optimization, with a focus on HRRs, as each tank, ancillary structure, or group is cleaned, as described in Appendix B to this Draft HTF 3116 Basis Document. A range of potential technologies for evaluation will potentially include technologies developed and/or used at other DOE sites, in domestic commercial industry and in international applications.[61] [V-ESR-G-00003] A recent example of how DOE evaluates potential technologies is documented in the Systems Engineering Evaluation accompanying the *Cost-Benefit Analysis for Removal of Additional Highly Radioactive Radionuclides from Tank 18,* discussed above and in Section 5.3. [SRR-CWDA-2012-00026] Another example of DOE's ongoing review of new technologies is provided in *CY 2011 Annual SCDHEC Technology Briefing*. [SRR-LWE-2012-00082]

The following discusses the current technologies and how they are being utilized at SRS.

5.2.2.1 Mechanical Cleaning

Over the past several decades at HTF, DOE has successfully used, and is continuing to use, mechanical cleaning approaches for several types of waste tanks in HTF. These mechanical approaches are described below by HTF waste tank, for bulk waste removal and, depending on the waste tank, heel removal.

- Tank 11 – bulk waste removal completed using several slurry pumps; awaiting heel removal.
- Tank 12 – bulk waste removal completed using several slurry pumps; slurry pumps continue to be used for heel removal.
- Tank 13 – bulk waste removal ongoing using several SMPs; heel removal will be completed after bulk waste removal.
- Tank 16 – bulk waste removal completed using several slurry pumps; heel removal successfully completed using a combination of slurry pumps and chemical (oxalic acid) cleaning.
- Tank 10 – technical design currently underway for mechanical bulk waste removal; after completion of technical design, bulk waste removal and heel removal will be completed.

In addition to the tanks listed above, DOE previously used slurry pumps successfully in HTF for bulk sludge removal in Tanks 15, 21, 22 and 42, and, prior to the development of slurry pumps utilized high-pressure water jets to remove sludge from Tanks 9, 10, 11 and 14. DOE used a combination of water dissolution and mechanical pumps as necessary to remove saltcake from Tanks 22, 24, 37 and 41 in HTF. Although these waste tanks were subsequently re-used and re-filled, they serve as further indicia of DOE experience and expertise using mechanical cleaning approaches at HTF. Furthermore, DOE has effectively implemented mechanical approaches to clean waste tanks in FTF, including Tanks 4, 5, 6, 17,

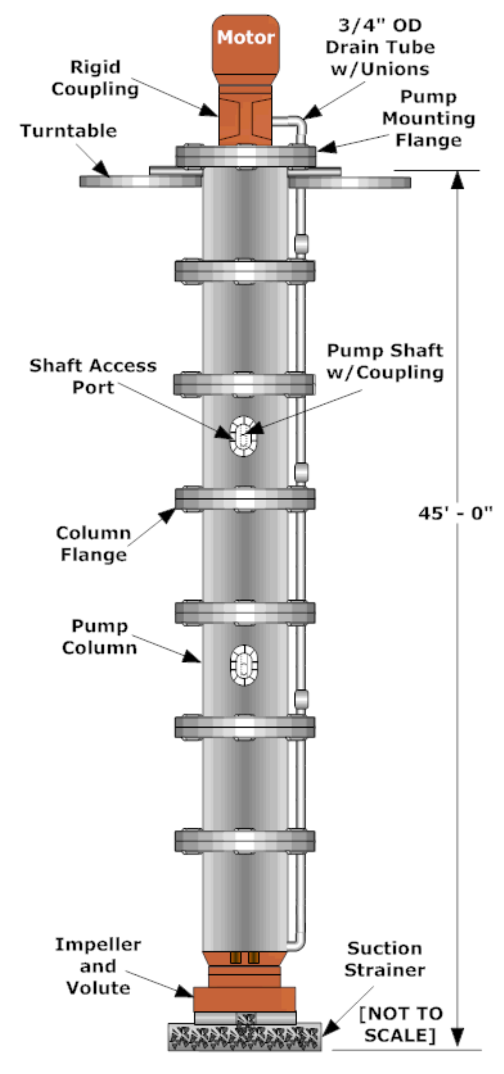
[61] NRC has previously acknowledged, on page 79 of its FTF Technical Evaluation Report (TER), that, "DOE has a program in place to identify, evaluate, and implement cleaning technologies to remove HRRs to the MEP." [ML112371715]

18, 19 and 20.[62] Removal of waste is influenced primarily by tank type and waste type, rather than the tank farm in which a particular tank is located, and DOE's successful use of mechanical cleaning approaches in FTF further evinces DOE's extensive experience and expertise in successfully using mechanical cleaning methods. The mechanical cleaning approaches for the SRS tank farms, and the predicate for their selection, are described in the ensuing discussion.

In the late 1960's, to consolidate sludge into a few waste tanks, DOE removed sludge from several Type I tanks using high-pressure water jets to disperse the sludge into slurry that was then removed using centrifugal transfer pumps. Although effective, the method created significant amounts of new waste (approximately five gallons of water for every gallon of sludge removed). Sludge removal utilizing this method was performed in several Type I tanks including HTF Tanks 9, 10, 11 and 14. In the 1970's, DOE began investigating ways to remove sludge without utilizing large volumes of water and encumbering the available waste tank space, which led to development of slurry pumps. [V-ESR-G-00003]

Since the late 1970's, mechanical mixing in HTF waste tanks has been performed utilizing standard slurry pumps or some variation thereof. The slurry pump is an older style mixing pump, with the motor located above the tank top. The pump connects to the motor with a long shaft through a water-filled column. The first successful test runs of a slurry pump were conducted in HTF Tank 16 in 1978 and 1979 and were utilized for the duration of the Tank 16 heel removal effort which included both mechanical and chemical heel removal. Mechanical heel removal in Tank 16 was carried out in five mixing and pumping campaigns utilizing one slurry pump for the first two campaigns and three slurry pumps for the remainder of the campaigns. The mechanical heel removal effort in Tank 16 was successful in reducing the waste volume in Tank 16 to an estimated 5,250 gallons prior to chemical heel removal. [SRR-CWDA-2011-00126] Since 1979, 16 waste tanks at SRS have used variations of the slurry pump design for sludge removal, salt dissolution and sludge mixing for DWPF feed preparation. The most recent design of the slurry pump, Figure 5.2-2, is referred to as the standard slurry pump. In the late 1990s, reliability problems with the standard slurry pumps coupled with the need for extensive tank top modifications and a separate support system (i.e., bearing water) led to an investigation of alternate mixing technologies and eventual development of the SMP. [V-ESR-G-00003] Standard slurry pumps previously installed in HTF waste tanks may continue to be used in heel removal activities. For example, HTF Tanks 11 and 12 underwent bulk waste removal efforts utilizing standard slurry pumps. The standard slurry pumps installed in Tank 12 continue to be used to support heel removal activities being performed within the waste tank. [SRR-LWE-2012-00059]

Figure 5.2-2: Typical Standard Slurry Pump



[WSRC-TR-2001-00313]

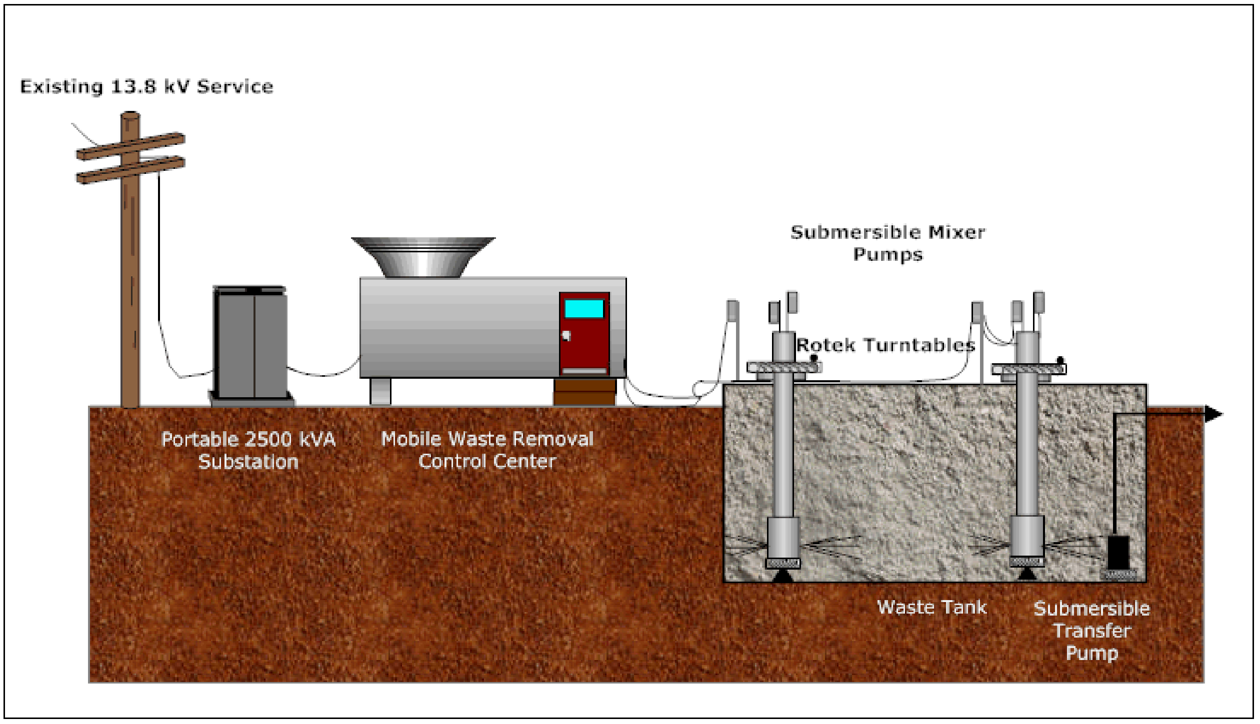
As documented in the 2003 Systems Engineering Evaluation (for HTF and FTF), the team of knowledgeable and experienced engineers and operations personnel recommended using floor-mounted, canned SMPs for bulk waste mixing and a mast-mounted STP for waste transfer.

[62] FTF waste tanks are not within the scope of this Draft HTF 3116 Basis Document, but are discussed here to demonstrate DOE's successful experience and extensive expertise in removing waste, including HRRs, from the SRS waste tanks.

Based on the recommendations of the team, DOE selected and implemented mechanical removal techniques that use liquid (water[63] and/or supernate) as the media for mixing. Mixer pumps used for bulk waste removal are also used in the subsequent heel removal process and may be augmented by spraying and lancing. Spraying and lancing within the waste tanks is performed by inserting a nozzle through an open riser in the waste tank and directing the liquid at a targeted location. Lancing typically is used to refer to a higher pressure, more concentrated spray pattern aimed at breaking-up or moving the solids within the waste tank. A recycle system, also referred to as a "feed and bleed" system, may be employed to enhance the efficiency and effectiveness of the mechanical removal of the solids, if practical.

The technology consists of a Mobile Substation that provides power, a Mobile Waste Removal Control Center that provides local control and monitoring capabilities, SMPs for mixing and suspending waste solids and an STP for waste transfer. These mobile units have the capability of being co-located near any tank or tanks scheduled for waste removal. This concept efficiently performs waste removal using mobile and reusable equipment (Figure 5.2-3).[64]

Figure 5.2-3: Submersible Mixer Pump Waste Removal Diagram



A key component of the mechanical waste removal equipment is the SMP because the ability to mix and suspend waste solids has a direct impact on the volume of solids remaining after mechanical heel removal. The SMPs are variable speed, single-stage centrifugal pumps with a 305-horsepower motor that can operate up to 1,600 revolutions per minute. The SMPs utilize the tank liquid waste to cool the motor and lubricate the upper and lower bearings. The SMPs are rotated by a turntable assembly that provides the motive force for oscillation or allows for stationary indexing operation. The SMPs have a rotating foot attached to the lower end of the pump, which allows the SMP to rest on the tank floor and oscillate. SMPs used for bulk waste removal are also used in the subsequent residual heel removal process and can be augmented by spraying or lancing. In some cases, a recycle system or feed and bleed system may be employed to enhance mechanical heel removal. Two discharge nozzles give the SMPs the capability to produce an effective cleaning radius of up to 50 feet. [M-CLC-G-00349] While

[63] Chemically-treated water is typically utilized when significant volumes will be added to the waste tanks to minimize the potential corrosion to the carbon steel primary tank walls and floors and the secondary annular pans, as applicable.
[64] Figure 5.2-2 depicts two SMPs located in the waste tank. However, during actual cleaning operations DOE may deploy from one to four SMPs within a waste tank based upon the particular waste tank configuration and waste characteristics.

obstructions such as cooling coils and support columns can significantly degrade the effective cleaning radius of SMPs, the use of multiple SMPs in an obstructed tank can make a significant contribution to removal of waste. To date, SMPs have been used to support bulk waste removal efforts on HTF Tank 13 and FTF Tanks 4, 5 and 6[65] and to support mechanical and chemical cleaning of residual heels in Tanks 5 and 6. The waste tank designs in HTF and FTF are essentially identical and the experience in FTF Tank 5 and Tank 6 mechanical heel removal has demonstrated that two or three SMPs can successfully suspend the majority of the sludge solids in a waste tank with internal obstructions. A Type I tank, such as Tank 5 and Tank 6, represents some of the most challenging tanks for waste removal activities due, in part, to a limited number of access points compared to a Type III/IIIA tank, the presence of roof support columns in the Type I tanks, and horizontal coiling coil runs at the bottom of the waste tank including stacked horizontal runs (often referred to as "fences") that were "field to fit" during the time of waste tank construction versus only having vertical cooling coils in the waste zone in Type III/IIIA tanks. Pump configurations are shown in Figure 5.2-4 and Figure 5.2-5.

Figure 5.2-4: Submersible Mixing Pump and Submersible Transfer Pump

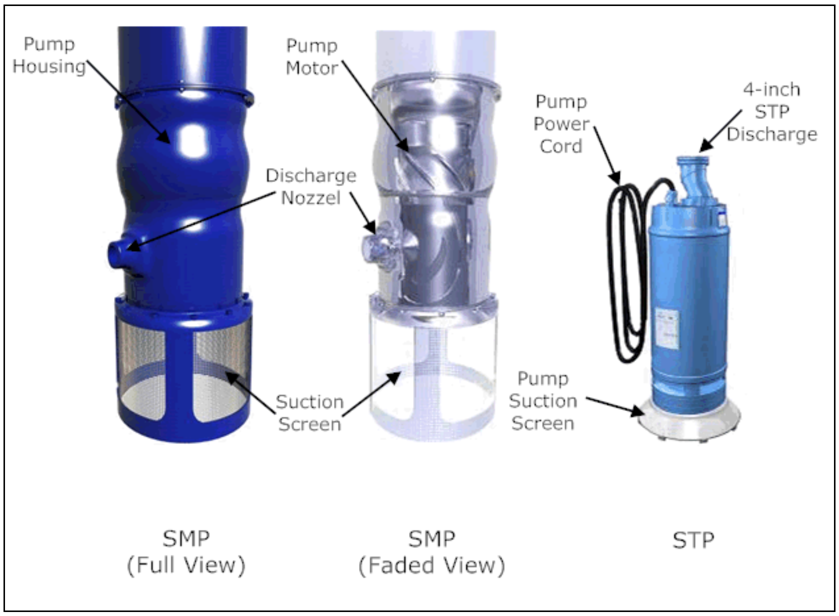


Figure 5.2-5: Submersible Mixing Pump in a Test Tank

The first deployments and operations of SMPs at SRS led to successful removal of sludge from two Type I tanks. Seven mechanical heel removal phases using SMPs in Tank 5 reduced the volume of sludge solids from approximately 34,000 gallons to approximately 3,500 gallons. In Tank 6, SMP operations during eleven mechanical heel removal phases resulted in the reduction of sludge solids from approximately 25,000 gallons to approximately 6,000 gallons. These first uses of SMPs provided the opportunity to gather and evaluate data to refine and enhance operational parameters such as mixer speed, mixer orientation and strategy (oscillation and fixed position) and coordination of mixer and transfer pump operations to optimize waste removal effectiveness in future tanks. Mechanical heel removal using SMPs successfully reduced the volume of sludge to the level required for chemical heel removal in Tank 5 and Tank 6. Following the chemical cleaning campaigns in Tanks 5 and 6, mechanical cleaning utilizing a feed and bleed process with three SMPs was carried out in each of the waste tanks. [SRR-CWDA-2011-00033, SRR-CWDA-2011-00005, M-ESR-F-00107, M-ESR-F-00147, M-ESR-F-00132]

[65] Discussion on Tanks 4, 5 and 6 cleaning is included for information; however, Tanks 4, 5 and 6 are located in the FTF at SRS and are not within the scope of this Draft HTF 3116 Basis Document.

5.2.2.2 Chemical Heel Removal Cleaning

The DOE also successfully uses chemical heel removal technology that employs oxalic acid for chemical treatment of the heel to dissolve solids that cannot be removed by mechanical methods and water addition alone. As practical, the oxalic acid also may be sprayed into the tank to further clean contaminants from the internal tank surfaces (e.g., walls, cooling coils, support columns, equipment). At the conclusion of chemical heel removal, the interior of the waste tank are washed with water to rinse oxalic acid from internal surfaces and dislodge loose contamination.

Chemically-aided cleaning techniques have been evaluated for additional levels of waste removal following mechanical heel removal. A team of knowledgeable and experienced engineers and scientists assessed the current knowledge base and collected and evaluated information available on chemical-based methods for removing residual solids from the waste tanks. [WSRC-TR-2003-00401] As part of this study, the team developed recommendations for chemical treatments to remove residual solids. The cleaning agents identified included:

- oxalic acid,
- a mixture of oxalic acid and citric acid,
- a combination of oxalic acid with hydrogen peroxide,
- nitric acid,
- formic acid, and
- organics.

The results of the evaluation support oxalic acid as the cleaning agent of choice. Nitric acid, formic acid and oxalic acid with hydrogen peroxide were all closely grouped for the next best choice. The mixture of oxalic acid and citric acid rated poorly (primarily due to the fact that it performed less well than oxalic acid and the presence of citrate could adversely impact downstream treatment operations, such as the DWPF). Organics rated even more poorly due to large uncertainties in performance and downstream impacts.

The use of oxalic acid was recommended for a number of reasons. First, oxalic acid has been widely studied and used several times to clean waste tanks at SRS and at other sites within the DOE Complex. Its effect on downstream waste treatment process (e.g., DWPF) and evaporator operations is better known. Oxalic acid has been shown to be effective for a wide variety of sludge types and out-performed nitric acid and other chemical cleaning agents in head-to-head laboratory tests. Lastly, oxalic acid is less corrosive to the carbon steel tanks than nitric acid or a combination of oxalic acid and hydrogen peroxide. [WSRC-TR-2003-00401]

Oxalic acid cleaning of tanks was successfully demonstrated through the cleaning of Tank 16 in the early 1980s. Oxalic acid cleaning in Tank 16 (part of an overall waste removal program which also employed mechanical cleaning) included, along with various water washes, three chemical heel removal campaigns each involving the addition of four weight percent oxalic acid to the waste tank, mixing of the waste tank contents and subsequent transfer of the mixed solution out of the waste tank. The volume of the residuals in the primary tank at the conclusion of the oxalic acid cleaning and water washes was estimated to be approximately 1,000 gallons, however, final inventory determination has not been completed. [SRR-CWDA-2011-00126]

Tanks 5 and 6[66] were cleaned using three large batches of eight weight percent oxalic acid similar to Tank 16 cleaning. This process is referred to as Bulk Oxalic Acid Cleaning. If needed, oxalic acid may be sprayed into the tank to clean contaminants from internal tank surfaces (e.g., walls, cooling coils, support columns, equipment, etc.). The internal surfaces of Tanks 5 and 6 were sprayed with oxalic acid during the cleaning process on those waste tanks. [SRR-CWDA-2011-00033, SRR-CWDA-2011-00005] Oxalic acid was applied multiple times in each tank using various methods (e.g., downcomer, spray nozzle, mixer agitation and non-agitation soak times) which provided data for process evaluation, improved effectiveness and overall process optimization. Oxalic acid cleaning in Tank 5 reduced the volume of residual solids to approximately 3,300 gallons, while the residual solids volume in Tank 6 was

[66] Discussion on Tanks 5 and 6 cleaning is included to demonstrate successful deployment of the oxalic acid cleaning process; however, Tank 5 and 6 are located in the FTF at SRS and is not within the scope of this Draft HTF 3116 Basis Document.

reduced to approximately 3,500 gallons. [SRR-CWDA-2011-00033, SRR-CWDA-2011-00005, M-ESR-F-00160, M-ESR-F-00165] A significant portion of the remaining waste is non-radioactive oxalate compounds that formed during the chemical cleaning process. Formation of these non-radioactive oxalate compounds is demonstrated by a greater than 30 % increase in waste volume between the first and second chemical cleaning cycles and the second and third chemical cleaning cycles for Tank 6 and between the first and second chemical cleaning cycles in Tank 5. [SRR-CWDA-2011-00033, SRR-CWDA-2011-00005, M-ESR-F-00158, M-ESR-F-00165]

As discussed above, chemical cleaning of waste tanks using oxalic acid produces sodium oxalates in the solids slurry that will be eventually included as feed to DWPF. Because of sodium limits and oxalate restrictions on the DWPF feed, preparation of the feed results in a significant amount of additional material being generated that eventually must be processed through SWPF and disposed of in the SDF.[67] The oxalic acid flowsheet evaluations have considered the downstream effects of oxalates on the DWPF process and salt processing to determine quantities of oxalic acid that can be tolerated by the Liquid Waste System. Modeling shows that for every tank that undergoes chemical cleaning, about 51,000 kg of new sodium oxalates (a non-radioactive compound) solids will be created for feed to DWPF. In addition, approximately 500,000 gallons of salt waste will be created. These quantities of oxalates result in additional wash cycles for DWPF feed, increased likelihood of feed breaks to DWPF and extension of the operating life of the entire Liquid Waste System. [SRR-STI-2010-00015] The oxalates are also anticipated to create evaporator foaming and scaling problems. [LWO-SPT-2008-00033] Due to these downstream impacts, the amount of Bulk Oxalic Acid Cleaning in HTF will be carefully controlled to optimize the cleaning effectiveness and the downstream waste treatment processes.

Another example of a chemical cleaning method is Low Temperature Aluminum Dissolution which DOE has deployed at HTF to help remove residual solids. This methodology has been utilized to help reduce the solids volume in SRS Tank 12 and is applicable to sludges that have a high percentage of aluminum, such as sludge that originated from H-Canyon. [X-CLC-H-00921] Under this process, aluminum is dissolved from sludge waste into the supernate by treatment with caustic, followed by decantation and water washing to subsequently remove aluminum. Aluminum solids in the sludge are believed to be present in primarily three compounds – aluminum trihydrate or gibbsite, alumina monohydrate or boehmite, and aluminosilicate. With caustic treatment, the gibbsite form dissolves readily at the relatively low dissolving temperatures possible in the waste tanks. The boehmite form dissolves much more slowly and is somewhat less soluble than gibbsite, but can still be dissolved at relatively low temperatures, given enough time. The aluminosilicate has such a low solubility in waste slurries that it is generally considered insoluble. [SRNS-STI-2008-00021]

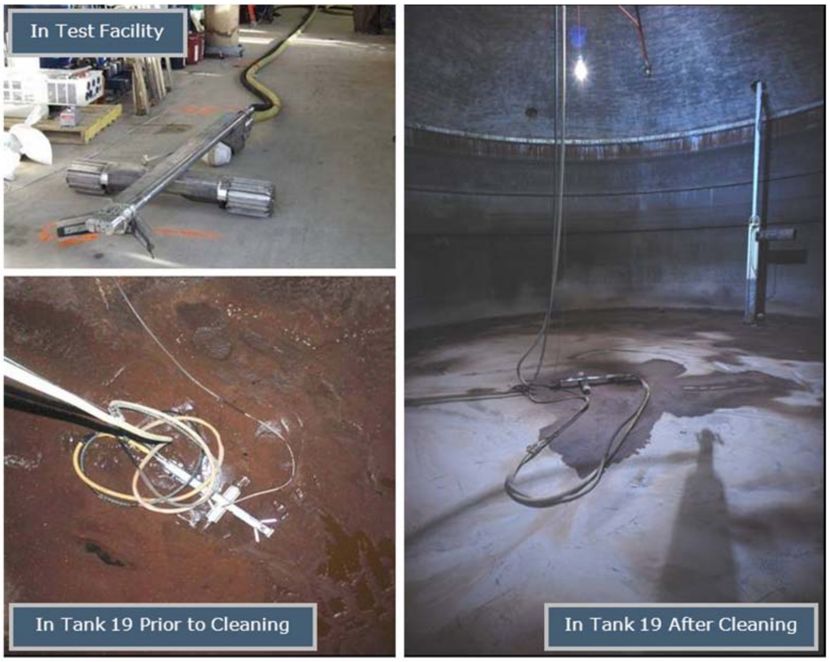
5.2.2.3 Vacuum Heel Removal Cleaning

As the result of a March 2006 DOE-sponsored Tank Cleaning Technical Exchange, a new vacuum technology was identified. The DOE has adapted and successfully used this new technology in unobstructed Type IV tanks, for which there are four in HTF, Tanks 21, 22, 23 and 24. This technology used an ultra-high-pressure water eductor to vacuum residual solids and transport the slurry to a receipt tank. This technology was initially deployed in Type IV tanks with no internal obstructions due the size of the device and the large accompanying tether system.

To deploy this technology in Tank 18 and Tank 19,[68] located at SRS FTF, DOE utilized a cleaning device, called a Mantis, which consists of a mechanical crawler and an eductor assembly that made up a retrieval system utilizing an ultra-high-pressure water eductor to vacuum residual solids and transport the slurry to a receipt tank (Figure 5.2-6). The process system consists of a remotely controlled, in-tank Mantis, an umbilical hose containing hydraulic supply lines and the high-pressure water hoses, in-tank waste retrieval hose, a diesel-driven ultra-high-pressure water pump, a motor-driven high pressure water pump, hydraulic pump skid, a diesel generator, above-ground hose-in-hose transfer lines, WMC and support equipment. The device was inserted into the tank through a 24-inch riser in a folded position. Once inside the tank, the device was unfolded into its operational configuration.

[67] See Appendix A for a brief description of DWPF, SWPF and SDF operations.
[68] Discussion of Tanks 18 and 19 is included for information regarding the use of the Mantis technology; however, Tanks 18 and 19 are located in FTF at SRS and are not within the scope of this Draft HTF 3116 Basis Document.

Figure 5.2-6: Mantis



The Mantis was remotely driven around the waste tank bottom by an operator located in the Control Center. A high pressure hydro-lance at its front was used to break up waste mounds and an eductor was used to vacuum waste from the floor of the waste tanks. The waste traveled through the eductor in-tank waste retrieval hose up into a tee spool piece located on top of the tank riser and then through an above-ground transfer line that terminated inside a WMC installed inside a riser on the receipt tank. An immersion mill, located near the bottom of the WMC, size-reduced solid waste particles so that the particles can be more easily re-suspended in future waste removal activities. [WSRC-TR-2007-00327]

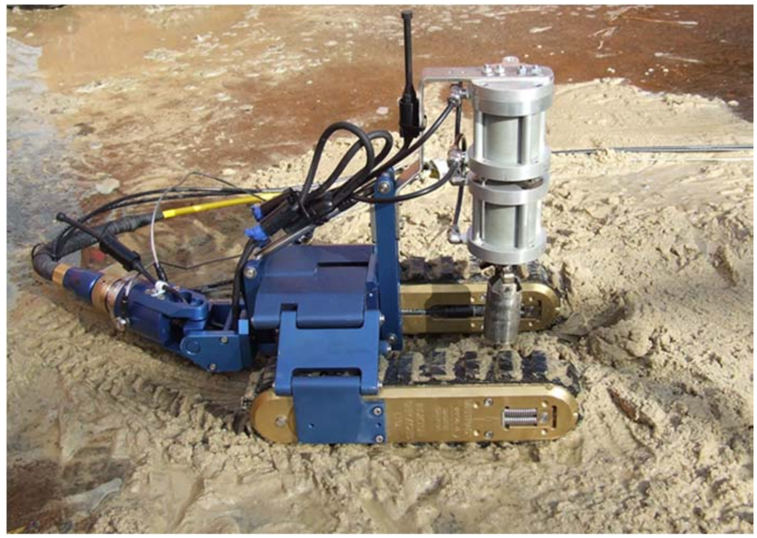
The deployment of this new cleaning device allowed removal of waste from Tanks 18 and 19 to a greater extent than the technologies available when waste removal was previously discontinued due to diminishing returns in 2003 and 2001, respectively.

The working end effecter of the Mantis, the ultra-high-pressure eductor system, effectively vacuumed residual solids and transported the slurry to the receipt tank. The cooling coils in Type I, Type II, Type III and Type IIIA tanks precludes the use of large tethered mechanical crawlers such as the Mantis platform. However, DOE recognizes the potential for future use of vacuum technology deployed on other platforms and continues to evaluate potential deployment on platforms such as alternate mechanical crawlers or robotic arm-based technologies. [SRR-LWE-2012-00082]

5.2.3 Optimization of Existing Technologies

DOE continues to optimize its existing technologies that have been successfully deployed for waste removal. DOE is continuing to pursue small-scale robotic technologies for waste removal and sampling applications in tanks with extensive internal obstructions. For example, a small robotic crawler was developed and utilized to sample both Type I and Type IV tanks at SRS (Figure 5.2-7), and DOE continues to evaluate available robotic technologies for applications in future waste tanks. [SRR-LWE-2012-00082] Such tactical applications of tailored robotic platforms will continue to be used in future waste removal activities in HTF.

Figure 5.2-7: Robotic Sampler at Test Facility



5.3 Removal to the Maximum Extent Practical

As described above, extensive waste removal operations have occurred at SRS. Based on waste removal experience to date and anticipated new technologies, HTF waste removal activities will result in significant collective removal of waste including HRRs.[69] For example, waste removal activities in HTF Tank 16 resulted in removal of over 99 % of the waste volume from the primary tank.[70] [SRR-CWDA-2011-00126] Furthermore, experience to date with waste removal for FTF Tanks 18 and 19 resulted in removal of over 99 % of the waste volume from Tanks 18 and 19, and approximately 99 % of the HRR inventory from Tank 18 and greater than 99 % of the HRR inventory from Tank 19, based on a starting point of the maximum historical radionuclide inventory in those tanks. [SRR-CWDA-2011-00091] In FTF Tanks 5 and 6, waste removal activities resulted in removal of over 99 % of the waste volume from the tanks. [SRR-CWDA-2011-00033, SRR-CWDA-2011-00005, U-ESR-F-00048, SRR-LWE-2011-00245]

Removal of HRR's begins with the removal of the solids and liquid from a waste tank or ancillary structure in a bulk waste removal phase.[71] Following bulk waste removal, heel removal is performed using a mix of technologies described above, as appropriate, accounting for the physical configuration of the tank and the chemical characteristics of the waste.

Throughout the heel removal process, DOE continually evaluates the ongoing effectiveness of the technology being implemented and optimizes the existing technologies. In addition, DOE evaluates the

[69] In this regard, NDAA Section 3116 does not specify "remedial goals" or other numerical objectives and does not require DOE to develop any such removal goals or objectives. Although the cleaning methodologies are expected to collectively remove approximately 99% of HRRs, based on a starting point of the maximum historical radionuclide inventory in the overall HTF, individual waste tanks or ancillary structures may not achieve this level of HRR removal on an individual basis. Demonstration that waste removal within a particular waste tank or ancillary structure has achieved 99% removal of HRRs is not, by itself, a justification for stopping HRR removal activities. In addition, demonstration that residual radionuclide inventory of a given waste tank or ancillary structure is below that assumed in the HTF PA is not sole justification to conclude cleaning activities on an individual waste tank or ancillary structure.

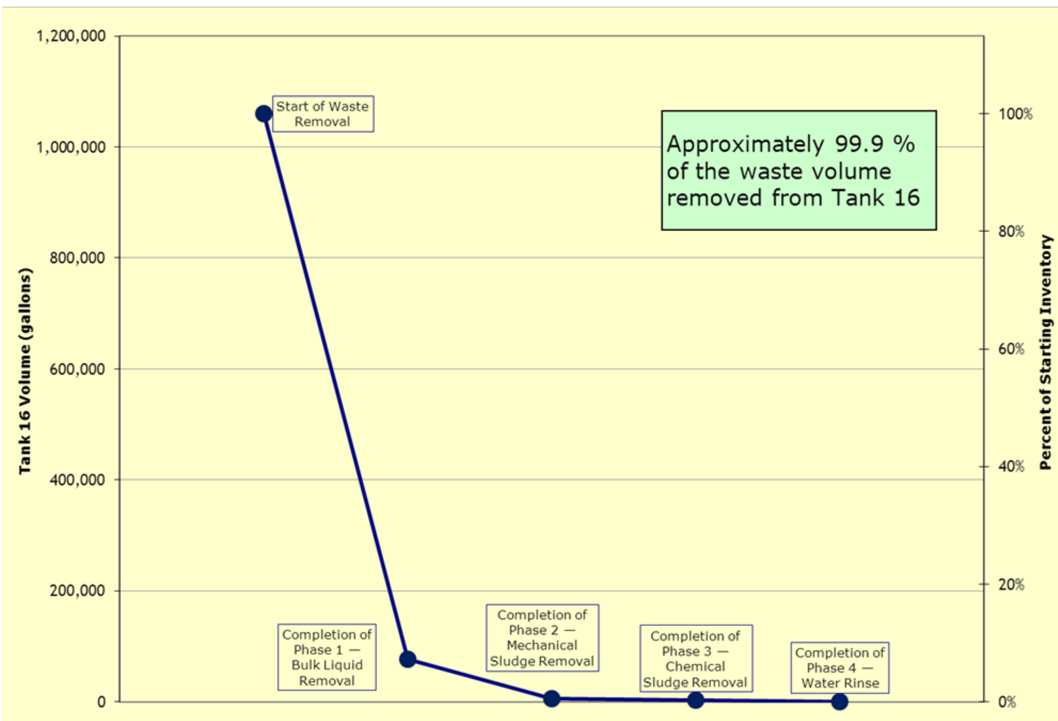
[70] Tank 16 final volume estimate is based on qualitative estimate of residuals; final volume determination is ongoing.

[71] Bulk waste removal efforts have been completed for Tanks 11 and 12 (Type I tanks), and bulk waste removal efforts are currently underway in Tank 13 (a Type II tank); preparation for bulk waste removal efforts in Tank 10 (a Type I tank) are in progress. In addition, DOE has previously performed waste removal activities in various HTF waste tanks to support efficient management of ongoing tank farm operations and preparation of feed batches for DWPF. Bulk sludge removal activities have been performed in HTF Tanks 9, 10, 11, 14, 15, 21, 22 and 42. Bulk saltcake removal has been performed in HTF Tanks 22, 24, 37 and 41. After completion of the waste removal activities in these tanks, the available storage space created within these tanks was subsequently re-used to support ongoing tank farm operations. Although DOE is or will be further removing waste from these tanks to support closure, DOE's prior experience in bulk waste (sludge and saltcake) removal confirms DOE's expertise in effectively using proven technologies to remove tank waste and associated HRRs during the bulk waste removal phase.

usefulness and practicality of additional technology deployment once the existing technology has reached the point of diminished effectiveness for HRR removal. The DOE's approach consists of the following phases: initial technology selection, technology implementation, technology execution, technology effectiveness evaluation and additional technology evaluation.[72] [DOE/SRS-WD-2011-001] Additional description of these phases is provided in Appendix B.

Tank 16, a Type II tank in HTF, has undergone extensive waste removal and tank cleaning activities. In 1972, due to continued leakage from the primary tank to the annulus, the supernate in Tank 16 was transferred out of the waste tank leaving approximately 77,000 gallons of sludge solids in the Tank 16 primary tank. In 1978, Tank 16 became the first tank to utilize slurry pumps to perform waste removal activities. Bulk sludge removal from Tank 16 was carried out in five mixing and pumping campaigns utilizing one slurry pump for the first two campaigns and three slurry pumps for the remainder of the campaigns. The mechanical heel removal effort in Tank 16 was successful in reducing the waste volume in Tank 16 to an estimated 5,250 gallons. In 1980, Tank 16 became the first waste tank to undergo chemical cleaning utilizing oxalic acid and underwent a series of chemical cleaning campaigns using oxalic acid, along with various water washes. During the chemical cleaning activities, three chemical heel removal campaigns each involving the addition of four weight percent oxalic acid to the waste tank, mixing of the waste tank contents and subsequent transfer of the mixed solution out of the waste tank were carried out. The volume of the residuals in the primary tank at the conclusion of the oxalic acid cleaning and water washes was estimated to be approximately 1,000 gallons, however, final inventory determination has not been completed. Figure 5.3-1 shows the overall waste removal effectiveness for the Tank 16 primary tank waste removal activities. [SRR-CWDA-2011-00126]

Figure 5.3-1: Tank 16 Waste Removal



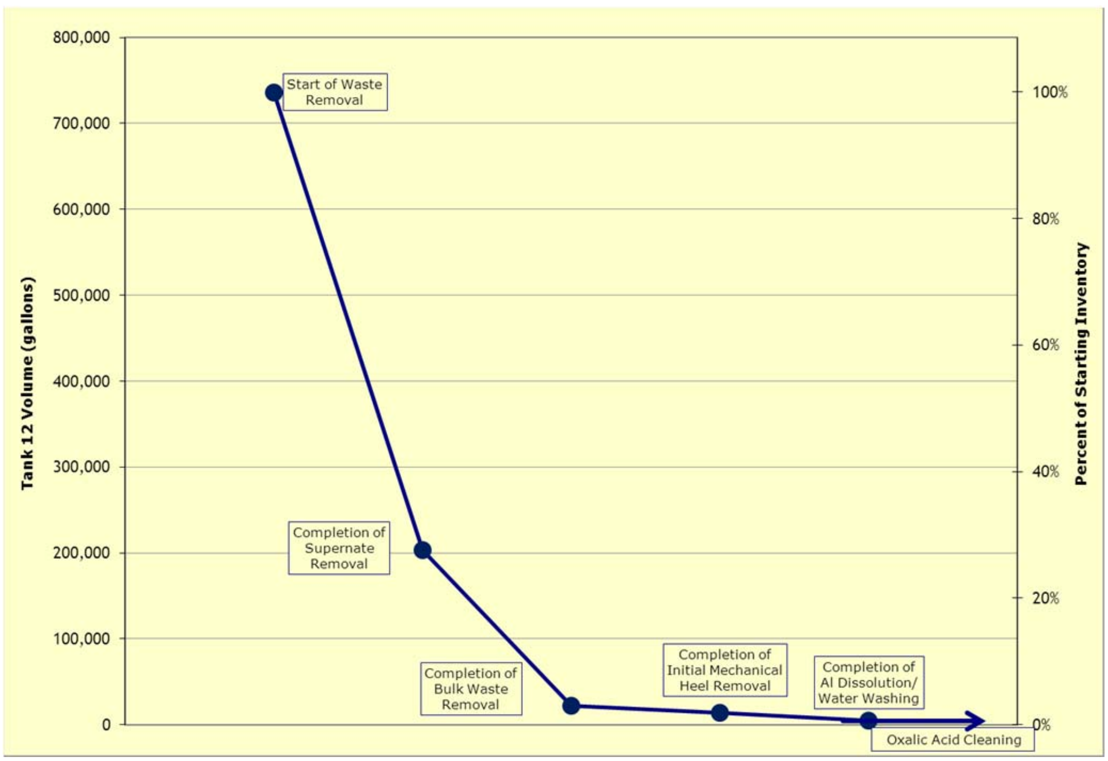
Tank 16 was put into service in 1959 and shortly thereafter leak sites were discovered in the primary tank. In 1960, the majority of waste that had leaked into the annulus was transferred out to another waste tank. Between 1960 and 1971, periodic inspection of the annulus revealed an increase in leak sites and slow but continued seepage into the annulus. In 1972, additional liquid was extracted from the annulus and at that time it was estimated that 6,000 gallons of saltcake remained in the annulus. In 1974, the outside of the primary tank wall was sandblasted to facilitate leak site inspection and about 20 cubic feet of sand

[72] Per the FFA, the waste tanks will be cleaned until DOE-SR, SCDHEC and EPA agree that waste removal may cease.

accumulated in the annulus. In 1976, vacuum operations removed some of the sand from the annulus. In 1977, water was introduced in the annulus to dissolve remaining solids and steam jets were used to increase the temperature and promote circulation. Approximately 1,400 gallons of material were estimated to have been removed from the annulus. [SRR-CWDA-2011-00126] In 2007 and again in 2010, DOE investigated the potential use of vendor supplied robotic equipment to remove additional material from the Tank 16 annulus. DOE is currently evaluating this technology and other alternate technologies to determine the practicality of additional waste removal from the Tank 16 annulus.

Tank 12, a Type I tank in HTF, has undergone bulk waste removal efforts and heel removal activities have been initiated. The largest volume of waste stored in Tank 12 has been approximately 736,000 gallons. [DPSPU 78-11-9] Bulk waste removal efforts within the tank were initiated with supernate removal in 1974. Design and installation of bulk sludge removal equipment began in 2003 and resulted in the installation of four slurry pumps to provide mechanical mixing of the sludge. Bulk waste removal efforts resumed in 2009, were completed in 2010 and involved multiple mixing and transfer sludge removal campaigns. The total volume of solids at the beginning of these campaigns was estimated to be approximately 203,000 gallons. Upon completion of the bulk waste removal efforts in Tank 12 the total volume of sludge remaining was estimated to be approximately 22,000 gallons. [U-ESR-H-00093] Mechanical heel removal utilizing the installed slurry pumps was initiated in 2010 and resulted in removal of approximately 8,000 gallons of sludge. In 2011, additional sludge was removed from Tank 12 utilizing Low Temperature Aluminum Dissolution. The volume of sludge remaining at the conclusion of the Low Temperature Aluminum Dissolution and subsequent water washes was estimated to be approximately 4,400 gallons. [X-CLC-H-00921, SRR-LWP-2012-00037] Preparations for additional chemical heel removal in Tank 12 utilizing oxalic acid are currently in-progress. Figure 5.3-2 depicts the overall waste removal effectiveness for waste removal activities to date in Tank 12.

Figure 5.3-2: Tank 12 Waste Removal

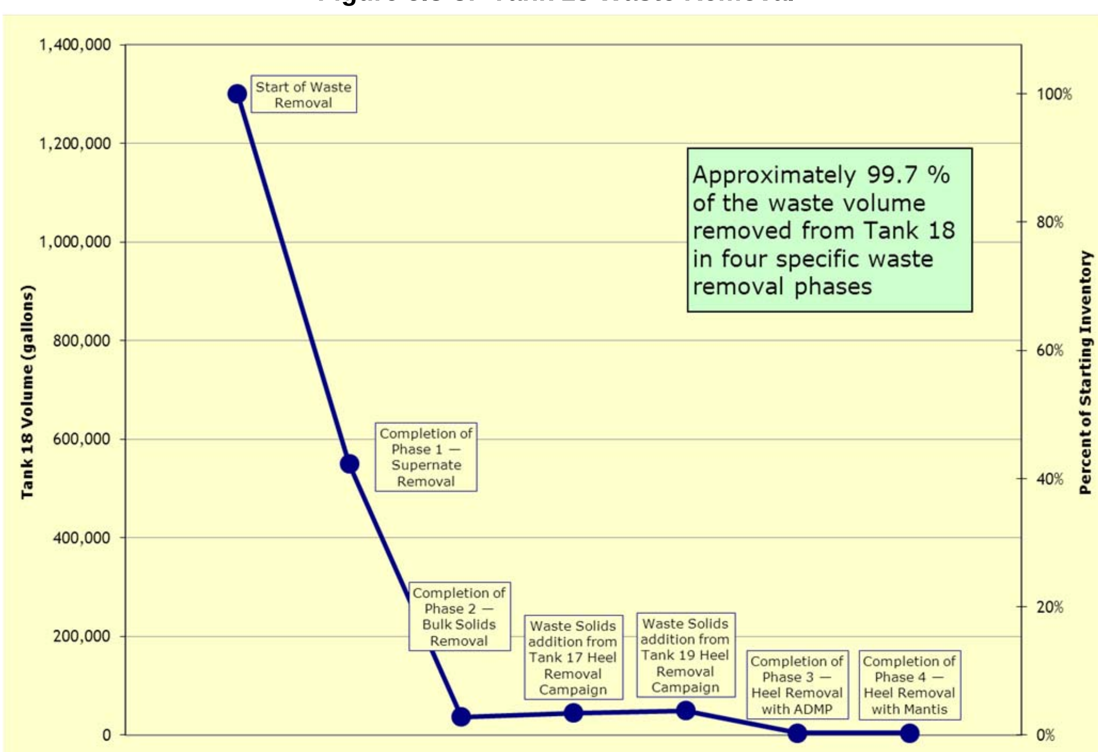


The FTF Type IV tanks, Tanks 17, 18, 19 and 20, which are essentially the same design as the HTF Type IV tanks, have all undergone waste removal and tank cleaning activities resulting in a relatively small quantity of resultant tank residuals. For example, in 1998 following bulk waste removal in Tank 19, DOE used a systematic selection process which was documented in a Systems Engineering Evaluation to select the best available technology at the time for heel removal activities in Tank 19. [PIT-MISC-0040]

Heel removal activities using the selected mechanical removal technology were carried out in 2001. In 2001, a similar selection process was also used to select a removal technology for the heel in Tank 18, similarly a Type IV waste tank. [WSRC-RP-2001-00024] This Tank 18 technology selection took into account additional technology studies conducted since the issuance of the Tank 19 Systems Engineering Evaluation. Heel removal activities were carried out in Tank 18 in 2002 utilizing a different mechanical removal technology. In these initial Tank 18 and Tank 19 heel removal campaigns a series of waste removal phases were carried out in each of the tanks until it was no longer practical to continue with the mechanical removal technologies that were being utilized. In 2006, following initial heel removal campaigns using the tailored mechanical removal techniques, it was determined that it was practical to deploy an alternative vacuum technology, the Mantis (as described above in Section 5.2.2.3), that could result in significant additional waste removal within these tanks.

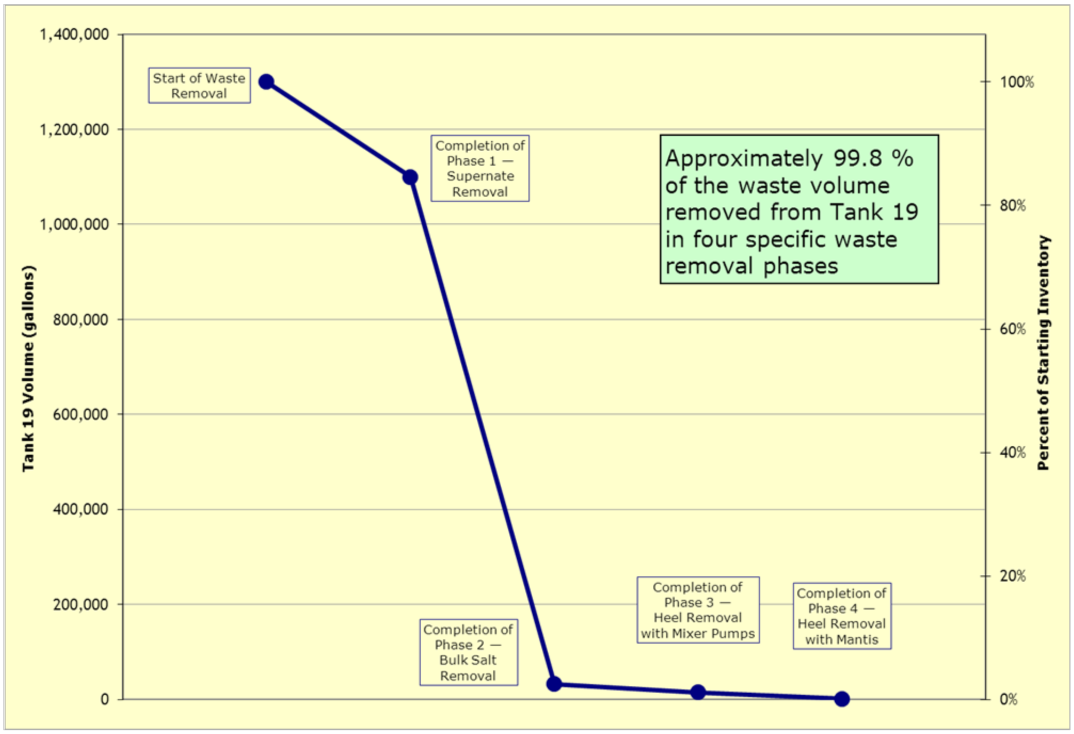
Throughout the heel removal activities in Tank 18 and Tank 19 utilizing the Mantis, DOE continually worked to optimize the effectiveness of the Mantis and minimize the impact on the rest of the Liquid Waste System by adjusting how the sprays were utilized, attempting different vacuuming patterns, using the hose/cable bundle to drag the solids into a concentrated area, or turning off the sprays when possible to improve removal efficiency and reduce space impacts on the receipt tank. During the Mantis campaigns on both Tank 18 and Tank 19, the Mantis became ineffective due to failure of one or more of the in-tank components on the equipment. In both cases, DOE evaluated the costs of repairing the Mantis and the anticipated effectiveness once repaired and determined that it was practical to make the repairs and continue the heel removal operations. The Mantis equipment was utilized within Tank 18 and Tank 19 until it was no longer effective. Factors leading to this decision included such things as: visual observation of remaining tank residuals, transfer line radiation readings, significant increase in ratio of water additions to solids removed and significant equipment degradation. Figure 5.3-3 and Figure 5.3-4 depict the overall waste removal effectiveness for Tanks 18 and 19 respectively. Mantis operations in Tanks 18 and 19 reduced the volume of residual solids to approximately 4,000 gallons in Tank 18 and

Figure 5.3-3: Tank 18 Waste Removal



2,000 gallons in Tank 19. [U-ESR-F-00041, U-ESR-F-00042]

Figure 5.3-4: Tank 19 Waste Removal



Once it was determined that the existing Mantis equipment was no longer effective, alternative HRR removal technologies were reviewed to determine practicality for design, construction, deployment and operation. An evaluation was completed to determine if it was useful to develop and deploy another cleaning technology assuming such a technology could be identified and safely deployed. This evaluation considered whether the costs, such as monetary costs, delays in higher- risk reducing activities, or occupational exposure of site workers to hazardous or potentially hazardous materials, including radioactive materials, outweighed the potential benefits associated with further waste removal in Tanks 18 and 19. Though no new practical technology was identified in the technology evaluation, an upgraded Mantis was considered to have the highest likelihood of success in removing additional residual waste, could be deployed in the least amount of time, and would be the least costly technology alternative to implement. A cost-benefit analysis was performed to determine the potential risk reduction from removing additional residual waste from Tanks 18 and 19. The cost-benefit analysis considered a broad range of costs including resultant schedule impacts on other ongoing cleaning activities and waste disposition activities, as well as the current state of waste removal capabilities and technologies. As a result of the cost-benefit analysis, DOE concluded that the relatively insignificant benefits of removing additional waste from Tank 18 or Tank 19 do not outweigh the costs of implementation or the detrimental impacts to ongoing and future FTF cleaning and stabilization activities to reduce risks to the public, the workers and the environment. Therefore, even if a technology could be identified and deployed, the relatively insignificant reduction of risk associated with further removal of residuals from Tank 18 or Tank 19 would not justify the associated additional costs. [SRR-CWDA-2011-00091]

In consideration of an NRC recommendation in the FTF TER, DOE conducted extensive additional analysis, including an additional Tank 18 waste removal Systems Engineering Evaluation and a new cost-benefit analysis, to provide further demonstration of removal of HRRs to the MEP from Tank 18. [ML112371715, SRR-CWDA-2012-00026] The Systems Engineering Evaluation was performed to identify the most promising technologies for removal of additional HRRs from Tank 18, and included a review of previous tank cleaning evaluations and assessed the potential for deployment of new or emerging technologies. The team performing the Systems Engineering Evaluation did not identify any new or emerging tank cleaning technologies that had not been previously considered by DOE, and identified no other new developments that appeared to be on the horizon. However, the team determined that the tools necessary to implement various cleaning technologies have become more mature in recent years, that more vendors can supply these tools, and that four technologies merited further study. The results of the new Tank 18 waste removal Systems Engineering Evaluation and the new cost-benefit analysis (SRR-CWDA-2012-00026) further supported DOE's conclusion reached in the previous cost-benefit analysis (SRR-CWDA-2011-00091) that removing additional HRRs from Tank 18 would not justify the associated additional costs.

Two Type I tanks have also undergone extensive heel removal campaigns. These two Type I tanks, Tank 5 and Tank 6 in FTF, which are essentially the same design as the HTF Type I tanks, originally contained approximately 34,000 and 25,000 gallons of sludge solids, respectively, at the conclusion of their bulk waste removal campaigns. A Type I tank, such as Tank 5 and Tank 6, represents the most challenging tank for waste removal activities due, in part, to a limited number of access points, horizontal cooling coil runs at the bottom of the waste tank including stacked horizontal runs (often referred to as "fences") that were "field to fit" during the time of waste tank construction and the presence of roof support columns. Experience in Tank 5 and Tank 6 demonstrates DOE's successful deployment of innovative technologies capable of removing HRRs even under the most challenging conditions. [SRR-CWDA-2010-00157, SRR-CWDA-2011-00033, SRR-CWDA-2011-00005] As described in Section 5.2.2, in 2003, DOE performed a Systems Engineering Evaluation to identify, evaluate and select equipment for waste removal tasks to accelerate waste removal and the removal of waste tanks from service. This evaluation resulted in the selection of new mechanical removal technologies in combination with chemical removal technologies, if necessary.

These new mechanical technologies, in combination with the chemical removal technology, were first utilized in Tank 5 and Tank 6. Throughout the initial mechanical heel removal operations in both Tank 5 and Tank 6, DOE performed numerous waste removal phases consisting of liquid addition followed by SMP operation and then pump down of the slurried waste. Prior to each of these phases, DOE evaluated the results from the previous phases and optimized the removal effectiveness by adjusting the indexing of the SMPs or utilizing a hydro-lance to disperse the solids from areas the SMPs were not effectively cleaning. Once it was determined that the existing mechanical cleaning method had reached a point of diminished effectiveness, chemical heel removal cleaning, described in Section 5.2.2.2, was utilized until it too reached a point of diminished effectiveness. The initial plan for both Tank 5 and Tank 6 was to first perform mechanical cleaning of the tank heels and follow that with chemical heel removal. However, at the conclusion of the chemical heel removal cleaning campaign in both tanks, DOE evaluated the tank conditions and determined that it would be practical to deploy additional cleaning methods within the tanks. In Tank 5, for example, following the implementation of three chemical cleaning cycles using a bulk oxalic acid flowsheet, a new mechanical cleaning method utilizing the three existing SMPs in the tank was deployed. Instead of adding liquid, attempting to slurry the solids and then pumping out the solution in a batch fashion, which required the SMP to be turned off at a certain point in the pump down, the operations were modified to allow for a continuous "feed and bleed" to occur. This new methodology was deployed until it was determined that the new methodology had reached diminished returns. A modified version of this "feed and bleed" mechanical cleaning technology was also utilized in Tank 6 as a final cleaning campaign until it had reached diminished returns. [SRR-CWDA-2011-00033, SRR-CWDA-2011-00005]

A qualitative assessment of additional waste removal options for Tanks 5 and 6 indicated that additional waste removal is not practical. Vacuum technology was considered, but the proven Mantis vacuum technology which has been deployed in Type IV tanks (i.e., Tanks 18 and 19) is not feasible due to in-tank obstructions (e.g., cooling coils) in the Type I tanks. Smaller robotic vacuum technology has not reached a technical maturity that would support in-tank deployment. A fourth SMP addition would produce a significant cost and time delay associated with procurement, or if removed from another waste tank, a delay would occur in other Liquid Waste System risk- reduction activities. Furthermore, the effectiveness of additional waste removal utilizing an additional SMP is unknown for the amount of residual solids remaining in Tanks 5 and 6. [SRR-CWDA-2010-00157, SRR-CWDA-2011-00033, SRR-CWDA-2011-00005] Figure 5.3-5 and Figure 5.3-6 depict the overall waste removal effectiveness for Tanks 5 and 6 respectively. Heel removal operations reduced the residual solids to approximately 1,900 gallons and 3,000 gallons respectively. [U-ESR-F-00048, SRR-LWE-2011-00245]

Figure 5.3-5: Tank 5 Waste Removal

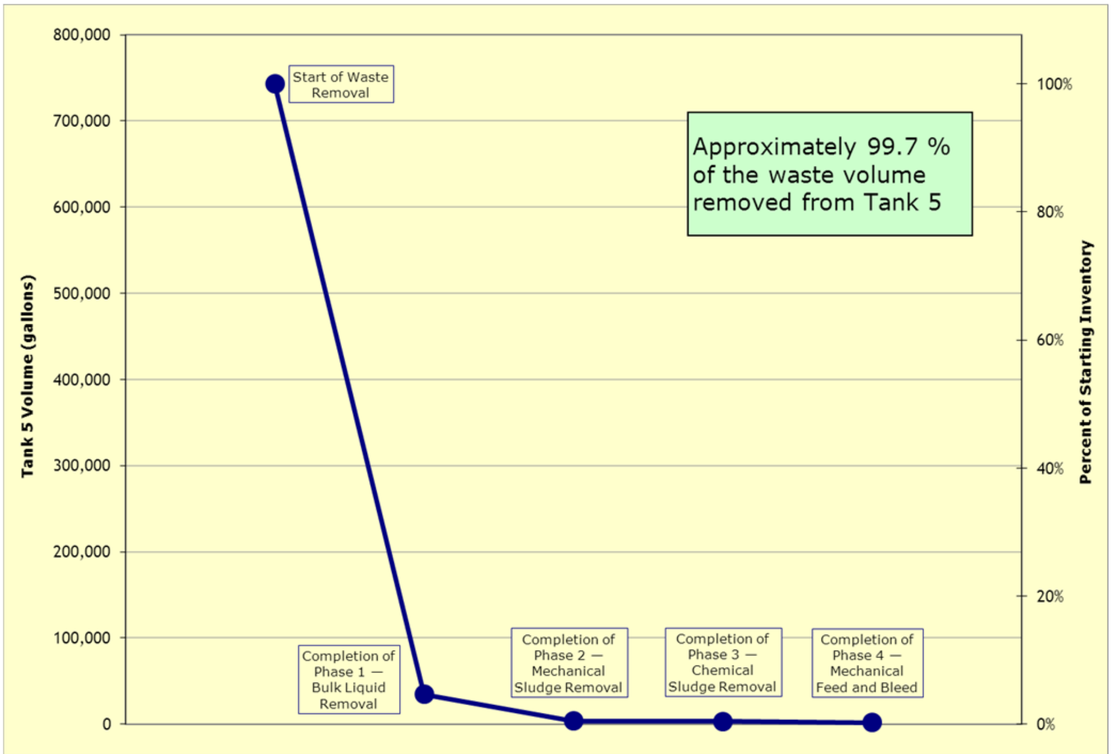
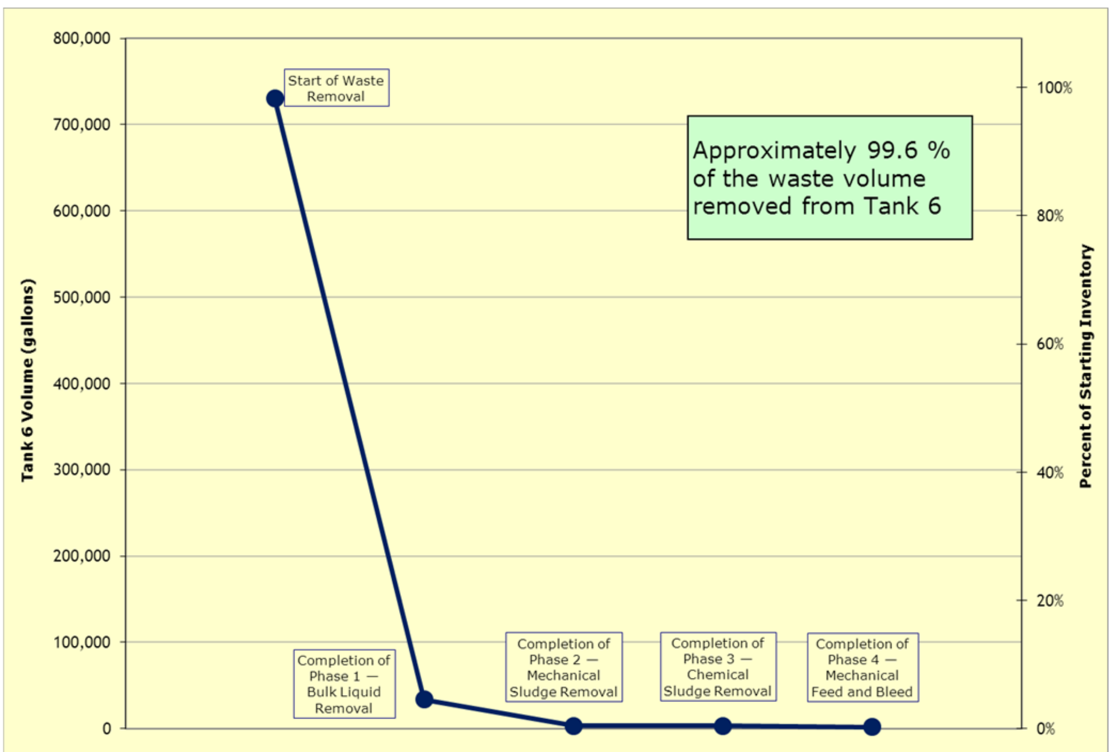


Figure 5.3-6: Tank 6 Waste Removal



DOE reviewed the above information with SCDHEC and EPA as required by the FTF GCP, and the three agencies reached concurrence to suspend waste removal activities and move into final sampling and analysis. Sampling of the waste tanks has been completed and analysis of the samples is also completed. As outlined in Appendix B of this document, DOE will be documenting final waste tank inventories, radionuclide removal effectiveness, with an emphasis on HRRs, and final cost-benefit analysis in the removal report for each waste tank. [SRR-CWDA-2010-00157, EPA_12-08-2010, DHEC_11-22-2010]

Effective radionuclide removal is expected to be achieved during cleaning of the HTF tanks, and the cleaning and/or flushing of ancillary equipment, for a number of reasons. As discussed above, DOE has extensive experience at the SRS Tanks Farms in removing waste, including HRRs, from various types of waste tanks. In HTF, Tank 16 (a Type II tank) has undergone an extensive waste removal campaign. Bulk waste removal efforts have been completed for Tanks 11 and 12 (Type I tanks), and bulk waste removal efforts are currently underway in Tank 13 (a Type II tank); similarly, preparation for bulk waste removal efforts in Tank 10 (a Type I tank) are in progress. Heel removal activities have been initiated in Tank 12. In addition, DOE has previously removed waste (and associated radionuclides) successfully from various HTF waste tanks to support ongoing tank farm and DWPF operations including bulk sludge removal from HTF Tanks 9, 10, 11, 14, 15, 21, 22 and 42, and bulk saltcake removal in HTF Tanks 22, 24, 37 and 41.[73] Furthermore, DOE has successfully removed waste from FTF tanks, including Type IV tanks (including Tanks 18 and 19) as well as Type I tanks (Tanks 5 and 6), which present the most challenging conditions in the SRS Tank Farms. DOE anticipates achieving comparable removal of HRRs from the HTF waste tanks and ancillary structures at the time of closure. Waste removal is primarily influenced by tank type and waste type (e.g., salt waste versus sludge), and the factors are primarily not tank farm dependent. The waste tank types between the two tank farms, FTF and HTF, are essentially identical and the waste removal experience in the FTF Type I and Type IV tanks that have been cleaned provides indicia of the level of waste removal that DOE anticipates achieving in the HTF waste tanks. In addition, DOE's experience to date in the cleaning of Tank 16, a Type II tank in HTF, has shown similar levels of waste removal to that achieved in FTF. The cleaning process employed is thorough, and the process is reviewed and documented during cleaning to maximize practical effectiveness, as explained in Appendix B.

DOE will continue to use such measures as visual (remote) observation of remaining tank residuals against benchmarks in the waste tank primary tank or annulus, as applicable (or ancillary equipment), transfer line radiation readings, sampling and analysis, radiation monitoring, and equipment operating parameters to evaluate efficiency and effectiveness of cleaning operations. Moreover, removal activities on a given tank or ancillary structure will not be considered complete until it is clearly demonstrated and documented, for each individual tank or ancillary structure, that further deployment of the technology is no longer useful or sensible, and that other proven technologies have been evaluated and would not be practical. These documented considerations will take into account a variety of factors including such things as the conditions in the specific waste tank or ancillary structure, the status of the HTF and the overall Liquid Waste System (e.g., available waste tank volume), available proven technologies, the potential benefits from long-term risk reduction from continued HRR removal, increased radiation exposure to site workers or the public due to removal activities, increased risk associated with impacts to other DOE missions involving risk-reducing activities, direct monetary expenditures and effectiveness of available technologies.[74] [DOE/SRS-WD-2011-001]

Furthermore, DOE has a well-documented, contractually required process in place, which requires that throughout the waste tank or ancillary structure cleaning process, numerous reports, evaluations, analyses, data, operational documents, and cost-benefit analyses must be developed for each waste tank and applicable ancillary structure to support completion of waste removal activities. This process is described in detail in Appendix B and has been successfully used to date.[75] As outlined in Appendix B, DOE documents final waste inventories, radionuclide removal effectiveness (with an emphasis on HRRs),

[73] As explained previously, the available storage space created within these tanks was subsequently re-used to support ongoing tank farm operations. DOE is or will be further removing waste, including HRRs, from these tanks to support closure.
[74] Typically, the cost-benefit analysis will be relatively simple and will focus on the financial costs for implementation of new technologies versus the decrease in the potential future doses resulting from the additional removal of residuals. [NUREG-1854]
[75] This process has been implemented successfully for Tanks 18 and 19 in FTF.

and final cost-benefit analysis in a final removal report for each waste tank and applicable ancillary structure. Documentation and information collected from each phase of the removal process eventually contributes to the final removal report, with an emphasis on removal of HRRs, which supports and is required before DOE provides authorization and approval to stabilize (grout) each tank or ancillary structure.[76] This process provides further confidence that HRRs will have been removed to the MEP from the HTF waste tanks and applicable ancillary structures at closure.

5.4 Conclusion

Removal of HRRs to the MEP in HTF waste tanks and ancillary structures occurs through a systematic progression of waste removal and cleaning activities using proven technologies to a point where further removal of HRRs is not sensible or useful in light of the overall benefit to human health, safety and the environment. The preceding subsections demonstrate that the HTF waste tanks, ancillary structures and their associated stabilized residuals will have had HRRs removed to the MEP at the time of closure.

[76] In addition, SCDHEC and EPA must concur in the suspension of waste removal activities and closure of each tank and applicable ancillary structure in accordance with the FFA

6.0 RADIONUCLIDE CONCENTRATIONS OF STABILIZED RESIDUALS, TANKS AND ANCILLARY STRUCTURES

Section Purpose

The purpose of this section is to demonstrate whether the HTF stabilized residuals at closure will meet concentration limits for Class C low-level waste as set out in 10 CFR Part 61, Section 61.55.

Section Contents

This section provides the methodology and assumptions to demonstrate whether the HTF stabilized residuals at closure meet Class C concentration limits.

Key Points

- DOE is using the NRC guidance in NUREG-1854, Category 3 – Site-Specific Averaging in its approach to determining whether the stabilized residuals meet Class C concentration limits.
- The Category 3 approach involves the use of the site-specific intruder-driller scenarios analyzed in the HTF PA.
- In addition, DOE, in previous consultation with the NRC,[77] has derived site-specific concentration averaging expressions for HTF waste based upon the site-specific intruder-driller scenarios and the guidance in NUREG-1854.
- While DOE believes there is a reasonable basis to conclude that none of the stabilized residuals, tanks and ancillary structures will exceed the Class C concentration limits in 10 CFR 61.55, DOE nevertheless is also consulting with the NRC on DOE's disposal plans, as described in this Draft HTF 3116 Basis Document, to take full advantage of the NDAA Section 3116 consultation process.

The NDAA Section 3116(a) provides in pertinent part:

[T]he term "high-level radioactive waste" does not include radioactive waste resulting from the reprocessing of spent nuclear fuel that the Secretary of Energy..., in consultation with the Nuclear Regulatory Commission…, determines –

(3)(A) does not exceed concentration limits for Class C low-level waste as set out in section 61.55 of title 10, Code of Federal Regulations, and will be disposed of—

(i) in compliance with the performance objectives set out in subpart C of part 61 of title 10, Code of Federal Regulations; and

(ii) pursuant to a State-approved closure plan or State-issued permit, authority for the approval or issuance of which is conferred on the State outside of this section; or

(B) exceeds concentration limits for Class C low-level waste as set out in section 61.55 of title 10, Code of Federal Regulations, but will be disposed of—

(i) in compliance with the performance objectives set out in subpart C of part 61 of title 10, Code of Federal Regulations; and

(ii) pursuant to a State-approved closure plan or State-issued permit, authority for the approval or issuance of which is conferred on the State outside of this section; and

(iii) pursuant to plans developed by the Secretary in consultation with the Commission.

[77] NRC suggested during a public Draft FTF 3116 Basis Document scoping meeting held on July 13-14, 2010 that DOE consider this approach. [SRR-CWDA-2010-00091] On page 85 of its FTF TER, NRC stated, "NRC staff has evaluated DOE's methodology for classifying waste and finds the approach an acceptable application of category 3 in NUREG-1854." [ML112371715] The methodology described in this Draft HTF 3116 Basis Document is consistent with the methodology used to support the FTF 3116 Basis Document.

6.1 Waste Concentrations

For the purposes of making a determination under NDAA Section 3116(a)(3), regardless of whether the waste exceeds or does not exceed the concentration limits for Class C low-level waste as set out in 10 CFR 61.55, the Secretary of Energy, in consultation with the NRC, must determine that the waste will be disposed of in compliance with the performance objectives of 10 CFR 61, Subpart C, and that the waste will be disposed of in accordance with State-approved closure plans. In Section 7.0 of this Draft HTF 3116 Basis Document, information is presented that demonstrates that the waste will be disposed of in compliance with the performance objectives of 10 CFR 61, Subpart C. In Section 8.0 of this Draft HTF 3116 Basis Document, information is presented that demonstrates that the waste will be disposed of in compliance with State-approved closure plans.

In situations where the waste exceeds the concentration limits for Class C low-level waste, NDAA Section 3116(a)(3)(B)(iii) provides for consultation with NRC about the disposal plans for the waste. [NDAA_3116]

As discussed in this section, under DOE's disposal plans, the stabilized residuals within the waste tanks and ancillary structures, the waste tanks, and the ancillary structures (including integral equipment) in the HTF are not expected to exceed concentration limits for Class C low-level waste. Nevertheless, DOE is also consulting with the NRC pursuant to the consultation process in NDAA Section 3116(a)(3)(B)(iii) to take full advantage of the consultation process established by NDAA Section 3116. In this regard, DOE is specifically requesting in this Draft HTF 3116 Basis Document that NRC identify what changes, if any, NRC would recommend to DOE's disposal plans as described in the Draft HTF 3116 Basis Document, and DOE intends to consider the NRC recommendations, as appropriate, in the development of DOE's plans. In the following subsections, the methodology for comparison to the Class C concentration limits for radionuclides included in 10 CFR 61.55 is presented. The radionuclides and their associated limits are specified in two separate tables within 10 CFR 61.55 which are reproduced in Table 6.1-1 and Table 6.1-2.

Table 6.1-1: 10 CFR 61.55 Table 1 Class C Concentration Limits

Radionuclides (Long-lived)	Concentration (Ci/m^3)
C-14	8
C-14 in activated metal	80
Ni-59 in activated metal	220
Nb-94 in activated metal	0.2
Tc-99	3
I-129	0.08
Alpha Emitting Transuranic nuclides with half-life greater than five years	[1]100
Pu-241	[1]3,500
Cm-242	[1]20,000

(1) Units are in nanocuries per gram.
[10 CFR 61]

Table 6.1-2: 10 CFR 61.55 Table 2 Class C Concentration Limits

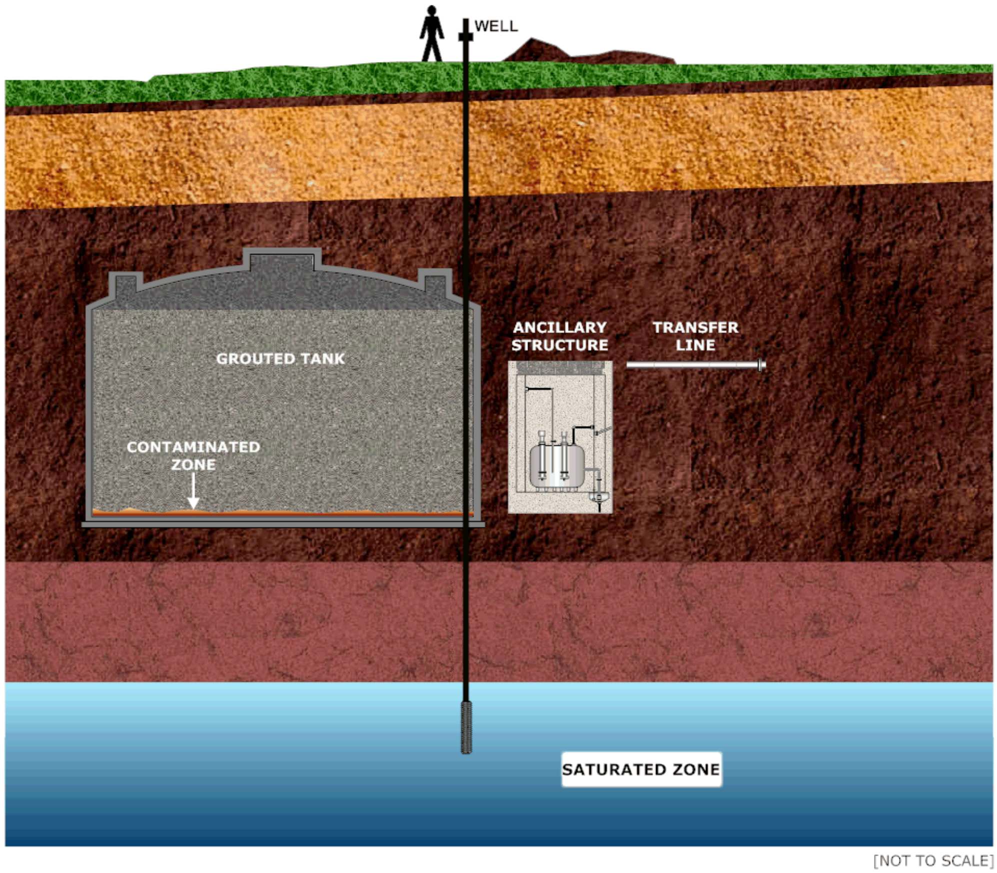
	Concentration (Ci/m^3)		
Radionuclides (Short-lived)	Column 1 [Class A]	Column 2 [Class B]	Column 3 [Class C]
Total of all nuclides with less than 5 year half-life	700	(1)	(1)
H-3	40	(1)	(1)
Co-60	700	(1)	(1)
Ni-63	3.5	70	700
Ni-63 in activated metal	35	700	7000
Sr-90	0.04	150	7000
Cs-137	1	44	4600

(1) There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in the table determine the waste to be Class C independent of these nuclides.
[10 CFR 61]

6.2 Approach to Waste Concentrations for H-Tank Farm Residuals

Prior NRC guidance to determine concentrations for comparison with Class C concentration limits of 10 CFR 61.55 was based on excavation as the likely pathway to expose an inadvertent member of the public to waste in a commercial shallow land burial site. [NUREG-1854] Due to the disposal depth of the HTF stabilized residuals in the waste tanks and the ancillary structures, the basement excavation scenario associated with development of 10 CFR 61.55 Table 1 and 2 is not applicable to the HTF waste tanks and ancillary structures. A more appropriate scenario for the purposes of calculation and comparison with Class C concentration limits is one that assumes the inadvertent intruder drills a groundwater well and drills through a waste tank or ancillary structure (Figure 6.2-1).

Figure 6.2-1: Intruder-Driller Scenarios for Concentration Calculations



Consistent with more recent NRC staff guidance, this Draft HTF 3116 Basis Document follows the Category 3—Site-Specific Averaging approach set forth in NUREG-1854, using the intruder-drilling scenario. [NUREG-1854] This approach utilizes a risk-informed approach that takes into consideration such things as the specific conditions of the HTF site, the final form of the stabilized residuals, site-specific parameters and the final closure configuration.

The following section describes the methodology, and presents the inputs and assumptions, DOE used to compare the concentration of the stabilized residuals in HTF at closure to the Class C concentration limits.

6.3 Methodology

The Category 3—Site-Specific Averaging approach to concentration averaging reflects site-specific conditions of HTF and the final form of the stabilized residuals to account for the volume, concentration and accessibility of the residual material. In order to account for the site-specific conditions relative to HTF, DOE has developed, consistent with the Category 3—Site-Specific Averaging methodology, averaging expressions for HTF based on the results of the inadvertent intruder analysis performed within the HTF PA. [SRR-CWDA-2010-00128] As discussed in the following sections, the concentrations of the stabilized residuals have been compared, utilizing these averaging expressions, against the concentration limits for Class C low-level waste as set out in 10 CFR 61.55 Table 1 and Table 2. For the waste tanks and the ancillary structures, this comparison was based on the projected inventories at closure in the HTF PA.

For purposes of comparison to the Class C concentration limits, and to align with the inputs used in developing the averaging expressions for HTF, the residual inventory used for these calculations are decayed to the inventory that will be present at the time of closure (assumed to be 2032 for the purposes of analysis in the HTF PA). [SRR-CWDA-2010-00128] As discussed below, the radionuclide concentrations of the stabilized residuals are compared, using the sum of fractions methodology and the HTF averaging expressions, to the concentration limits for Class C low-level waste as set out in 10 CFR 61.55 Table 1 and Table 2.

In order to demonstrate compliance with, among other things, the performance objectives set out in 10 CFR Part 61, Subpart C, as required by NDAA Section 3116(a)(3), DOE developed a performance assessment covering closure activities within HTF. [SRR-CWDA-2010-00128] To demonstrate compliance with 10 CFR 61.42, the HTF PA is used to demonstrate that there is reasonable assurance the dose to an inadvertent intruder will remain below 500 mrem/yr taking into consideration a variety of intruder scenarios. DOE utilized the inadvertent human intruder analysis in the HTF PA to develop the HTF averaging expressions used for waste classification.

The HTF PA models used to simulate the performance of the HTF closure system take into account the release of radiological contaminants from the waste tanks and the associated ancillary structures in the HTF and simulates transport of the radiological contaminants through soil and groundwater to the assessment point. The models use numerous HTF-specific input parameters to represent the HTF closure system behavior over time. Many of the input parameters are based on site-specific data (e.g., soil and cementitious materials distribution coefficient (K_d) values) used in transport modeling. In addition, site-specific information is used to model the behavior of individual barriers within the HTF, such as the waste tank carbon steel primary tanks and secondary liners (as applicable), and cementitious barriers. Numerous bioaccumulation factors (e.g., soil-to-plant transfer factors), human health exposure parameters (e.g., water ingestion rates, vegetable consumption data) and dose conversion factors are used in the computer modeling to calculate doses for each of the exposure pathways. All of these parameters factor into development of the HTF averaging expressions. A detailed discussion of the HTF PA intruder analyses is provided in Section 7.2 of this Draft HTF 3116 Basis Document and the HTF PA. [SRR-CWDA-2010-00128]

The stabilized contaminant materials after HTF closure will be primarily located in areas protected by significant materials (e.g., grouted waste tanks, diversion box cell covers and valve box shielding) which are clearly distinguishable from the surrounding soil and make drilling an unlikely scenario based on regional drilling practices. Regional drilling conditions are such that a barrier such as the closure cap erosion barrier, tank top or grout fill are situations that would cause drillers to stop operations and move drilling location. The most vulnerable location for stabilized residuals is in a transfer line which may be near grade-level prior to closure and are of a small size (typically a three-inch diameter or less) which makes them the most credible stabilized contaminants vulnerable during any intruder drilling operations although the probability of hitting a transfer line is small due to the small surface area of transfer lines versus the large HTF footprint. However, for the purposes of developing averaging expressions for HTF, it is assumed that the structures would be penetrated and that construction of the well would be completed.

The following subsections describe how the sum of fractions is calculated for the HTF waste tanks and ancillary structures.

6.3.1 Methodology Inputs

The following inputs are used for the concentration calculations. Generally, the inputs and assumptions underestimate or do not take credit for certain masses or volumes that would lower the calculated radionuclide contribution to the sum of fractions.

- The residual inventory used for the concentration calculations is the total inventory of the residual material within the waste tank or ancillary structure and includes all material on the floor, walls, annulus, sand layer, piping, cooling coils and any structure that will be left in the tank.
- The residual material layer in the waste tanks and ancillary structures, with the exception of transfer lines, is assumed to be spread evenly across the floor of the waste tank or ancillary structure. The residual material within transfer lines is assumed to be spread evenly over the internal surface of the transfer line.
- The volume of the residual material used in the calculations will be determined on an individual basis for each waste tank or ancillary structure at the time it is being removed from service.
- For the purpose of calculating mass-based concentrations, the density of the residual material within the waste tanks is assumed to be the same as the grout used for stabilization.
- Site-specific averaging expressions for HTF, as described in Section 6.3.2, are utilized for comparison against the concentration limits for Class C low-level waste as set out in Table 1 and Table 2 of 10 CFR 61.55.
- The HTF averaging expressions utilizing transfer line volumes, mass and surface area, have been established on the basis of one linear foot of transfer line piping. This basis was used only for the purpose of standardizing the format for use in performing the calculation and does not impact the calculated radionuclide contributions to the sum of fractions. The ratio between these parameters is constant and the length of pipe does not impact the results of the equations.
- The projected inventories for the ancillary structures (other than the transfer lines discussed above) are bounded by the residuals projected for the waste tanks. [SRR-CWDA-2010-00128]

6.3.2 Site-Specific HTF Waste Concentration Calculation Averaging Expressions

As described above, the Category 3—Site-Specific Averaging approach to concentration averaging contemplates consideration of site-specific conditions of HTF and the stabilized residuals. In development of Table 1 and 2 of 10 CFR 61.55, the underlying assumption was that the concentration limits and disposal requirements ensure that an inadvertent intruder (e.g., assuming excavation to a depth of 10 feet for construction of a house) would not receive a dose exceeding an equivalent of 500 mrem/yr to the whole body.[78] At closure, the depth of the stabilized residuals within the HTF waste tanks and ancillary structures will be well below (i.e., greater than 10 feet) the HTF closure cap and a robust intruder barrier (e.g., grouted waste tanks, diversion box cell covers and valve box shielding), as described in the HTF PA, will be in place. [SRR-CWDA-2010-00128] Therefore, the intruder-construction scenario is considered inapplicable. Based on the depth to the stabilized residuals and the presence of a robust intruder barrier, the "Deep waste, intruder barrier" scenario from Table 3-2 of NUREG-1854 is being utilized. In order to account for the site-specific conditions relative to HTF, site-specific averaging expressions for HTF, based on the results of the Inadvertent Intruder Analyses performed within the HTF PA, have been developed.

The HTF PA provides the estimated dose to an intruder who resides within the boundary of the HTF after the period of institutional control (100 years). The intruder is assumed to be exposed via various pathways from water collected from a one-meter well and from drill cuttings. The groundwater associated with the one-meter well is contaminated from all the sources within the HTF (waste tanks, transfer lines and other ancillary structures). In addition, drill cuttings that pull up contamination from striking a transfer line are deposited on the ground surface. The Base Case in the HTF PA assumes that a three-inch transfer line is penetrated by a driller and the cuttings are spread among the garden – thus an additional source is added to the contaminated well source. The impact of drilling into a four-inch transfer line has been presented in the HTF PA with respect to the chronic intruder. The impact of drilling into a waste tank was also considered in the HTF PA with respect to the acute intruder, the well driller. Since the likelihood of a well driller penetrating a waste tank is very remote based on local drilling practices that

[78] NUREG-1854 states, "Although multiple scenarios were considered, the limiting intruder scenario that was used (in deriving the concentration limits for waste classification found in Table 1 and Table 2 of 10 CFR 61.55) was an intruder construction scenario (NRC, 1981). This scenario involved excavation of a foundation for a house. Approximately 232 m^3 [8,190 ft^3] of waste was assumed to be exhumed, and the excavation was assumed to be to a depth of 3 m [10 ft]…The underlying assumption of the values in Tables 1 and 2 of 10 CFR 61.55 is that the concentration limits and disposal requirements ensure that an inadvertent intruder would not receive a dose exceeding an equivalent of 5 mSv [500 mrem] to the whole body." [NUREG-1854]

would terminate the drilling once significant resistance is encountered, a chronic intruder was not assessed. [SRR-CWDA-2010-00128]

Because the stabilized residuals in HTF at closure are expected to have multiple radionuclides from Table 1 and Table 2 of 10 CFR 61.55, the sum of fractions approach for comparing to Class C concentration limits was applied. The sum of fractions approach requires that the concentration of each of the Table 1 and Table 2 radionuclides contained in the stabilized residuals be divided by the appropriate Table 1 or Table 2 Class C concentration limit. The resulting fraction for each of the radionuclides are then totaled for the applicable 10 CFR 61.55 Table 1 or Table 2 radionuclides. If the sum of the fractions is less than 1.0 for the individual tables, the waste is below the Class C concentration limits set out in 10 CFR 61.55. Consistent with the Category 3—Site-Specific Averaging approach, the averaging expressions used to determine the individual radionuclide contribution to the sum of fractions is represented by the following equation:

$$SOF_i = \frac{C_R}{Table\_Value_i} \, x \, Site\,Factor_i$$

where:

SOF_i	=	Radionuclide “i” contribution to the sum of the fractions
C_R	=	Concentration of the drilled source for radionuclide “i” at closure
$Table\_Value_i$	=	Class C concentration limit from 10 CFR 61.55 Table 1 or Table 2 for radionuclide “i”
$Site\ Factor_i$	=	Site-specific factor for radionuclide “i” based on site-specific conditions within the HTF after closure

The HTF averaging expressions, based on the above equation, that DOE is utilizing are shown below.

6.3.2.1 HTF Waste Tank Waste Concentration Calculation Averaging Expressions

For HTF waste tanks individual radionuclide concentrations for the sum of the fractions calculations are determined with the following equations:

For volume-based concentrations:

$$SOF_i = \frac{1}{Table\_Value_i} \, x \, \frac{I_R}{V_R} \, x \, Site\,Factor_i$$

where:

SOF_i	=	Radionuclide “i” contribution to the sum of the fractions
$Table\_Value_i$	=	Class C concentration limit in Ci/m^3 from 10 CFR 61.55 Table 1 or Table 2 for radionuclide “i”
I_R	=	Total tank residuals inventory for radionuclide “i” decayed to date of closure (i.e., 2032), units in curies
V_R	=	Total volume of residuals remaining in the waste tank, units in m^3
$Site\ Factor_i$	=	Site-specific factor for radionuclide “i” at closure (Table 6.3-1 or Table 6.3-2, see Section 6.3.2.3 for derivation of site-specific factors)

For mass-based concentrations:

$$SOF_i = \frac{1}{Table\_Value_i} \, x \, \frac{I_R}{(V_R) \times (\rho_G) \times (1{,}000{,}000)} \, x \, Site\,Factor_i$$

where:

SOF_i	=	Radionuclide "i" contribution to the sum of the fractions
$Table\_Value_i$	=	Class C concentration limit in nCi/g from 10 CFR 61.55 Table 1 for radionuclide "i"
I_R	=	Total tank residuals inventory for radionuclide "i" decayed to date of closure (i.e., 2032), units in nanocuries
V_R	=	Total volume of residuals remaining in the waste tank, units in m^3
ρ_G	=	Density of stabilizing grout, units in g/cm^3
$Site\ Factor_i$	=	Site-specific factor for radionuclide "i" at closure (Table 6.3-1, see Section 6.3.2.3 for derivation of site-specific factors)

The calculated fractions are totaled for the applicable 10 CFR 61.55 Table 1 or Table 2 radionuclides. If the sum of the fractions is less than 1.0 for the individual tables, the waste is below the Class C concentration limits set out in 10 CFR 61.55.

6.3.2.2 HTF Transfer Line Waste Concentration Calculation Averaging Expressions

For HTF transfer lines the individual radionuclide concentrations for the sum of the fractions calculations are determined with the following equations:

For volume-based concentrations:

$$SOF_i = \frac{1}{Table\_Value_i} \, x \, \frac{(I_R) \times (Surface\,Area)}{V_{TL}} \, x \, Site\,Factor_i$$

where:

SOF_i	=	Radionuclide "i" contribution to the sum of the fractions
$Table\_Value_i$	=	Class C concentration limit in Ci/m^3 from 10 CFR 61.55 Table 1 or Table 2 for radionuclide "i"
I_R	=	Transfer line residuals inventory for radionuclide "i" decayed to date of closure (i.e., 2032), units in Ci/ft^2
$Surface\ Area$	=	Transfer line internal surface area for one linear-foot of transfer line piping, units in ft^2
V_{TL}	=	Total volume of piping material for one linear-foot of transfer line piping, units in m^3
$Site\ Factor_i$	=	Site-specific factor for radionuclide "i" at closure (Table 6.3-3 or Table 6.3-4, see Section 6.3.2.3 for derivation of site-specific factors)

For mass-based concentrations:

$$SOF_i = \frac{1}{Table\_Value_i} \, x \, \frac{(I_R) \times (Surface\,Area)}{M_{TL}} \, x \, Site\,Factor_i$$

where:

SOF_i	=	Radionuclide "i" contribution to the sum of the fractions
$Table\_Value_i$	=	Class C concentration limit in nCi/g from 10 CFR 61.55 Table 1 for radionuclide "i"
I_R	=	Transfer line residuals inventory for radionuclide "i" decayed to date of closure (i.e., 2032), units in nCi/ft^2

Surface Area	=	Transfer line internal surface area for one linear-foot of transfer line piping, units in ft^2
M_{TL}	=	Total mass of piping material for one linear-foot of transfer line piping, units in g
Site Factor$_i$	=	Site-specific factor for radionuclide "i" at closure (Table 6.3-3, see Section 6.3.2.3 for derivation of site-specific factors)

The calculated fractions are totaled for the applicable 10 CFR 61.55 Table 1 or Table 2 radionuclides. If the sum of the fractions is less than 1.0 for the individual tables, the waste is below the Class C concentration limits set out in 10 CFR 61.55.

6.3.2.3 Site-Specific Factors for Use in HTF Averaging Expressions

The site-specific factors in the HTF averaging expressions discussed previously were developed to account for site-specific conditions while ensuring the same protection as the concentration limits in Table 1 and Table 2 and the Part 61.55 analysis provides. To develop the site-specific factors, the results of the HTF PA inadvertent intruder analyses along with the HTF PA inventory at closure were utilized. The HTF PA deterministic model and its associated dose calculation methodology was utilized to determine the dose to the chronic intruder assuming the one-meter well contaminated source and one of three drill cutting sources including a three-inch diameter transfer line, a four-inch diameter transfer line or a waste tank. Because it is a major contributor to the peak dose from the one-meter well in the HTF, Tank 13 was used for determining waste tank site-specific factors. The peak dose for each radionuclide, regardless of the time of the peak, was determined and site-specific factors were developed based on the assumed concentrations at closure from the drill cutting source. For the waste tank analysis, the time-period evaluated started at 500 years after closure and for transfer lines the time-period started at 100 years after closure. Although the HTF closure design does provide a robust intruder barrier that would prevent intrusion into the waste for the first 500 years after closure, for conservatism, the HTF PA evaluated the transfer line scenario beginning at 100 years after closure. Therefore, in selecting the peak doses for the transfer line scenarios, the peak dose was not just the dose after 500 years but also included any individual radionuclide peaks which may have occurred between the 100- and 500-year period.

To determine, based on the inadvertent intruder analysis performed within the HTF PA, the individual radionuclide site-specific factors that would result in an inadvertent intruder under the HTF site-specific conditions receiving an equivalent dose, 500 mrem/yr, to that used in developing the 10 CFR 61.55 concentration limits, the following equation was used:

$$Site\ Factor_i = \frac{Table\_Value_i}{C_{PA}}\ x\ \frac{Dose_i}{500\,mrem/yr}$$

where:

Site Factor$_i$	=	Site-specific factor for radionuclide "i" at closure
Table_Value$_i$	=	Class C concentration limit from 10 CFR 61.55 Table 1 or Table 2 for radionuclide "i"
C_{PA}	=	Concentration, based on the HTF PA inventory at closure, of the drilled source for radionuclide "i"
Dose$_i$	=	Peak dose, based on results of the HTF PA, that occurs beyond 100 years (for transfer lines) or beyond 500 years (for waste tank) after closure, for radionuclide "i", units in mrem/yr

Using values for the HTF PA closure inventory along with the mass, for mass based limits, and volume, for volume based limits, of the residual material, the radionuclide concentrations at closure were determined. The calculated concentration for each radionuclide, the peak dose for each radionuclide and the equation developed above, were then used to determine the site-specific factors, on a radionuclide basis, for the three different sources (i.e., three-inch diameter transfer line, a four-inch diameter transfer line or a waste tank) to be used in the site-specific averaging expression as shown in Section 6.3.2.1 and 6.3.2.2.

Recognizing that the peak dose for a specific radionuclide may be dominated by the contaminated groundwater source and not the drilling source, the site-specific factor for the transfer lines was set at the limiting value based on either the three-inch diameter transfer line or the four-inch diameter transfer line.

Table 6.3-1 and Table 6.3-2 provide the HTF waste tank site-specific factors for 10 CFR Table 1 and Table 2 radionuclides, respectively, which are used in the HTF averaging expressions. Table 6.3-3 and Table 6.3-4 provide the HTF transfer line site-specific factors for 10 CFR Table 1 and Table 2 radionuclides, respectively, which are used in the HTF averaging expressions. [SRR-CWDA-2012-00109]

Table 6.3-1: HTF Waste Tank Site-Specific Factors for 10 CFR 61.55 Table 1 Radionuclides

Table 1 Radionuclide	Site-Specific Factor
C-14	3.0E-02
Ni-59	1.0E-01
Nb-94	8.4E-03
Tc-99	5.8E-01
I-129	7.0E+00
Np-237	9.3E-03
Pu-238	9.5E-06
Pu-239	2.2E-03
Pu-240	9.2E-04
Pu-241	4.9E-04
Pu-242	1.3E-02
Pu-244	1.3E-02
Am-241	4.5E-04
Am-242m	2.0E-03
Am-243	2.5E-02
Cm-243	1.4E-06
Cm-244	4.8E-06
Cm-245	1.8E-02
Cm-247	3.1E-02
Cm-248	2.5E-01
Cf-249	3.9E-04
Cf-251	6.1E-04

Note: Radionuclides listed are from SRR-CWDA-2010-00023. Only the 10 CFR 61.55 Table 1 radionuclides in the tank inventory are listed.

Table 6.3-2: HTF Waste Tank Site-Specific Factors for 10 CFR 61.55 Table 2 Radionuclides

Table 2 Radionuclide	Site-Specific Factor
H-3	(1)
Co-60	(1)
Ni-63	1.2E-03
Sr-90	3.1E-03
Cs-137	8.4E-04

(1) There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in the table determine the waste to be Class C independent of these nuclides.

Note: Radionuclides listed are from SRR-CWDA-2010-00023. Only the 10 CFR 61.55 Table 2 radionuclides in the tank inventory are listed.

Table 6.3-3: HTF Transfer Line Site-Specific Factors for 10 CFR 61.55 Table 1 Radionuclides

Table 1 Radionuclide	Site-Specific Factor
C-14	1.6E+03
Ni-59	2.0E+02
Nb-94	1.7E+02
Tc-99	2.1E+00
I-129	8.7E+03
Np-237	2.0E+01
Pu-238	3.7E-04
Pu-239	1.1E+00
Pu-240	5.3E-01
Pu-241	4.5E-02
Pu-242	1.6E+02
Pu-244	3.7E+04
Am-241	5.3E-02
Am-242m	1.5E-02
Am-243	1.4E+01
Cm-243	6.4E-05
Cm-244	9.4E-06
Cm-245	1.0E+03
Cm-247	7.3E+11
Cm-248	5.7E+12
Cf-249	3.9E+01
Cf-251	4.7E+08

Note: Radionuclides listed are from SRR-CWDA-2010-00023. Only the 10 CFR 61.55 Table 1 radionuclides in the transfer line inventory are listed.

Table 6.3-4: HTF Transfer Line Site-Specific Factors for 10 CFR 61.55 Table 2 Radionuclides

Table 2 Radionuclide	Site-Specific Factor
H-3	(1)
Co-60	(1)
Ni-63	1.5E-02
Sr-90	1.5E+01
Cs-137	4.3E+00

(1) There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in the table determine the waste to be Class C independent of these nuclides.

Note: Radionuclides listed are from SRR-CWDA-2010-00023. Only the 10 CFR 61.55 Table 2 radionuclides in the transfer line inventory are listed.

6.4 Waste Concentration Calculations

The following subsections provide calculations of radionuclide concentrations and compare those concentrations to the Class C concentration limits set out in 10 CFR 61.55.

6.4.1 Waste Tank Concentration Calculation

For this calculation, the best estimate residual radionuclide inventory and residual volume for Tank 32 based on the HTF PA projected inventory at closure is used. [SRR-CWDA-2010-00023] This tank was selected on the basis that it represents the waste tank grouping (i.e., Type III/IIIA-Sludge) that has the highest resulting sum of the fractions based on the HTF PA projected inventories. [SRR-CWDA-2012-00129] The contribution of each radionuclide to the sum of the fractions was calculated using the HTF averaging expressions presented in Section 6.3.2.1 for a mass or volume basis as necessary. For example, using the inventory values for C-14 and Pu-241, the mass- and volume-based averaging expressions from Section 6.3.2.1 become:

For the volume-based C-14 fraction of Class C concentration limit:

$$SOF_{[C-14]} = \frac{1}{8.0\mathrm{E}+00 Ci/m^3} x \frac{(1.0\mathrm{E}+00\ Ci)}{15.1\ m^3} x3.0\mathrm{E}-02 = 2.5\mathrm{E}\text{-}04$$

For the mass-based Pu-241 fraction of Class C concentration limit:

$$SOF_{[Pu-241]} = \frac{1}{3.5E+03nCi/g} x \frac{(4.6\mathrm{E}+12\ nCi)}{(15.1m^3)\times(1.97g/cm^3)\times(1.0\mathrm{E}+06cm^3/m^3)} x4.9\mathrm{E}-04 = 2.2\mathrm{E}\text{-}02$$

The remainder of the Table 1 and Table 2 radionuclides are calculated similarly and the results are presented in Table 6.4-1 and Table 6.4-2.

Table 6.4-1: Sum of the Fractions Calculation Using the HTF PA, Revision 1 Inventory for Tank 32 (10 CFR 61.55 Table 1 Radionuclides)

Table 1 Radionuclide	Tank Inventory (Ci)	Class C Concentration Limit[a]	Fraction of Class C Concentration Limit
C-14	1.0E+00	8.0E+00 Ci/m3	2.5E-04
Ni-59	1.0E+00	2.2E+02 Ci/m3	3.0E-05
Nb-94	1.1E-01	2.0E-01 Ci/m3	3.1E-04
Tc-99	9.7E+00	3.0E+00 Ci/m3	1.2E-01
I-129	6.7E-03	8.0E-02 Ci/m3	3.9E-02
Np-237	4.0E-01	1.0E+02 nCi/g	1.2E-03
Pu-238	1.5E+04	1.0E+02 nCi/g	4.8E-02
Pu-239	2.4E+02	1.0E+02 nCi/g	1.8E-01
Pu-240	1.5E+02	1.0E+02 nCi/g	4.6E-02
Pu-241	4.6E+03	3.5E+03 nCi/g	2.2E-02
Pu-242	1.0E+00	1.0E+02 nCi/g	4.4E-03
Pu-244	1.0E+00	1.0E+02 nCi/g	4.4E-03
Am-241	1.1E+03	1.0E+02 nCi/g	1.7E-01
Am-242m	1.0E+00	1.0E+02 nCi/g	6.7E-04
Am-243	1.0E+00	1.0E+02 nCi/g	8.4E-03
Cm-243	1.0E+00	1.0E+02 nCi/g	4.7E-07
Cm-244	2.2E+03	1.0E+02 nCi/g	3.5E-03
Cm-245	1.0E+00	1.0E+02 nCi/g	6.0E-03
Cm-247	1.0E+00	1.0E+02 nCi/g	1.0E-02
Cm-248	1.0E+00	1.0E+02 nCi/g	8.4E-02
Cf-249	1.0E+00	1.0E+02 nCi/g	1.3E-04
Cf-251	1.0E+00	1.0E+02 nCi/g	2.0E-04
		Sum of the Fractions	**7.4E-01**

[a] Values from 10 CFR 61.55 Table 1.
Note: Inventory values are from SRR-CWDA-2010-00023. Only the 10 CFR 61.55 Table 1 radionuclides in the tank inventory are listed.

Table 6.4-2: Sum of the Fractions Calculation Using the HTF PA, Revision 1 Inventory for Tank 32 (10 CFR 61.55 Table 2 Radionuclides)

Table 2 Radionuclide	Tank Inventory (Ci)	Class C Concentration Limit(Ci/m^3)[a]	Fraction of Class C Concentration Limit
H-3	1.0E+00	(1)	NA
Co-60	1.0E+00	(1)	NA
Ni-63	7.9E+02	7.0E+02	8.9E-05
Sr-90	2.0E+04	7.0E+03	5.9E-04
Cs-137	5.5E+03	4.6E+03	6.6E-05
		Sum of the Fractions	**7.4E-04**

[a] Values from 10 CFR 61.55 Table 2.
(1) There are no limits established for these radionuclides in Class C waste.
NA - Not Applicable
Note: Inventory values are from SRR-CWDA-2010-00023. Only the 10 CFR 61.55 Table 2 radionuclides in the tank inventory are listed.

The sum of the fractions from Table 6.4-1 and Table 6.4-2 are 7.4E-01 and 7.4E-04, respectively. Using the inventory values assumed for this calculation, the stabilized residuals would not exceed Class C concentration limits.

6.4.2 Transfer Line Concentration Calculation

For this calculation, the HTF PA estimated residual inventory for a three-inch transfer line is used.[79] [SRR-CWDA-2010-00023] This inventory was selected on the basis that over 98 % of the transfer lines located in HTF are three-inch transfer lines or smaller. The contribution of each radionuclide to the sum of the fractions was calculated using the averaging expressions presented in Section 6.3.2.2 for a mass or volume basis as necessary. For example, using the inventory values for C-14 and Pu-241, and assuming schedule 40 three-inch piping, the mass- and volume-based averaging expressions from Section 6.3.2.2 become:

For the volume-based C-14 fraction of Class C concentration limit:

$$SOF_{[C-14]} = \frac{1}{8.0\mathrm{E}+00 Ci/m^3} x \frac{(1.8\mathrm{E}-09\ Ci/\ ft^2)\times(8.03\mathrm{E}-01 ft^2)}{4.38\mathrm{E}-04\ m^3} x1.6\mathrm{E}+03 = 6.6\mathrm{E}\text{-}04$$

For the mass-based Pu-241 fraction of Class C concentration limit:

$$SOF_{[Pu-241]} = \frac{1}{3.5E+03 nCi/g} x \frac{(2.2\mathrm{E}+05\ nCi/\ ft^2)\times(8.03\mathrm{E}-01 ft^2)}{3{,}438\ g} x4.5\mathrm{E}-02 = 6.6\mathrm{E}\text{-}04$$

The remainder of the Table 1 and Table 2 radionuclides are calculated similarly and the results are presented in Table 6.4-3 and Table 6.4-4.

[79] The inventory used for this calculation is based on the three-inch transfer line inventory developed to support the HTF PA. [SRR-CWDA-2010-00023]

Table 6.4-3: Sum of the Fractions Calculation Using the HTF PA, Revision 1 Inventory for a Three-inch Transfer Line (10 CFR 61.55 Table 1 Radionuclides)

Table 1 Radionuclide	3-inch Transfer Line Inventory[80] (Ci/ft^2)	Class C Concentration Limit[a]	Fraction of Class C Concentration Limit
C-14	1.8E-09	8.0E+00 Ci/m3	6.6E-04
Ni-59	1.7E-06	2.2E+02 Ci/m3	2.8E-03
Nb-94	3.9E-10	2.0E-01 Ci/m3	6.1E-04
Tc-99	1.7E-05	3.0E+00 Ci/m3	2.2E-02
I-129	1.8E-10	8.0E-02 Ci/m3	3.6E-02
Np-237	7.5E-08	1.0E+02 nCi/g	3.5E-03
Pu-238	1.1E-03	1.0E+02 nCi/g	9.5E-04
Pu-239	1.8E-05	1.0E+02 nCi/g	4.6E-02
Pu-240	1.1E-05	1.0E+02 nCi/g	1.4E-02
Pu-241	2.2E-04	3.5E+03 nCi/g	6.6E-04
Pu-242	3.1E-08	1.0E+02 nCi/g	1.2E-02
Pu-244	1.4E-10	1.0E+02 nCi/g	1.2E-02
Am-241	1.4E-04	1.0E+02 nCi/g	1.7E-02
Am-242m	1.0E-07	1.0E+02 nCi/g	3.5E-06
Am-243	2.2E-06	1.0E+02 nCi/g	7.2E-02
Cm-243	5.3E-08	1.0E+02 nCi/g	7.9E-09
Cm-244	1.8E-05	1.0E+02 nCi/g	4.0E-07
Cm-245	7.3E-09	1.0E+02 nCi/g	1.7E-02
Cm-247	1.7E-17	1.0E+02 nCi/g	2.9E-02
Cm-248	1.8E-17	1.0E+02 nCi/g	2.4E-01
Cf-249	9.5E-17	1.0E+02 nCi/g	8.7E-12
Cf-251	3.3E-18	1.0E+02 nCi/g	3.6E-06
		Sum of the Fractions	**5.3E-01**

a Values from 10 CFR 61.55 Table 1.
Note: Inventory values are from SRR-CWDA-2010-00023. Only the 10 CFR 61.55 Table 1 radionuclides in the transfer line inventory are listed.

Table 6.4-4: Sum of the Fractions Calculation Using the HTF PA, Revision 1 Inventory for a Three-inch Transfer Line (10 CFR 61.55 Table 2 Radionuclides)

Table 2 Radionuclide	3-inch Transfer Line Inventory[81] (Ci/ft^2)	Class C Concentration Limit(Ci/m^3) [a]	Fraction of Class C Concentration Limit
H-3	5.3E-07	(1)	NA
Co-60	3.7E-06	(1)	NA
Ni-63	1.2E-04	7.0E+02	4.7E-06
Sr-90	2.7E-02	7.0E+03	1.1E-01
Cs-137	6.1E-03	4.6E+03	1.0E-02
		Sum of the Fractions	**1.2E-01**

a Values from 10 CFR 61.55 Table 2.
(1) There are no limits established for these radionuclides in Class C waste.
NA - Not Applicable
Note: Inventory values are from SRR-CWDA-2010-00023. Only the 10 CFR 61.55 Table 2 radionuclides in the tank inventory are listed.

The sum of the fractions from Table 6.4-3 and Table 6.4-4 are 5.3E-01 and 1.2E-01, respectively. Using the inventory values assumed for this calculation, the stabilized residuals in this three-inch transfer line would not exceed Class C concentration limits.

6.5 Conclusion

As demonstrated by the above discussion, the stabilized HTF wastes at closure are anticipated to meet concentration limits for Class C low-level waste as set out in 10 CFR 61.55. Nevertheless, DOE is also consulting with the NRC on its disposal plans for HTF pursuant to the consultation process in NDAA

[80] See footnote 79.
[81] See footnote 79.

Section 3116(a)(3)(B)(iii) to take full advantage of the consultation process established by NDAA Section 3116. In this regard, DOE is specifically requesting in this Draft HTF 3116 Basis Document that NRC identify what changes, if any, NRC would recommend to DOE's disposal plans as described in the Draft HTF 3116 Basis Document, and DOE intends to consider the NRC recommendations, as appropriate, in the development of DOE's plans.

7.0 THE WASTE WILL BE DISPOSED OF IN ACCORDANCE WITH THE PERFORMANCE OBJECTIVES SET OUT IN 10 CFR 61, SUBPART C

Section Purpose

The purpose of this section is to demonstrate that the stabilized residuals in the HTF waste tanks and ancillary structures, the waste tanks, and the ancillary structures (including integral equipment) will be disposed of in compliance with the performance objectives for land disposal of low-level waste found in 10 CFR Part 61, Subpart C, Sections 61.41 through 61.44.

Section Contents

This section describes key parameters and results from the HTF PA that demonstrate compliance with the performance objectives in 10 CFR 61.41 and 10 CFR 61.42, DOE regulatory and contractual requirements which ensure compliance with 10 CFR 61.43 and relevant factors of HTF siting, design, use, operation and closure, which ensure compliance with 10 CFR 61.44.

Key Points

- Based on the HTF PA there is reasonable assurance that the 10 CFR 61.41 and 10 CFR 61.42 performance objectives will be met.
- The DOE is using an assumed institutional control period of 100 years for the purpose of analysis although the SRS Land Use Plan [PIT-MISC-0041] calls for federal ownership in perpetuity.
- For the purpose of calculating doses to a member of the public, a 100-meter buffer zone around the HTF boundary is assumed.
- The HTF PA analysis demonstrates compliance with the performance objective in 10 CFR 61.41 based on compliance with a 25 mrem/yr peak all-pathways Total Effective Dose Equivalent (TEDE) to a hypothetical member of the public.
- The HTF PA analysis demonstrates compliance with the performance objective in 10 CFR 61.42 based on consideration of a dose of 500 mrem/yr to a future hypothetical inadvertent intruder of the closed HTF.
- The DOE regulatory and contractual requirements for HTF facilities and activities establish dose limits based on 10 CFR 835 and relevant DOE Orders. These dose limits correspond to the radiation protection standards set out in 10 CFR 20, as cross-referenced in 10 CFR 61.43.
- The HTF waste tanks will be filled with grout to provide long-term stability.
- The HTF ancillary structures may be filled with appropriate fill materials, as necessary, to provide long-term stability. There are currently no plans to grout or fill the HTF transfer lines.

The NDAA Section 3116(a) provides in pertinent part:

> *[T]he term "high-level radioactive waste" does not include radioactive waste resulting from the reprocessing of spent nuclear fuel that the Secretary of Energy..., in consultation with the Nuclear Regulatory Commission…, determines –*
>
> > *(3)(A)(i) [Will be disposed of] in compliance with the performance objectives set out in subpart C of part 61 of title 10, Code of Federal Regulations.*

The 10 CFR 61, Subpart C, Sections 61.41 through 61.44 detail performance objectives the NRC established for land disposal of radioactive waste. These performance objectives address protection of the general population from radioactivity releases (10 CFR 61.41), individuals from inadvertent intrusion on the disposal site (10 CFR 61.42), protection of workers and the public during disposal facility operations (10 CFR 61.43) and the stability of the disposal site after closure (10 CFR 61.44).

10 CFR 61.40 states:

> *Land disposal facilities must be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to humans are within the limits established in the performance objectives in §§61.41 through 61.44.*

10 CFR 61.40 requires "reasonable assurance" that exposures are within the limits of the subsequent performance objectives for 10 CFR 61.41 through 10 CFR 61.44.[82]

The DOE has developed an HTF PA which provides the technical basis and results demonstrating there is reasonable assurance that the 10 CFR 61.41 and 10 CFR 61.42 performance objectives will be met after HTF closure. These analyses were performed using a variety of modeling codes including the PORFLOW deterministic code and GoldSim probabilistic code. As required by the DOE Manual 435.1-1, maintenance of the HTF PA will include future revisions as needed (e.g., to incorporate new information and update model codes).

The HTF PA modeling consisted of a hybrid approach using both deterministic modeling (Base Case — also called Case A — and sensitivity analyses) as well as probabilistic modeling for certain sensitivity and uncertainty analyses. The HTF PA includes deterministic and probabilistic analyses for 100,000 years after HTF closure. This approach envelopes both the 1,000-year period after closure, as described in DOE Manual 435.1-1 for performance assessments for DOE low-level waste disposal facilities, as well as the 10,000-year period suggested in NRC's NUREG-1854. DOE is providing all modeling results (i.e., up to 100,000 years) for purposes of consulting with NRC under Section 3116 (a) of the NDAA.

The HTF PA details the analyses performed to provide "reasonable assurance" that the stabilized residuals, waste tanks and ancillary structures will be disposed of in compliance with the 10 CFR 61.41 and 61.42 performance objectives in conjunction with closure of the HTF. Individual HTF system behaviors are evaluated within the HTF PA for various waste tank and ancillary structure configurations, including a Base Case, which provides results reflecting the closure system behavior. The HTF PA provides the development and calculation of the following doses:

- potential radiological doses to a hypothetical member of the public and
- potential radiological doses to a hypothetical inadvertent intruder.

These calculations were performed to provide information regarding potential peak doses from the closed HTF. In addition, uncertainty and sensitivity analyses were used to ensure reasonably conservative information is available to develop risk-informed conclusions related to the closure of HTF.[83]

The following general definitions are used in the HTF PA and will serve as the basis for future HTF PA revisions.

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[82] The general requirement at 10 CFR 61.40 provides that land disposal facilities must be "controlled after closure". Consistent with this requirement, the HTF will be "controlled after closure" through a number of mechanisms, including the following:

- DOE Order 435.1 and its associated Manual 435.1-1 requires the DOE to manage radioactive wastes and associated facilities in accordance with DOE requirements, in a manner that protects the public, workers and the environment, and that complies with applicable federal, state and local laws. Among other things, DOE Manual 435.1-1 requires the development, review, approval, and implementation of closure plans for radioactive waste management facilities, and specifies the requirements that such plans must meet. DOE Manual 435.1-1 also requires continued monitoring of DOE facilities after closure. [DOE O 435.1, DOE M 435.1-1]
- The SRS FFA, a formal agreement between DOE, Region 4 of the EPA and SCDHEC provides for a comprehensive remediation of SRS, governs the corrective/remedial action process from site investigation through site remediation, and describes procedures for that process. The FFA, in conjunction with applicable South Carolina law and regulation, establish the framework for the operation, new construction, removal from service, and any appropriate RCRA/CERCLA response action related to the waste tank systems. The FFA provides timetables for the removal from service of waste tanks that do not meet the secondary containment standards of FFA Section IX.C, or that leak or have leaked, as well as provisions for new construction and prevention and mitigation of releases or potential releases from the waste tank systems. [WSRC-OS-94-42]
- DOE will maintain active institutional control and ownership of HTF such that HTF facility maintenance and controls will be performed to prevent inadvertent intrusion and protect public health and the environment. For the purposes of the HTF PA, the period of active institutional control is assumed to be for 100 years to ensure a conservative analysis relative to potential public risk, although the SRS Land Use Plan requires federal ownership and control of the site well beyond 100 years after closure.

[83] DOE predicated the HTF PA and this Draft HTF 3116 Basis Document on reasonable assumptions and reasonably foreseeable natural processes, recognizing that, in DOE's view, validation of assumptions over extreme periods of time is not consistent with a risk-informed approach under DOE requirements and NRC guidance.

HTF Boundary: The HTF boundary is the line of demarcation enclosing the HTF waste tanks (Figure 7.0-1).

Buffer Zone: The buffer zone is the radial area that encompasses the HTF 100 meters from its boundary (Figure 7.0-1).

Institutional Control: Institutional control is a 100-year period in which DOE retains ownership and control of HTF such that HTF facility maintenance and controls will be performed to prevent inadvertent intrusion and protect public health and the environment.[84]

Base Case: The waste tank system configuration modeling case within the HTF PA that represents the most probable and defensible estimate of expected conditions for the HTF closure system based on currently available information.[85]

Uncertainty and Sensitivity: Uncertainty and sensitivity analyses are employed to consider the effects of uncertainties in the conceptual models and sensitivity of simulation results to the parameters in the mathematical models. The sensitivity analyses consider sensitivity of results to parameters both individually and collectively. The HTF PA includes uncertainty and sensitivity analyses.

Figure 7.0-1: HTF Boundary and Buffer Zone

Legend:
Boundary   Buffer Zone (100 meters from HTF)
Red Line = Demarcation line from which the one-meter and 100-meter concentrations are calculated.

For additional information, the *Savannah River Site DOE 435.1 Composite Analysis* presents the results of a site-wide radiological assessment of SRS.[86] [SRNL-STI-2009-00512] The Composite Analysis (CA) documents the projected cumulative impacts to future members of the public from the disposal of low-level radioactive waste, closure of radioactive liquid waste tanks, and all other sources of residual radioactive material projected to be left at SRS that could interact with the disposal facilities and closure sites to affect the future radiological dose to a member of the public. The CA uses methodologies and assumptions similar to, or derived from, the performance assessments for E Area, SDF, FTF, HTF and additional radioactive source terms from other SRS production and deactivated facilities (e.g., F- and H-Canyons, reactors and decommissioned facilities). In summary, the CA identified that during the 10,025-year period following the projected site end-state date (2025), the maximum expected member of

[84] To ensure a conservative analysis relative to potential public risk, DOE is using an institutional control period of 100 years. As described in Section 7.4.4 of this Draft HTF 3116 Basis Document, the SRS Land Use Plan requires federal ownership and control of the site well beyond 100 years after closure.

[85] To demonstrate in this Draft HTF 3116 Basis Document that there is "reasonable assurance" (as called for by 10 CFR 61.40) that the performance objectives at 10 CFR 61.41 and 61.42 are met, DOE utilizes the most probable and defensible HTF PA estimates of expected conditions (the HTF PA Base Case, also called Case A) based on available information and reasonable assumptions, and informed by the uncertainty and sensitivity analyses in the HTF PA.

[86] Information about this CA is included to further inform the reader. DOE has prepared the CA under DOE Manual 435.1-1, which accompanies DOE Order 435.1, pursuant to DOE's responsibilities under the Atomic Energy Act of 1954, as amended. The CA is not a NDAA Section 3116 requirement, and is not relied upon in this Draft HTF 3116 Basis Document to demonstrate compliance with the NDAA Section 3116 criteria. As such, the CA should be viewed as outside the scope of both this Draft HTF 3116 Basis Document and NDAA Section 3116.

the public dose would be approximately 3 mrem/yr compared to DOE's 30 mrem/yr dose constraint to ensure compliance with the 100 mrem/yr dose limit. [SRNL-STI-2009-00512] DOE will periodically update and maintain the CA, in accordance with DOE policy and DOE Manual 435.1-1.

The following subsections discuss the 10 CFR 61.41 (see Section 7.1), 10 CFR 61.42 (see Section 7.2), 10 CFR 61.43 (see Section 7.3) and 10 CFR 61.44 (see Section 7.4) performance objectives.

7.1 10 CFR 61.41

10 CFR 61.41 states:

> *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.*

7.1.1 General Approach

To demonstrate compliance with this performance objective, a 25 mrem/yr peak all-pathways TEDE is used, rather than individual organ doses. The NRC states in NUREG-1854 that use of the 25 mrem/yr all-pathways TEDE is used by the NRC in making the assessment for compliance with the whole body, thyroid and any other organ limits in 10 CFR 61.41 and is protective of human health and the environment.[87]

In addition NUREG-1854 states:

> *…incidental waste determinations may use total effective dose equivalent (TEDE) without specific consideration of individual organ doses. Intruder calculations should be based on 5 mSv [500 mrem] TEDE limit, without specific consideration of individual organ doses, to ensure consistency between 10 CFR 61.41 and 10 CFR 61.43. Because of the tissue weighting factors and the magnitude of the TEDE limit, specific organ dose limits are not necessary for protection from deterministic effects.*

The hypothetical future member of the public is assumed to be located at the boundary of the DOE controlled area until the assumed active institutional control period ends (i.e., 100 years after closure), at which point the receptor is assumed to move to the point of maximum exposure at or outside of the HTF 100-meter buffer zone. For the purposes of demonstrating reasonable assurance that the performance objective at 10 CFR 61.41 will be met, the peak all-pathways dose at or outside of the 100-meter buffer zone is used.

The pathways for release to a member of the public considered in the HTF PA analyses are discussed below. The scenarios are not assumed to occur until after the assumed 100-year institutional control period ends. [SRR-CWDA-2010-00128]

7.1.2 Public Release Pathways Dose Analysis

The primary water sources for the member of the public release pathways are either a well drilled into the groundwater aquifers or a GSA stream. The bounding dose scenario and associated exposure pathways for the member of the public was determined to be an agricultural resident who uses water from a well for domestic purposes. The bounding public dose scenario and associated exposure pathways are documented in the HTF PA. The following exposure pathways involving the use of contaminated[88] well water were considered (Figure 7.1-1):

- direct ingestion of well water,
- ingestion of milk and meat from livestock (e.g., dairy and beef cattle) that drink well water,
- ingestion of meat and eggs from poultry that drink well water,

[87] At page 151 of the FTF TER, NRC explains "NRC staff considers DOE's use of 0.25 mSv (25 mrem) TEDE to demonstrate compliance with 10 CFR 61.41 without specific consideration of individual organ doses acceptable for incidental waste determinations." [ML112371715]
[88] Contaminated in this context refers to radioactive materials that have been projected to migrate from the closed HTF.

- ingestion of vegetables grown in garden soil irrigated with well water,
- ingestion of milk and meat from livestock (e.g., dairy and beef cattle) that eat fodder from a pasture irrigated with well water,
- ingestion of meat and eggs from poultry that eat fodder from a pasture irrigated with well water, and
- ingestion and inhalation of well water while showering.

The following exposure pathways involving the use of contaminated surface water (from the applicable stream) for recreational use are assumed to occur:

- direct irradiation during recreational activities (e.g., swimming, fishing, boating) from stream water,
- dermal contact with stream water during recreational activities (e.g., swimming, fishing),
- incidental ingestion and inhalation of stream water during recreational activities, and
- ingestion of fish from the stream water.

Additional exposure pathways could involve releases of radionuclides into the air from the water taken from the well (i.e., volatile radionuclides such as C-14 and I-129). Exposures from the air pathway in the HTF PA are:

- direct plume shine and
- inhalation.

Secondary and indirect pathways that contribute relatively minor doses to a receptor when compared to direct pathways (e.g., ingestion of milk and meat) include:

- inhalation of well water used for irrigation,
- inhalation of dust from the soil that was irrigated with well water,
- ingestion of or dermal contact with soil that was irrigated with well water, and
- direct radiation exposure from radionuclides deposited on the soil that was irrigated with well water.

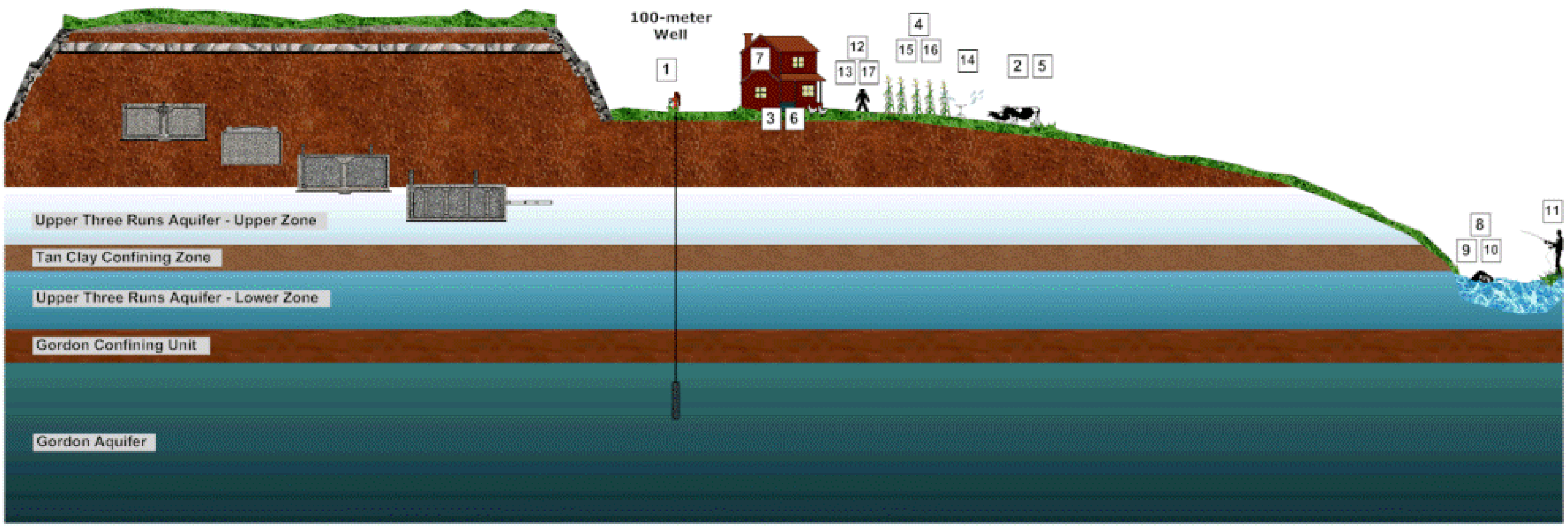
The point of assessment for the groundwater wells used in the member of the public scenario is located 100 meters from the HTF, as shown in Figure 7.0-1. The peak concentrations used to determine the peak doses for the member of the public exposure pathways are calculated and documented in the HTF PA. The groundwater concentrations used are peak concentrations for each radionuclide at the given point of assessment, from any of the aquifers.

The groundwater concentrations were calculated based on the HTF PA conceptual model. The conceptual model is used to simulate the performance of the HTF closure system following HTF closure and is comprised of both near-field and far-field models that represent the HTF closure system and the environmental media through which radionuclides may migrate. The conceptual model was used to simulate transport of the radiological contaminants through soil and groundwater to the 100-meter assessment point and nearby streams.

The conceptual model used numerous HTF-specific input parameters to represent the HTF closure system behavior over time. Many of the input parameters are based on site-specific data (e.g., soil and cementitious materials K_d values) used in transport modeling. In addition, site-specific information is used to model the behavior of individual barriers within the HTF conceptual model, such as the waste tank carbon steel primary tanks and secondary liners or annular pans, if applicable, and cementitious barriers. The models and model inputs used in the HTF conceptual model to calculate groundwater concentrations are described in detail in the HTF PA.

The groundwater peak dose for the member of the public is calculated in the HTF PA using site-specific input parameters, and the bounding dose scenario exposure pathways and peak concentrations discussed previously. Numerous bioaccumulation factors (e.g., soil-to-plant transfer factors), human health exposure parameters (e.g., water ingestion rates, vegetable consumption data) and dose conversion factors are used in the computer modeling to calculate doses for each of the exposure pathways, and these parameters are documented in the HTF PA.

Figure 7.1-1: Scenario with Well Water as Primary Source



SCENARIO WITH WELL WATER AS PRIMARY WATER SOURCE

1. Direct ingestion of well water
2. Ingestion of milk and meat from livestock (e.g., dairy and beef cattle) that drink well water
3. Ingestion of meat and eggs from poultry that drink well water
4. Ingestion of vegetables grown in garden soil irrigated with well water
5. Ingestion of milk and meat from livestock (e.g., dairy and beef cattle) that eat fodder from a pasture irrigated with well water
6. Ingestion of meat and eggs from poultry that eat fodder from a pasture irrigated with well water
7. Ingestion and inhalation of well water while showing
8. Direct irradiation during recreational activities (e.g., swimming, fishing, boating) from stream water
9. Dermal contact with stream water during recreational activities (e.g., swimming, fishing)
10. Incidental ingestion and inhalation of stream water during recreational activities
11. Ingestion of fish from the stream water
12. Direct plume shine
13. Inhalation
14. Inhalation of well water used for irrigation
15. Inhalation of dust from the soil that was irrigated with well water
16. Ingestion of or dermal contact with soil that was irrigated with well water
17. Direct radiation exposure from radionuclides deposited on the soil that was irrigated with well water

An air-pathway analysis was also performed in addition to the groundwater analysis to determine the dose contribution from the air pathway. This analysis utilized an atmospheric screening methodology to identify radionuclides for air-pathway modeling based on waste tank radionuclide projected inventories and the limited number of radionuclides susceptible to volatilization. Computer modeling was performed to calculate the transport of radionuclides through the stabilized waste form and the closure cap to the surface of HTF. An air-pathway dose was then calculated based on the specific curies of each radionuclide assumed to be transported to the surface of HTF. The air pathway analysis and groundwater analysis are combined to determine an all-pathways peak dose for a member of the public.

In addition to the deterministic all-pathways peak dose Base Case analysis, additional analyses are provided in the HTF PA to characterize the context of uncertainty and sensitivity surrounding the HTF PA all-pathways peak dose results. These evaluations focused on the key uncertainties and sensitivities identified during calculation of the member of the public dose. The uncertainty analyses provide information regarding how collective uncertainty in model input parameters is propagated through the model to the various model results. The sensitivity analyses provide information as to how various individual input parameters affect dose results. Together the uncertainty and sensitivity analyses provide assurance that the impacts of variability and uncertainty in the member of the public dose analyses are understood and addressed.

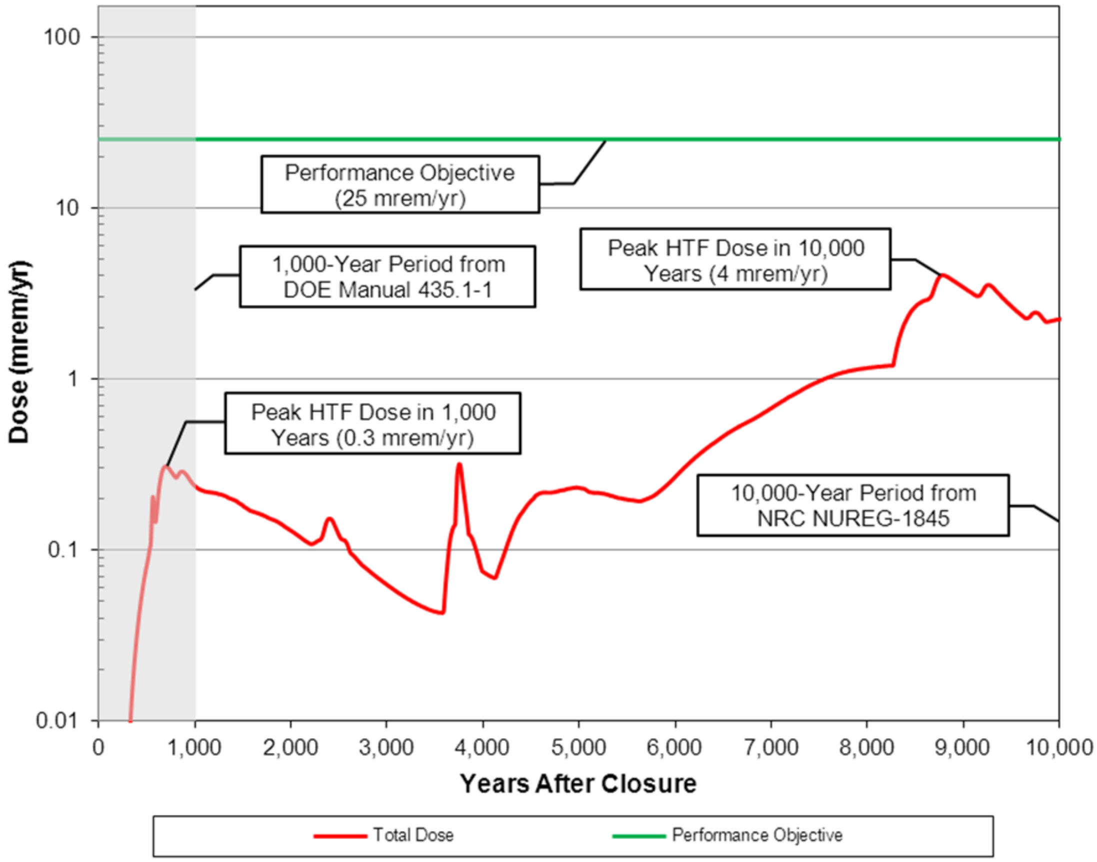
The uncertainty and sensitivity analyses were primarily performed using a probabilistic model, with some additional single parameter sensitivity analyses (e.g., solubility value sensitivity analysis, liner failure sensitivity analysis, alternate configuration sensitivity analysis) performed through deterministic modeling. The probabilistic model allows for variability of multiple parameters simultaneously, including variability of the flow data, so concurrent effects of changes in the model can be analyzed. The deterministic model single parameter analyses provide a method to evaluate the importance of the uncertainty around a single parameter of concern. The deterministic model single parameter analyses included a comprehensive barrier analyses that identified barriers to waste migration and evaluated the capabilities of each barrier as understood from the results of the HTF PA. The barrier analyses assessed the contribution of individual barriers (e.g., closure cap, grout, contamination zone, waste tank liner and waste tank concrete) by comparing contaminant flux results under various barrier conditions. Using both probabilistic and deterministic models for sensitivity analysis versus a single approach provides additional information, to inform the decision making process, concerning which parameters are of most importance to the HTF PA model. [SRR-CWDA-2010-00128] DOE performed a review of potential Features, Events and Processes (FEPs), and analyzed and documented how the FEPs are considered in the HTF PA. As a result of this evaluation, DOE found that all applicable FEPs have been covered by existing analyses in the HTF PA. [SRR-CWDA-2012-00044, SRR-CWDA-2012-00011]

7.1.3 Results of the Analyses

The HTF PA modeling was used to determine an all-pathways dose to a member of the public for comparison with the 10 CFR 61.41 performance objectives. The deterministic Base Case analysis in the HTF PA, Revision 1, projected the peak all-pathways dose to the HTF public receptor (i.e., individual greater than or equal to 100 meters from the HTF) to be less than the 25 mrem/yr performance objective as shown in Figure 7.1-2.[89] The peak all-pathways dose projection captured in Figure 7.1-2 includes the groundwater pathways and air pathways associated with all 29 HTF waste tanks and associated ancillary structures with the groundwater pathway being the most significant contributor. The peak doses to the member of the public depicted in Figure 7.1-2 are primarily from Tc-99.

[89] The Figure 7.1-2 peak all-pathways dose curve reflects the current results of the Base Case through deterministic (PORFLOW) modeling for HTF PA, Revision 1, and reflects dose projections following closure of HTF. The peak HTF all-pathways Base Case dose results provided in the HTF PA are not to be considered limits. The horizontal green lines in Figures 7.1-2 through 7.1-5 are presented for visual illustration only. As required by DOE Manual 435.1-1, maintenance of the HTF PA will include future updates to incorporate new information, update model codes, analysis of actual residual inventories, and other information, as appropriate.

Figure 7.1-2: Peak All-Pathways Dose to a Member of the Public Within 10,000 Years (Base Case Deterministic Analysis)



[SRR-CWDA-2010-00128]

For additional information, Figure 7.1-3 displays the peak all-pathways dose within 100,000 years after closure to demonstrate consideration of the uncertainty inherent in the timing of the peak dose. [SRR-CWDA-2010-00128] Later dose peaks, beyond the initial 10,000 years after HTF closure, are associated with loss of containment due to failure of the primary tank walls.[90] Loss of the primary tank wall initiates changes to the chemistry and radionuclide holding capability of the grout, which directly affects radionuclide release rates. Peak doses to the member of the public within 100,000 years are primarily from Ra-226.[91]

[90] The Base Case for HTF PA, Revision 1, assumes that the primary tank walls for Tanks 12, 14, 15 and 16 are completely failed at the time of HTF closure. Therefore, Tanks 12, 14, 15 and 16 are modeled as having no primary tank wall and no annular pan in place at the time of closure. The primary tank walls for Type IV tanks fail at approximately year 3,600, Type I tanks, not including Tank 12, at approximately year 11,400, Tank 13 at approximately year 12,700 and Type III/IIIA tanks at approximately year 12,800. [SRR-CWDA-2010-00128]

[91] Dose contribution from Ra-226 is not a result of initial inventories of this radionuclide at the time of closure but is a result of ingrowth from decay of parent radionuclides, i.e., U-234 and Pu-238.

Figure 7.1-3: Peak All-Pathways Dose to a Member of the Public Within 100,000 Years (Base Case Deterministic Analysis)

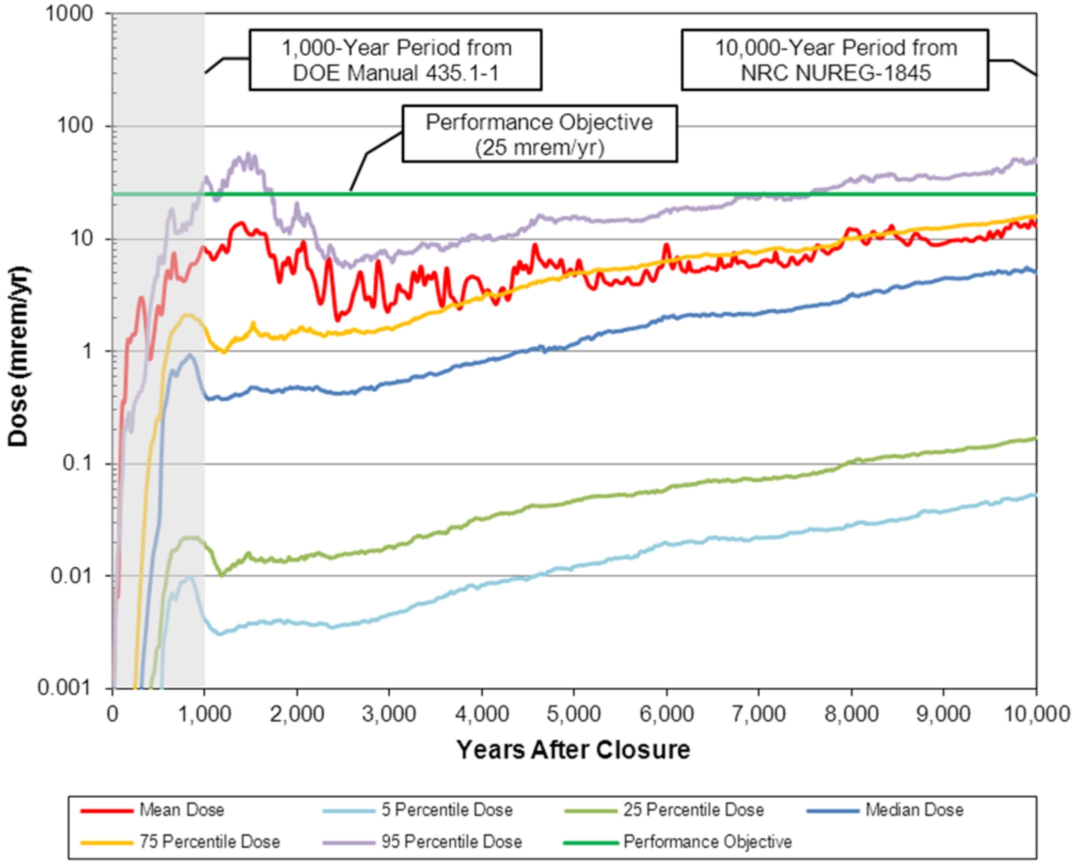
[SRR-CWDA-2010-00128]

As discussed previously, additional analyses are provided in the HTF PA to characterize the context of uncertainty and sensitivity surrounding the HTF PA peak dose results. The HTF PA probabilistic modeling performed for the uncertainty and sensitivity analyses was used to better understand the projected dose to the HTF public receptor for the Base Case, as well as other tank configurations, over a wide range of variability in input parameters. The HTF PA, Revision 1, uncertainty and sensitivity analysis projected various statistical results associated with the All Cases[92] dose (i.e., plots of dose versus time showing 5th percentile, 25th percentile, median, mean, 75th percentile and 95th percentile doses) to a member of the public within the initial 10,000 years, as shown in Figure 7.1-4, for additional information.[93] Figure 7.1-5 displays the uncertainty analyses dose results within 100,000 years after HTF closure to reflect consideration of the uncertainty inherent in the timing of the dose results. The fact that the peak of the means dose from the HTF probabilistic analyses is higher than the deterministic peak dose is not unexpected, since many of the stochastic distributions used in the probabilistic modeling are reasonably conservative, driving the peak of the means higher than the deterministic peak dose. This is demonstrated in Figure 7.1-4 by the fact that the mean dose consistently exceeds the median dose. [SRR-CWDA-2010-00128]

[92] As part of the probabilistic analyses, a set of realizations was performed to collectively evaluate the effects of all postulated waste tank configurations. In the "All Cases" run, every waste tank model independently sampled the possible waste tank configurations during each realization, allowing the probabilistic analysis to consider tank configuration variability.

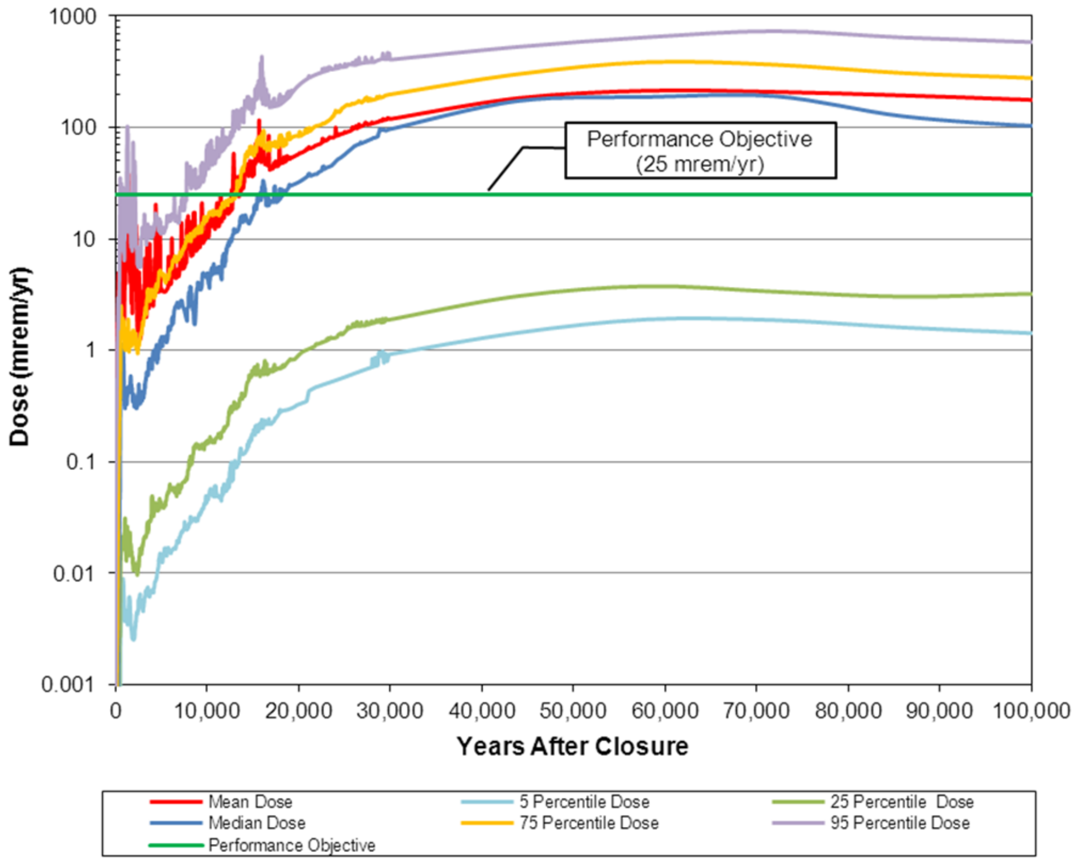
[93] The Figure 7.1-4 probabilistic dose statistics reflect the current results of the uncertainty analyses projected through probablilistic modeling for HTF PA, Revision 1. The probabilistic dose results provided in the HTF PA are not to be considered limits. As required by DOE Manual 435.1-1, maintenance of the HTF PA will include future updates to incorporate new information, update model codes, analysis of actual residual inventories, and other information, as appropriate.

Figure 7.1-4: Statistical Summary of Time History of Total Member of the Public Dose, at the Well of Maximum Concentration, Within 10,000 Years (All Cases Probabilistic Analysis)



[SRR-CWDA-2010-00128]

Figure 7.1-5: Statistical Summary of Time History of Total Member of the Public Dose, at the Well of Maximum Concentration Within 100,000 Years (All Cases Probabilistic Analysis)



[SRR-CWDA-2010-00128]

Since there are over 40 unique and independent inventory sources modeled in the HTF model, there is significant temporal and spatial complexity inherent in the modeling system. The uncertainty and sensitivity analyses demonstrated that the impact of individual parameters and/or specific barriers can be variable, with the impact depending to a great extent upon the tank type and/or radionuclide involved.[94] [SRR-CWDA-2010-00128] Additional discussion regarding the radionuclides most impacting the dose results can be found in Section 5.1 of this Draft HTF 3116 Basis Document.

The HTF all-pathways Base Case dose results, calculated in the HTF PA remain below the 25 mrem/yr peak all-pathways dose limit, as shown in Figure 7.1-2. In addition, the uncertainty and sensitivity analyses included in the HTF PA provide sufficient information on parameter sensitivities and modeling uncertainties to provide reasonable assurance that the 25 mrem/yr all-pathways dose limit will be met. [SRR-CWDA-2010-00128] Additional discussion on HTF PA dose results is provided in Appendix C of this Draft HTF 3116 Basis Document.

7.1.4 As Low As Reasonably Achievable

The NRC performance objective in 10 CFR 61.41 also provides that reasonable effort shall be made to maintain releases of radioactivity in effluents to the environment ALARA. The HTF PA was developed in accordance with the comparable requirement in DOE Manual 435.1-1:

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[94] Detailed discussion of the uncertainty and sensitivity analyses can be found in Section 5.6 of the HTF PA. The impact of the various integrated conceptual model segments on the dose results is detailed in Section 7.1 of the HTF PA. [SRR-CWDA-2010-00128]

Performance assessments shall include a demonstration that projected releases of radionuclides to the environment shall be maintained as low as reasonably achievable (ALARA).

As discussed previously, the HTF PA provides the information to demonstrate compliance with the 25 mrem all-pathways dose performance objective, including stabilization[95] of the residual waste using grout to minimize releases to the environment. [SRR-CWDA-2010-00128] Section 5.2 of this Draft HTF 3116 Basis Document provides the information to show that HRRs in the waste tanks and ancillary structures will have been removed to the maximum extent practical at closure.

In addition to removal of HRRs to the maximum extent practical, other HTF closure design features also serve to support the ALARA objective set forth in 10 CFR 61.41. The closure design of the HTF stabilizes the residual waste, minimizes infiltration of water through the waste tanks and ancillary structures, and provides long-term stability. These features of the HTF closure design serve to impede release of stabilized contaminants into the general environment.

The residual material remaining in the waste tanks after HRRs have been removed to the maximum extent practical will be stabilized with reducing grout, a chemically reducing environment known to minimize the mobility of the contaminants after closure. The waste tank fill grout will also have low permeability, which enhances its ability to limit the migration of contaminants after closure.

There are multiple elements of the HTF design that will serve to minimize infiltration of water through the waste tanks and ancillary structures. The waste tank concrete vaults and primary and secondary steel liners serve to significantly retard water flow through the waste tanks. In addition, the waste tank liners and annular space, if applicable, are filled with cementitious material, which will further serve to limit the amount of water infiltration into the waste tanks. The concrete structures, steel wall liners, if applicable, and transfer line encasements or outer jackets will serve to significantly retard water flow into ancillary structures. In addition, the waste tanks and ancillary structures are expected to be covered with a closure cap,[96] which further limits the water infiltration.

Final HTF closure will also support long-term stability consistent with the ALARA objective set forth in 10 CFR 61.41. Because the waste tanks will be filled with grout at closure, significant structural failure (i.e., collapse) is not likely. Ancillary structures such as diversion boxes, pump pits, and pump tanks are expected to be filled with appropriate fill materials, as necessary, to prevent subsidence. Additionally, the engineered closure cap will also provide physical stabilization of the closed site.

The design features described above serve to impede the release of stabilized contaminants into the general environment. These features, along with the removal of HRRs to the maximum extent practical, are consistent with the ALARA objective in 10 CFR Part 61.41 to maintain releases of radioactivity in effluents to the general environment ALARA.

Sections 7.3.11 and 7.3.12 provide discussion relative to compliance with the ALARA objective set forth in 10 CFR Part 61.43.

7.1.5 Conclusion

As demonstrated in the preceding discussion, reasonable assurance is provided that the performance objective at 10 CFR 61.41 will not be exceeded.

[95] Stabilization of the HTF waste tanks will be carried out by filling the waste tanks with grout after completion of waste removal activities. Ancillary structures will be filled, as necessary, to prevent subsidence of the structure or final closure cap. The DOE currently does not plan to grout the HTF transfer lines.

[96] The closure cap design described in the HTF PA is based on the best information available at the time the HTF PA was developed. [SRR-CWDA-2010-00128] The design information utilized is for planning purposes sufficient to support evaluation of the closure cap as part of the integrated site conceptual model evaluated in the HTF PA. Any actual closure cap design will be finalized closer to the time of HTF closure in accordance to the FFA for SRS (e.g., Section IX.E.(2).) [WSRC-OS-94-42], to take advantage of possible advances in materials and closure cap technology that could be used to improve the design. The final closure cap design will minimize water infiltration into the waste tanks and ancillary structures, and the likelihood of intrusion into the waste.

7.2 10 CFR 61.42

Provisions in 10 CFR 61.42 require:

> *Design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed.*

7.2.1 General Approach

The requirement of 10 CFR 61.42 exhibits the NRC's intent to protect persons who inadvertently intrude on the waste. While the performance objective does not establish quantitative limits on exposure, the 10 CFR 61 Final EIS suggests a dose limit of 500 mrem/yr for the waste classification scheme in 10 CFR 61.55. By way of guidance, the NRC uses 500 mrem/yr dose limit for evaluating impacts to an inadvertent intruder for purposes of 10 CFR 61.42.[97] [NUREG-0945, NUREG-1854] For the purposes of demonstrating reasonable assurance that the performance objective at 10 CFR 61.42 will be met, the 500 mrem/yr peak intruder dose is used.

The 10 CFR 61.42 regulations do not specify use of a particular scenario to demonstrate compliance. In developing intruder scenarios, the DOE assumes that humans will continue land use activities, which are consistent with past (e.g., recent decades) and present regional practices, after the end of the assumed active institutional control period.

To calculate the dose to an inadvertent intruder, potential intruder scenarios were considered in the HTF PA and the bounding Acute Intruder and Chronic Intruder dose scenarios were determined to be the Acute Intruder-Drilling Scenario and Chronic Intruder-Agricultural (Post-Drilling) Scenario respectively.

7.2.2 Acute Intruder-Drilling Scenario

The bounding Acute Intruder scenario analyzed in the HTF PA is an Acute Intruder-Drilling Scenario. This scenario assumes that after the end of active institutional controls a well is drilled within the HTF buffer zone. The well is assumed to be used for domestic water use and irrigation. Because no other natural resources have been identified in the HTF, no additional drilling scenarios are considered. In a drilling scenario, an Acute Intruder is assumed to be the person or persons who install the well and are exposed to drill cuttings during well installation.

The exposure pathways for this acute drilling scenario include (Figure 7.2-1):

- inhalation of resuspended drill cuttings,
- external exposure to the drill cuttings, and
- inadvertent drill cuttings ingestion.

7.2.3 Chronic Intruder-Agricultural (Post-Drilling) Scenario

The bounding chronic intruder scenario analyzed in the HTF PA is Chronic Intruder-Agricultural (Post-Drilling) Scenario. This scenario assumes that after the end of active institutional controls, a farmer lives within the HTF buffer zone and consumes food crops grown, and meat and milk from animals raised there, using water from a well drilled within the HTF buffer zone. The Chronic Intruder-Agricultural Scenario (i.e., post-drilling) is an extension of the Acute Intruder-Drilling Scenario. This scenario assumes that an intruder lives in a building near the well drilled as part of the intruder-drilling scenario and engages in agricultural activities within the HTF buffer zone. Excavation to the surface of the stabilized contaminants in the waste tanks was not considered credible because its depth is more than 40 feet below the closure cap. Therefore, the intruder-agricultural scenario was retained for the ancillary structures inventory and specifically a waste transfer line. This is because it is less protected than a diversion box, valve box or pump pit, which are protected by thick shield covers, equaling several feet of concrete. The soil used for agricultural purposes is assumed to be contaminated by both drill cuttings and well water used for irrigation.

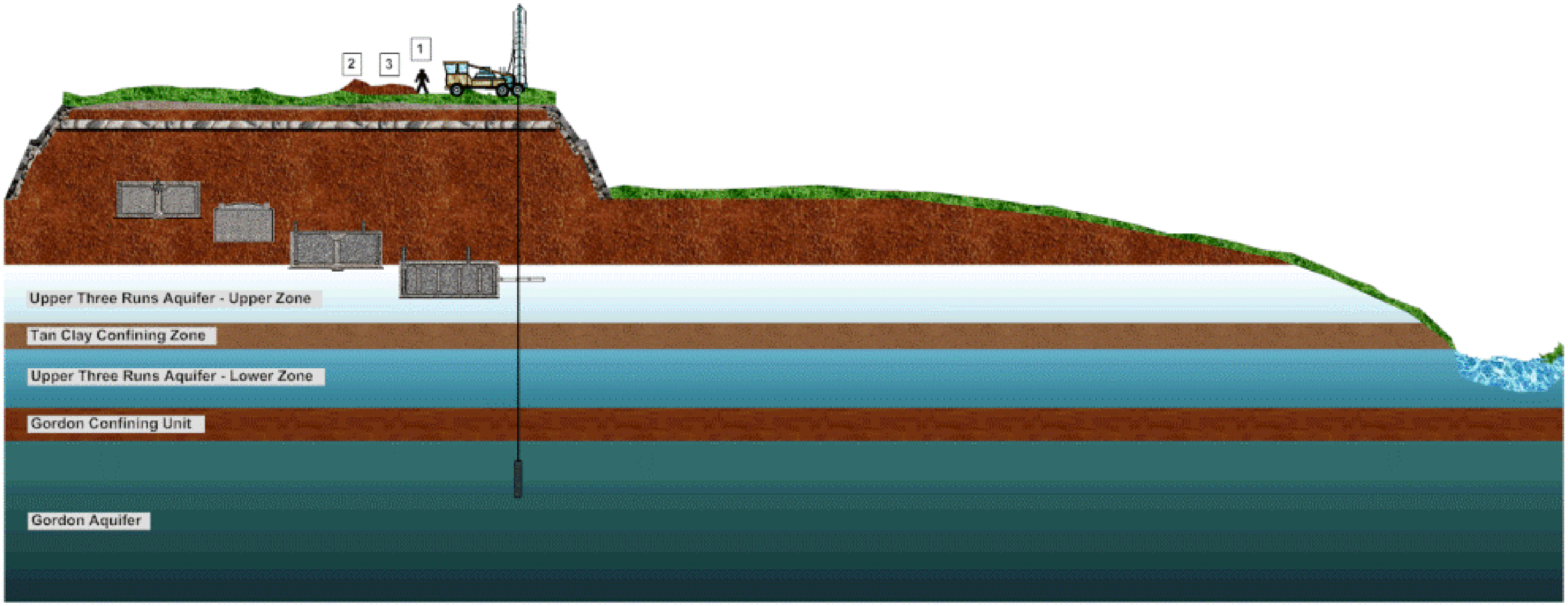
[97] For additional information, DOE Manual 435.1-1 also establishes a 100 mrem/yr chronic dose limit for evaluating impacts of an inadvertent intruder.

The intruder is exposed to (Figure 7.2-2):

- direct ingestion of well water,
- ingestion of milk and meat from livestock (e.g., dairy and beef cattle) that drink well water,
- ingestion of meat and eggs from poultry that drink well water,
- ingestion of vegetables grown in garden soil irrigated with well water and containing contaminated drill cuttings,
- ingestion of milk and meat from livestock (e.g., dairy and beef cattle) that eat fodder from a pasture irrigated with well water,
- ingestion of meat and eggs from poultry that eat fodder from a pasture irrigated with well water,
- ingestion and inhalation of well water while showering,
- direct irradiation during recreation activities (e.g., swimming, fishing, boating) from stream water,
- dermal contact with stream water during recreational activities (e.g., swimming, fishing),
- incidental ingestion and inhalation of stream water during recreational activities,
- ingestion of fish from the stream water,
- direct plume shine,
- inhalation,
- inhalation of well water used for irrigation,
- inhalation of dust from the soil that was contaminated by drill cuttings and irrigated with well water,
- ingestion of soil that was contaminated by drill cuttings and irrigated with well water, and
- direct radiation exposure from radionuclides deposited on the soil that was contaminated by drill cuttings and irrigated with well water.

The intruder may also be exposed to a release of volatile radionuclides (e.g., C-14 and I-129) from the drill cuttings and contaminated well water. These pathways include direct plume shine and inhalation.

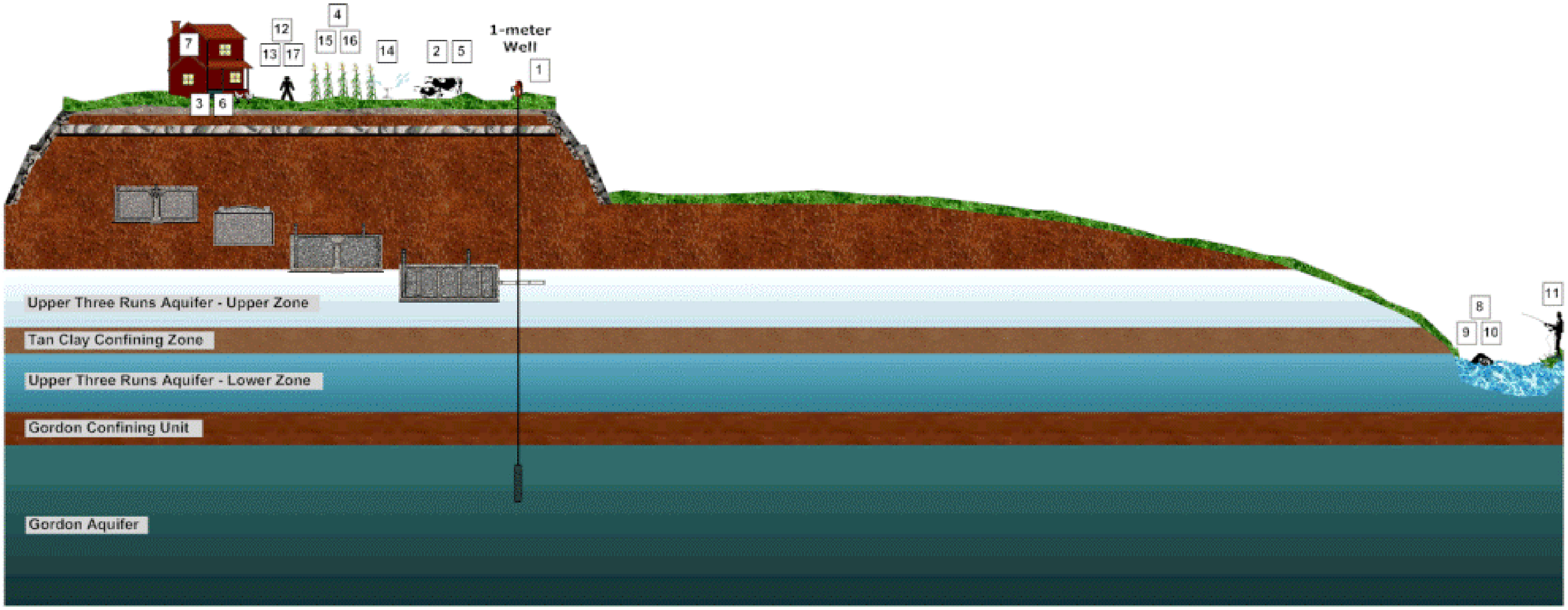
Figure 7.2-1: Acute Intruder-Drilling Scenario



ACUTE INTRUDER-DRILLING SCENARIO

1. **Inhalation of resuspended drill cuttings**
2. **External exposure to drill cuttings**
3. **Inadvertent drill cuttings ingestion**

Figure 7.2-2: Chronic Intruder-Agricultural (Post-Drilling) Scenario



CHRONIC INTRUDER-AGRICULTURAL (POST-DRILLING) SCENARIO

1. Direct ingestion of well water
2. Ingestion of milk and meat from livestock (e.g., dairy and beef cattle) that drink well water
3. Ingestion of meat and eggs from poultry that drink well water
4. Ingestion of vegetables grown in garden soil irrigated with well water and containing contaminated drill cuttings
5. Ingestion of milk and meat from livestock (e.g., dairy and beef cattle) that eat fodder from a pasture irrigated with well water
6. Ingestion of meat and eggs from poultry that eat fodder from a pasture irrigated with well water
7. Ingestion and inhalation of well water while showing
8. Direct irradiation during recreation activities (e.g., swimming, fishing, boating) from stream water
9. Dermal contact with stream water during recreational activities (e.g., swimming, fishing)
10. Incidental ingestion and inhalation of stream water during recreational activities
11. Ingestion of fish from the stream water
12. Direct plume shine
13. Inhalation
14. Inhalation of well water used for irrigation
15. Inhalation of dust from the soil that was contaminated by drill cuttings and irrigated with well water
16. Ingestion of soil that was contaminated by drill cuttings and irrigated with well water
17. Direct radiation exposure from radionuclides on the soil that was contaminated by drill cuttings and irrigated with well water

7.2.4 Intruder Release Pathways Dose Analysis

As discussed previously, the bounding Acute Intruder and Chronic Intruder dose scenarios are the Acute Intruder-Drilling Scenario and Chronic Intruder-Agricultural (Post-Drilling) Scenario, respectively. These bounding intruder dose scenarios and associated exposure pathways are documented in the HTF PA. The water source for the intruder release pathways is a well drilled into the groundwater aquifers. The contaminated drill cuttings in the intruder release pathways are from drilling into a waste transfer line.

The point of assessment for the groundwater wells used in the intruder scenario is located one meter from the HTF boundary (Figure 7.0-1). The peak concentrations used to determine the peak doses for the intruder release exposure pathways are calculated and documented in the HTF PA. The groundwater concentrations used are peak concentrations for each radionuclide at the given point of assessment, from any of the aquifers.

The groundwater concentrations were calculated based on the HTF PA conceptual model. The conceptual model is used to simulate the performance of the closed HTF for the purpose of informing closure actions associated with HTF waste tanks and ancillary structures. The conceptual model is comprised of models that represent the HTF closure system and the environmental media through which radionuclides may migrate. The conceptual model was used to simulate transport of the radiological contaminants through soil and groundwater.

The conceptual model used numerous HTF-specific input parameters to represent the HTF closure system behavior over time. Many of the input parameters are based on site-specific data (e.g., soil and cementitious materials K_d values) used in transport modeling. In addition, site-specific information is used to model the behavior of individual barriers within the HTF conceptual model, such as the waste tank carbon steel primary tanks and secondary tanks or annular pans (as applicable), and cementitious barriers. The models and model inputs used in the HTF conceptual model to calculate groundwater concentrations and the waste transfer line drill cutting inventory are described in detail in the HTF PA.

The peak intruder dose is calculated in the HTF PA using site-specific input parameters and the bounding dose scenario exposure pathways and peak concentrations discussed previously. Numerous bioaccumulation factors (e.g., soil-to-plant transfer factors), human health exposure parameters (e.g., water ingestion rates, vegetable consumption data) and dose conversion factors are used in the computer modeling to calculate doses for each of the exposure pathways, and these parameters are documented in the HTF PA.

In addition to the intruder peak dose analyses, additional analyses are provided in the HTF PA to characterize the context of uncertainty and sensitivity surrounding the HTF PA intruder peak dose results. These evaluations focused on the key uncertainties and sensitivities identified during calculation of the intruder dose. The uncertainty analyses provide information regarding how collective uncertainty in model input parameters is propagated through the model to the various model results. The sensitivity analyses provide information as to how various individual input parameters affect dose results. Together the uncertainty and sensitivity analyses provide assurance that the impacts of variability and uncertainty in the intruder dose analyses are understood and addressed.

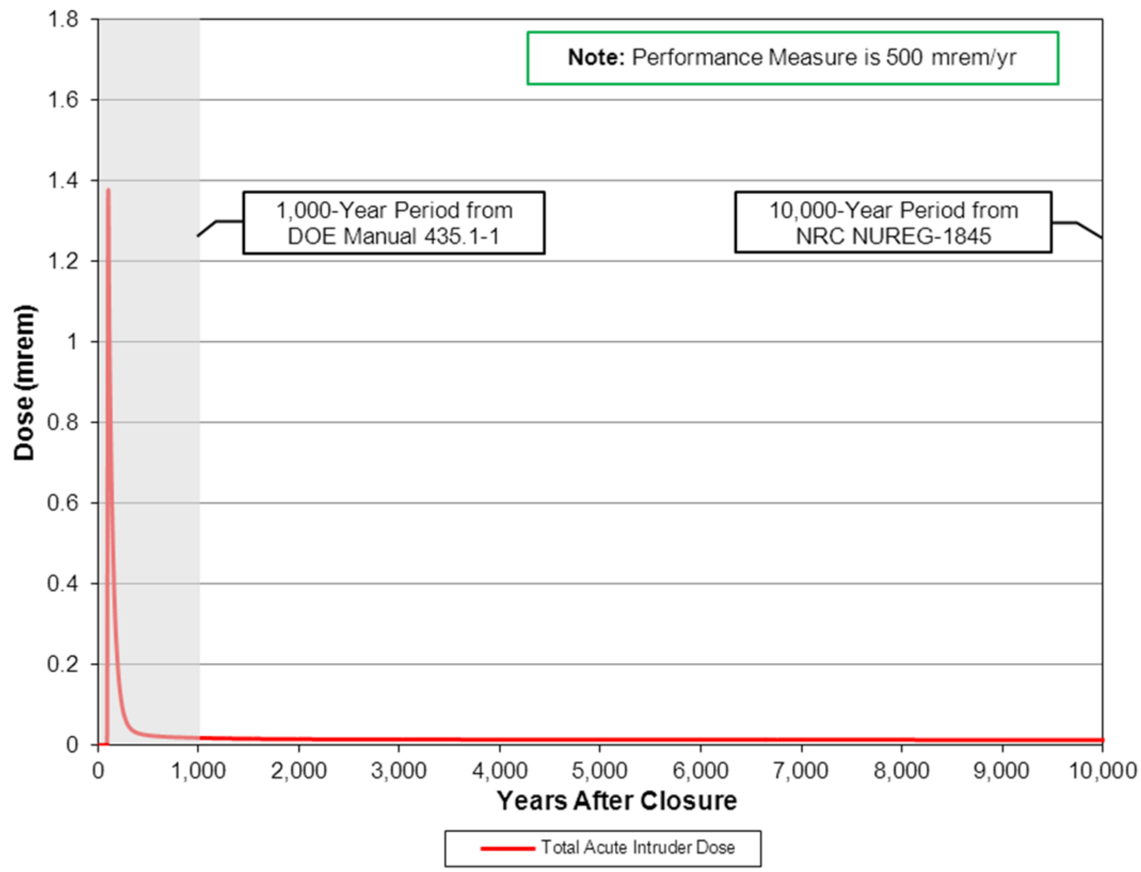
The uncertainty and sensitivity analyses were primarily performed using a probabilistic model, with some additional single parameter sensitivity analyses (e.g., alternate configuration sensitivity analysis) performed through deterministic modeling. The probabilistic model allows for variability of multiple parameters simultaneously, including variability in flow data, so concurrent effects of changes in the model can be analyzed. The deterministic model single parameter analyses provide a method to evaluate the importance of the uncertainty around a single parameter of concern. The deterministic model single parameter analyses included comprehensive barrier analyses that identified barriers to waste migration and evaluated the capabilities of each barrier as understood from the results of the HTF PA. The barrier analyses assessed the contribution of individual barriers (e.g., closure cap, grout, contamination zone, waste tank liner and waste tank concrete) by comparing contaminant flux results under various barrier conditions. Using both probabilistic and deterministic models for sensitivity analyses versus a single approach provides additional information to inform the decision making process concerning which parameters are of most importance to the HTF PA model. [SRR-CWDA-2010-00128] DOE performed a review of potential FEPs and analyzed how the FEPs are considered in the HTF PA.

As a result of this evaluation, it was determined that all applicable FEPs have been covered by existing analyses in the HTF PA. [SRR-CWDA-2012-00044, SRR-CWDA-2012-00011]

7.2.5 Results of the Analysis

The HTF PA deterministic model was used to determine an inadvertent intruder dose for comparison with the 10 CFR 61.42 performance objective. The HTF PA projected the peak inadvertent intruder (i.e., individual within the HTF boundary) acute and chronic doses to be less than the 500 mrem/yr performance measure as shown in Figures 7.2-3 and 7.2-4, respectively.[98] Figure 7.2-4 displays the peak chronic dose for 20,000 years in consideration of the uncertainty inherent in the timing of the peak dose. The 500 mrem/yr inadvertent intruder dose considers releases associated with the closure of all 29 waste tanks and related ancillary structures within HTF.

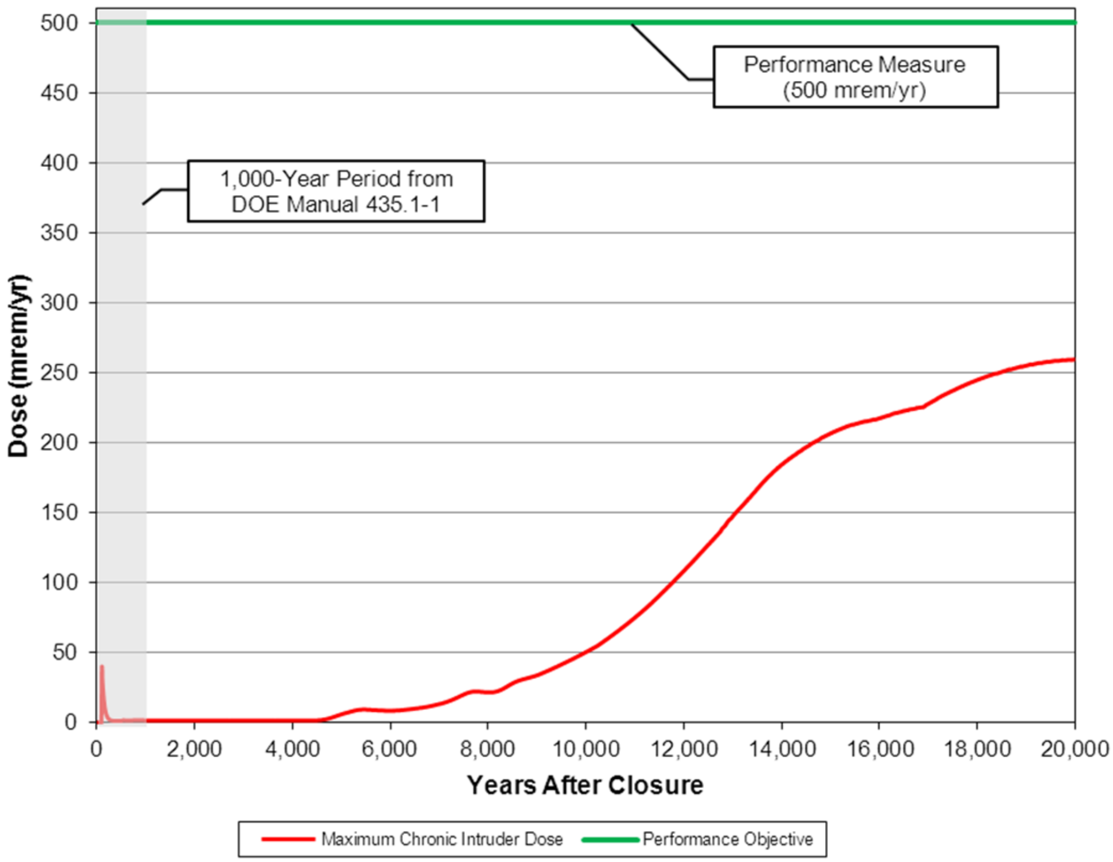
Figure 7.2-3: Peak Acute Dose to the Inadvertent Intruder (Base Case Deterministic Analysis)



[SRR-CWDA-2010-00128]

[98] The acute and chronic dose results shown in Figures 7.2-3 and 7.2-4 reflect results from the Base Case through deterministic (PORFLOW) modeling for HTF PA and reflect dose projections out to 10,000 and 20,000 years, respectively, following closure of HTF. The peak HTF inadvertent intruder dose results provided in the HTF PA are not to be considered as limits. The green text box in Figure 7.2-3 and horizontal green line in Figure 7.2-4 are presented for visual illustration only. As required by DOE Manual 435.1 1, maintenance of the HTF PA will include future updates to incorporate new information, update model codes, analysis of actual residual inventories, and other information, as appropriate.

Figure 7.2-4: Peak Chronic Dose to the Inadvertent Intruder (Base Case Deterministic Analysis)



[SRR-CWDA-2010-00128]

The HTF PA modeling performed for the uncertainty and sensitivity analyses was used to determine the projected dose to an inadvertent intruder for the Base Case, as well as other tank configurations, over a wide range of variability in input parameters. The HTF PA uncertainty analysis projected a 760 mrem/yr peak of the mean chronic dose to an inadvertent intruder within a 10,000-year period following HTF closure for 1,000 Base Case realizations. The peak of the mean dose is greater than 500 mrem/yr due to the tendency for many of the stochastic distributions used in the uncertainty analysis to be conservatively biased high, thereby skewing the uncertainty analysis results to the high dose side of their distributions.[99]

Since there are over 40 unique and independent inventory sources modeled in the HTF model, there is significant temporal and spatial complexity inherent in the modeling system. The uncertainty and sensitivity analyses demonstrated that the impact of individual parameters and/or specific barriers can be variable, with the impact depending to a great extent upon the tank type and/or radionuclide involved.[100] Additional discussion regarding the radionuclides most impacting the dose results can be found in Section 5.1 of this Draft HTF 3116 Basis Document.

[99] The 760 mrem/yr dose reflects the current results of the uncertainty analyses results projected through probablilistic modeling for HTF PA. The peak of the means dose provided in the HTF PA is not to be considered a limit. As required by DOE Manual 435.1-1, maintenance of the HTF PA will include future updates to incorporate new information, update model codes, analysis of actual residual inventories, and other information, as appropriate.

[100] Detailed discussion of the uncertainty and sensitivity analyses can be found in Section 5.6 of the HTF PA. The impact of the various integrated conceptual model segments on the dose results is detailed in Section 7.1 of the HTF PA. [SRR-CWDA-2010-00128]

Demonstration of compliance with the performance objective concerning an inadvertent intruder is provided by the fact that peak HTF Base Case inadvertent intruder dose calculated in the HTF PA is less than 500 mrem/yr. In addition, the uncertainty and sensitivity analyses included in the HTF PA provide sufficient information on parameter sensitivities and modeling uncertainties. [SRR-CWDA-2010-00128] Additional discussion on HTF PA dose results is provided in Appendix C of this Draft HTF 3116 Basis Document.

7.2.6 Conclusion

The preceding discussion demonstrates that there is reasonable assurance that the 10 CFR 61.42 performance objective will not be exceeded after HTF closure.

7.3 10 CFR 61.43

Provisions in 10 CFR 61.43 states:

> *Operations at the land disposal facility must be conducted in compliance with the standards for radiation protection set out in part 20 of this chapter, except for releases of radioactivity in effluents from the land disposal facility, which shall be governed by §61.41 of this part. Every reasonable effort shall be made to maintain radiation exposures as low as is reasonably achievable.*

This requirement references 10 CFR 20, which contains radiological protection standards for workers and the public. The DOE requirements for occupational radiological protection are provided in 10 CFR 835 and those for radiological protection of the public and the environment are provided in DOE Order 458.1.

Consistent with NDAA Section 3116(a), the cross-referenced "standards for radiation protection" in 10 CFR 20 that are considered in detail in this Draft HTF 3116 Basis Document are the dose limits for the public and the workers during disposal operations set forth in 10 CFR 20.1101(d), 10 CFR 20.1201(a)(1)(i), 10 CFR 20.1201(a)(1)(ii), 10 CFR 20.1201(a)(2)(i), 10 CFR 20.1201(a)(2)(ii), 10 CFR 20.1201(e), 10 CFR 20.1208(a), 10 CFR 20.1301(a)(1), 10 CFR 20.1301(a)(2) and 10 CFR 20.1301(b).[101] [NDAA_3116] Consistent with NUREG-1854, the following sections explain that these dose limits correspond to the dose limits in 10 CFR 835 and relevant DOE Orders which establish DOE regulatory and contractual requirements for DOE facilities and activities. The following subsections show the HTF closure meets these dose limits and that doses will be maintained ALARA.[102] Table 7.3-1 provides a crosswalk between the standards set forth in 10 CFR 20 and the applicable DOE requirements.

[101] The introductory "notwithstanding" phrase to NDAA Section 3116 makes it clear that the provisions of NDAA Section 3116(a) are to apply in lieu of other laws that "define classes of radioactive waste." As is evident from the plain language of this introductory "notwithstanding" phrase, NDAA Section 3116(a) pertains to classification and disposal, and radiation protection standards for disposal, of certain waste at certain DOE sites. Thus, the factors for consideration set forth in NDAA Section 3116(a)(1) through NDAA Section 3116(a)(3) are those which pertain to classification and disposal of waste, and the radiation protection standards for disposal. The Joint Explanatory Statement of the Committee of Conference in Conference Report 108-767, accompanying H.R. 4200 (the NDAA), also confirms that NDAA Section 3116(a) concerns classification, disposal, and radiation protection standards associated with disposal, and does not concern general environmental laws or laws regulating radioactive waste for purposes other than disposal. Moreover, in the plain language of NDAA Section 3116, Congress directed that the Secretary of Energy consult with the NRC but did not mandate that DOE obtain a license or any other authorization from NRC, and did not grant NRC any general regulatory, administrative, or enforcement authority for disposal of the DOE wastes covered by NDAA Section 3116. As such, the "standards for radiation protection" in 10 CFR Part 20 (as cross-referenced in the performance objective at 10 CFR 61.43), which are relevant in the context of NDAA Section 3116, are the dose limits for radiation protection of the public and the workers during disposal operations, and not those which address general licensing, administrative, programmatic, or enforcement matters administered by NRC for NRC licensees. Accordingly, this Draft HTF 3116 Basis Document addresses in detail the radiation dose limits for the public and the workers during disposal operations that are contained in the provisions of 10 CFR Part 20 referenced above. Although 10 CFR 20.1206(e) contains limits for planned special exposures for adult workers, there will not be any such planned special exposures for closure operations at HTF. Therefore, this limit is not discussed further in this Draft HTF 3116 Basis Document. Likewise, 10 CFR 20.1207 specifies occupational dose limits for minors. However, there will not be minors working at HTF who will receive an occupational dose. Therefore, this limit is not discussed further in this Draft HTF 3116 Basis Document.

[102] In addition, 10 CFR Part 835, like Part 20 for NRC licensees, includes requirements that do not set dose limits, such as requirements for radiation protection programs, monitoring, entrance controls for radiation areas, posting, records, reporting or training.

Table 7.3-1: Crosswalk Between Applicable 10 CFR 20 Standards and DOE Requirements

10 CFR 20 Standard	DOE Requirement	Basis Document Section	Title
10 CFR 20.1101(d)	DOE Order 458.1	7.3.1	*Air Emissions Limit for Individual Member of the Public*
10 CFR 20.1201(a)(1)(i)	10 CFR 835.202 (a)(1)	7.3.2	*Total Effective Dose Equivalent Limit for Adult Workers*
10 CFR 20.1201(a)(1)(ii)	10 CFR 835.202 (a)(2)	7.3.3	*Any Individual Organ or Tissue Dose Limit for Adult Workers*
10 CFR 20.1201(a)(2)(i)	10 CFR 835.202 (a)(3)	7.3.4	*Annual Dose Limit to the Lens of the Eye for Adult Workers*
10 CFR 20.1201(a)(2)(ii)	10 CFR 835.202 (a)(4)	7.3.5	*Annual Dose Limit to the Skin of the Whole Body and to the Skin of the Extremities for Adult Workers*
10 CFR 20.1201(e)	DOE Order 440.1B	7.3.6	*Limit on Soluble Uranium Intake*
10 CFR 20.1208(a)	10 CFR 835.206 (a)	7.3.7	*Dose Equivalent to an Embryo/Fetus*
10 CFR 20.1301(a)(1)	DOE Order 458.1	7.3.8	*Total Effective Dose Equivalent Limit for Individual Members of the Public*
10 CFR 20.1301(a)(2)	10 CFR 835.602 10 CFR 835.603	7.3.9	*Dose Limits for Individual Members of the Public in Unrestricted Areas*
10 CFR 20.1301(b)	10 CFR 835.208	7.3.10	*Dose Limits for Individual Members of the Public in Controlled Areas*

7.3.1 Air Emissions Limit for Individual Member of the Public (10 CFR 20.1101(d))

The NRC regulation at 10 CFR 20.1101(d) provides in relevant part:

> *[A] constraint on air emissions of radioactive material to the environment, excluding Radon-222 and its daughters, shall be established … such that the individual member of the public likely to receive the highest dose will not be expected to receive a total effective dose equivalent in excess of 10 mrem(0.1 mSv), per year from these emissions.*

The DOE similarly limits effective dose equivalent from air emissions to the public at 10 mrem/yr in DOE Order 458.1 to comply with the EPA requirement in 40 CFR 61.92, which has the same limit.[103] The estimated dose per year from airborne emissions to the maximally exposed individual member of the public located at or beyond the SRS boundary from all operations at SRS ranged from 0.04 mrem to 0.11 mrem from 1997 through 2010. [WSRC-TR-97-00322, WSRC-TR-98-00312, WSRC-TR-99-00299, WSRC-TR-2000-00328, WSRC-TR-2001-00474, WSRC-TR-2003-00026, WSRC-TR-2004-00015, WSRC-TR-2005-00005, WSRC-TR-2006-00007, WSRC-TR-2007-00008, WSRC-STI-2008-00057, SRNS-STI-2009-00190, SRNS-STI-2010-00175, SRNS-STI-2011-00059] These values (0.04 mrem to 0.11 mrem from 1997 to 2010) for the SRS operations, not only HTF closure operations, are well below the dose limit specified in 10 CFR 20.1101(d) of 10 mrem, 0.1 mSv per year.

7.3.2 Total Effective Dose Equivalent Limit for Adult Workers (10 CFR 20.1201(a)(1)(i))

The NRC regulation at 10 CFR 20.1201(a), concerning occupational dose limits for adults, provides in relevant part:

> *(a) [C]ontrol the occupational dose to individual adults, except for planned special exposures…to the following dose limits.*
>
> *(1) An annual limit, which is the more limiting of –*
>
> *(i) The total effective dose equivalent being equal to 5 rems (0.05 Sv).*

[103] 40 CFR 61.92 provides in relevant part as follows: "Emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr."

The DOE regulation in 10 CFR 835.202 (a)(1) has the same annual dose limit for the annual occupational dose to general employees.[104] For the occupational dose to adults during HTF closure, the total effective dose (TED) per year will be controlled using the ALARA principles, and will be below 5 rem as described in 5Q Manual, Chapter 2, *Radiological Standards*. Occupational doses to workers have been well below the annual limits specified in 10 CFR 20.1201(a)(1)(i) for all SRS work activities. Since 1995, the highest annual dose received by an SRS worker is 1,808 mrem in 2003. [SRR-CWDA-2012-00097] The highest total dose received by an HTF worker from 1995 - 2011 was 687 mrem in 2005. [PIT-MISC-0062, SRR-CWDA-2012-00097] Considering the dose histories for HTF and the doses received during waste tank closure activities in FTF the TED to workers from HTF closure is expected to remain well below the DOE/NRC limit. Because of the similarities between HTF and FTF waste removal processes, doses received during FTF waste removal activities provide insight into the magnitude of the doses that can be anticipated during HTF waste removal activities. F-Tank Farm Tank 17 and FTF Tank 20 were operationally closed in 1997. Given that the highest FTF worker dose was 215 mrem in 1997, reasonable assurance is provided that doses received by a worker during closure activities will be below 5 rem. [PIT-MISC-0062, SRR-CWDA-2012-00097]

7.3.3 Any Individual Organ or Tissue Dose Limit for Adult Workers (10 CFR 20.1201(a)(1)(ii))

The NRC regulation at 10 CFR 20.1201(a), concerning occupational dose limits for adults, provides in relevant part:

(a) [C]ontrol the occupational dose to individual adults, except for planned special exposures…to the following dose limits.

(1) An annual limit, which is the more limiting of –

(ii) The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rems (0.5 Sv).

The dose limit specified in 10 CFR 20.1201(a)(1)(ii) is similar[105] to the dose limit specified in 10 CFR 835.202 (a)(2). For the occupational dose to adults during HTF closure, the sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye will be controlled to ALARA, below a maximum of 50 rem/yr. The SRS Engineering Standard Number 01064, *Radiological Design Requirements*, provides the design basis annual occupational exposure limits for any organ or tissue, other than the eye, cannot exceed 10 rem/yr, which is well below the NRC limit of 50 rem/yr. [5Q Manual, Chapter 2, WSRC-TM-95-1]

7.3.4 Annual Dose Limit to the Lens of the Eye for Adult Workers (10 CFR 20.1201(a)(2)(i))

The NRC regulation at 10 CFR 20.1201(a), concerning occupational dose limits for adults, provides in relevant part:

(a) [C]ontrol the occupational dose to individual adults, except for planned special exposures…to the following dose limits.

(2) The annual limits to the lens of the eye, to the skin of the whole body, and to the skin of the extremities, which are:

(i) A lens dose equivalent of 15 rems (0.15 Sv).

The dose limit specified in 10 CFR 20.1201(a)(2)(i) is the same as that specified in the DOE regulation at 10 CFR 835.202 (a)(3). For the occupational dose to adults during HTF closure, the annual dose limit to the lens of the eye will be controlled using the ALARA principles, and will be below 15 rem/yr. The SRS Engineering Standard Number 01064 provides the design basis annual occupational exposure limits for the lens of the eye cannot exceed 3 rem/yr, which is well below the NRC limit of 15 rem/yr. [5Q Manual, Chapter 2, WSRC-TM-95-1]

[104] The DOE regulation requires that the occupational dose per year for general employees shall not exceed both a TED of 5 rems which is the sum of the equivalent dose to the whole body for external exposures and the committed effective dose, which includes the weighted internal exposures to any other organ or tissue other than the skin or the lens of the eye.

[105] 10 CFR 835.202(a)(2) also excludes exposure to skin as well as exposure to the lens of the eye and the dose term is Committed Equivalent Dose.

7.3.5 Annual Dose Limit to the Skin of the Whole Body and to the Skin of the Extremities for Adult Workers (10 CFR 20.1201(a)(2)(ii))

The NRC regulation at 10 CFR 20.1201(a), concerning occupational dose limits for adults, provides in relevant part:

> *(a) [C]ontrol the occupational dose to individual adults, except for planned special exposures…to the following dose limits.*
>
> > *(2) The annual limits to the lens of the eye, the skin of the whole body, or to the skin of the extremities, which are:*
> >
> > > *(ii) A shallow-dose equivalent of 50 rem (0.5 Sv) to the skin of the whole body or to the skin of any extremity.*

This NRC dose limit specified in 10 CFR 20.1201(a)(2)(ii) is the same as the DOE dose limit specified at 10 CFR 835.202 (a)(4). For the occupational dose to adults during HTF closure, which involve limited hands-on activity, the annual dose limit to the skin of the whole body or to the skin of any extremity will be controlled using the ALARA principles, and will be below a shallow-dose equivalent of 50 rem/yr. [5Q Manual, Chapter 2]

7.3.6 Limit on Soluble Uranium Intake (10 CFR 20.1201(e))

The NRC regulation at 10 CFR 20.1201(e), concerning occupational dose limits for adults, provides in relevant part:

> *(e) In addition to the annual dose limits,…limit the soluble uranium intake by an individual to 10 milligrams in a week in consideration of chemical toxicity[.]*

In addition to the adult annual dose limits during HTF closure, the soluble uranium intake by an individual is controlled to less than 10 milligrams per week. DOE Order 440.1B specifies that soluble uranium intake requirements are the more restrictive concentrations in the American Conference of Governmental Industrial Hygienists Threshold Limit Values (0.2 milligrams per cubic meter, same as noted in 10 CFR 20 Appendix B footnote 3) or the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) (0.05 milligrams per cubic meter). The soluble uranium OSHA PEL limit, which equates to a soluble uranium intake of 2.4 milligrams per week, is the more restrictive of the two. The soluble uranium intake, if any, during HTF closure will be controlled to 2.4 milligrams per week, which is below the NRC limit in 10 CFR 20.1201(e). [4Q1.1, Procedure 101A]

7.3.7 Dose Equivalent to an Embryo/Fetus (10 CFR 20.1208(a))

The NRC regulation at 10 CFR 20.1208(a), concerning the dose equivalent to an embryo/fetus, provides in relevant part:

> *(a) [E]nsure that the dose equivalent to the embryo/fetus during the entire pregnancy, due to the occupational exposure of a declared pregnant woman, does not exceed 0.5 rem (5 mSv).*

The DOE regulation at 10 CFR 835.206 (a) has the same dose limit. For the embryo/fetus occupational dose during HTF closure, doses will be controlled so the dose equivalent to the embryo/fetus during the entire pregnancy for a declared pregnant worker will not exceed 0.5 rem. Furthermore, after pregnancy declaration, DOE provides a mutually agreeable assignment option of work tasks, without loss of pay or promotional opportunity, such that further occupational radiation exposure during the remainder of the gestation period is unlikely. In addition, personnel dosimetry is provided and used to carefully track exposure as controlled by the 5Q Manual, Chapter 2.

7.3.8 Total Effective Dose Equivalent Limit for Individual Members of the Public (10 CFR 20.1301(a)(1))

The NRC regulation at 10 CFR 20.1301(a), concerning dose limits for individual members of the public, provides in relevant part:

> *(a) [C]onduct operations so that –*

> (1) *The total effective dose equivalent to individual members of the public …does not exceed 0.1 rem (1 mSv) in a year, exclusive of the dose contributions from background radiation,* from any medical administration the individual has received, from exposure to individuals *administered radioactive material and released…, from voluntary participation in medical research programs, and from the …disposal of radioactive material into sanitary sewerage[.]*

Provisions in DOE Order 458.1 similarly limit public doses to less than 100 mrem/yr. However, the DOE application of the limit is more restrictive, in that it requires DOE to make a reasonable effort to ensure multiple sources (e.g., DOE sources and NRC regulated sources) do not combine to cause the limit to be exceeded. For individual members of the public during HTF closure, the TED limit to an individual member of the public will be controlled to less than 0.1 rem/yr. [5Q Manual, Chapter 2] The air pathway is the predominant pathway for doses to the public from SRS operations. The air pathway doses to members of the public have been, and are expected to continue to be, well below the 0.1 rem annual limit specified in 10 CFR 20.1301(a). [WSRC-TR-97-00322, WSRC-TR-98-00312, WSRC-TR-99-00299, WSRC-TR-2000-00328, WSRC-TR-2001-00474, WSRC-TR-2003-00026, WSRC-TR-2004-00015, WSRC-TR-2005-00005, WSRC-TR-2006-00007, WSRC-TR-2007-00008, WSRC-STI-2008-00057, SRNS-STI-2009-00190, SRNS-STI-2010-00175, SRNS-STI-2011-00059]

7.3.9 Dose Limits for Individual Members of the Public in Unrestricted Areas (10 CFR 20.1301(a)(2))

The NRC regulation at 10 CFR 20.1301(a), concerning dose limits for individual members of the public, provides in relevant part:

> *(a) [C]onduct operations so that –*
>
> *(2) The dose in any unrestricted area from external sources, exclusive of the dose contributions from patients administered radioactive material and released …, does not exceed 0.002 rem (0.02 millisievert) in any one hour.*

The DOE regulation at 10 CFR 835.602 establishes the expectation that TED in controlled areas will be less than 0.1 rem in a year. For individual members of the public during HTF closure, operations will be conducted such that the dose in any unrestricted area from external sources, exclusive of the dose contributions from patients administered radioactive material, will be less than 0.00005 rem per hour above background. The 5Q Manual, Chapter 2, also restricts the TED in controlled areas to less than 0.1 rem in a year. To ensure these dose limits are met, the following measures have been instituted within controlled areas. Per 10 CFR 835.603, radioactive materials areas have been established for radioactive material accumulation possibly resulting in a radiation dose of 100 mrem in a year or greater. In addition, SRS has established Radiological Buffer Areas (RBAs) around posted radiological areas. Standard SRS practice is to assume a 2,000 hour per year continuous occupancy at the outer boundary of these areas; therefore, the dose rate at a RBA boundary is 0.00005 rem/hour (100 mrem/2,000 hours = 0.05 mrem/hour or 0.00005 rem/hour). Since the controlled area encompasses a RBA, it is ensured the dose in the controlled area (but outside of radioactive material areas and RBA) will be less than 0.1 rem in a year. [5Q Manual, Chapter 2] Therefore, SRS implementation of the provisions at 10 CFR 835.602 and 10 CFR 835.603 provides limits protective of the dose limit specified in 10 CFR 20.1301(a)(2). Training is required for individual members of the public for unescorted entry into controlled areas. In addition, to ensure no member of the public exceeds radiation exposure limits, use of dosimetry is required if a member of the public is expected to enter a controlled area and receive a dose that may exceed 0.05 rem/yr.[106] [5Q Manual, Chapter 5]

7.3.10 Dose Limits for Individual Members of the Public in Controlled Areas (10 CFR 20.1301(b))

The NRC regulation at 10 CFR 20.1301(b), concerning dose limits for individual members of the public, provides in relevant part:

[106] 10 CFR 20.1003 defines restricted areas as "an area, access to which is limited … for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials." A very similar definition is located in 10 CFR 835.2 for a controlled area.

(b) If … members of the public [are permitted] to have access to controlled areas, the limits for members of the public continue to apply to those individuals.

The DOE regulation at 10 CFR 835.208 has the same dose limit. The TED limit to an individual member of the public granted access to controlled areas during HTF closure will be controlled to 0.1 rem/yr. Furthermore, training is required for individual members of the public for entry into controlled areas. In addition, to ensure no member of the public exceeds radiation exposure limits, use of dosimetry is required if a member of the public is expected to enter a controlled area and receive a dose that may exceed 0.05 rem/yr.[107] [5Q Manual, Chapter 5]

7.3.11 As Low As Reasonably Achievable (10 CFR 20.1003)

The NRC regulation at 10 CFR 20.1003 defines ALARA in relevant part:

ALARA … means making every reasonable effort to maintain exposures to radiation as far below the dose limits … as is practical consistent with the purpose for which the … activity is undertaken…[.]

The DOE has a similar requirement, and the DOE regulation at 10 CFR 835.2 defines ALARA as "… the approach to radiation protection to manage and control exposures (both individual and collective) to the work force and to the general public to as low as reasonable…." For radiological work activities during HTF closure, every reasonable effort will be made to maintain exposures to radiation as far below the dose limits as is practical consistent with the purpose for which the activity is undertaken. Furthermore, the DOE regulation at 10 CFR 835.101(c) requires the contents of each Radiation Protection Program (RPP) to include formal plans and measure for applying the ALARA process to occupational exposure as further discussed in Section 7.3.12.1 of this Draft HTF 3116 Basis Document.

7.3.12 Reasonable Assurance

Measures that provide reasonable assurance that HTF closure will comply with the applicable dose limits and with the ALARA provisions include the documented RPP, the Documented Safety Analysis (DSA), design, regulatory and contractual enforcement mechanisms and access controls, training and dosimetry. These measures are discussed in the following subsections.

7.3.12.1 SRS Radiation Protection Program

The DOE regulates occupational radiation exposure at its facilities through 10 CFR 835, which establishes exposure limits and other requirements to ensure DOE facilities are operated in a manner such that occupational exposure to workers is maintained within acceptable limits and as far below these limits as is reasonably achievable. The requirements in 10 CFR 835, if violated, provide a basis for the assessment of civil penalties under the Atomic Energy Act of 1954, Section 234A, as amended. [42 USC 2282a]

Pursuant to 10 CFR 835, activities at SRS, including HTF closure operations, must be conducted in compliance with the documented RPP for SRS as approved by DOE. The key RPP elements include monitoring of individuals and work areas, access control to areas containing radiation and radioactive materials, use of warning signs and labels, methods to control the spread of radioactive contamination, radiation safety training qualification, objectives for the design of facilities, criteria for radiation and radioactive material workplace levels, and continually updated records to document compliance with the provisions of 10 CFR 835. The RPP also includes formal plans and measures for applying the ALARA process.

The 10 CFR 835 requirements, as contained in the RPP, are incorporated in the Standards/Requirement Identification Document (S/RID) system. The S/RID system links the requirements of 10 CFR 835 to the site-level and lower-level implementing policies and procedures that control radiological work activities conducted across the site. These procedures control the planning of radiological work, the use of radiation monitoring devices by employees, the bioassay program, the air monitoring program, the contamination control program, the ALARA program, the training of general employees, radiological

[107] 10 CFR 20.1301(d) allows licensees to request NRC authorization to allow an individual member of the public to operate up to an annual dose limit of 0.5 rem (5 mSv). 10 CFR 835 is more restrictive for the dose to an individual member of the public with a limit of 0.1 rem maximum annual dose as discussed in Section 7.3.8.

workers, radiological control inspectors and health physics professionals and technicians and the other aspects of an occupational RPP as required by 10 CFR 835.

7.3.12.2 Documented Safety Analysis

The HTF operates under a DSA in accordance with 10 CFR Part 830. As the first step in the development of the DSA, a formal Hazard Analysis (HA) was performed to systematically present the results of potential process-related hazards, Natural Phenomena Hazards and external hazards that can affect the public, workers and environment through the occurrence of single or multiple failures. [DOE-STD-3009-94] The HA was performed by subject matter experts including operations, engineering, industrial hygiene, radiological protection, environmental compliance and maintenance professionals.

The HA consisted of three phases:

1. hazard identification
2. hazard classification
3. hazard evaluation [DOE-STD-3009-94]

The hazard identification phase identifies possible radiological and chemical hazardous materials associated with normal and abnormal operations as well as potential energy sources to disperse hazardous materials into the environment.

The hazard classification phase evaluates for the maximum possible quantities of hazardous materials, which are then evaluated against DOE criterion to determine the overall hazard classification. [DOE-STD-1027-92]

The hazard evaluation phase identifies possible normal and abnormal operational events that could expose the public and workers to hazardous material and, therefore, are evaluated to establish the magnitude of the risk. Additionally, the consequence and frequency of each operational event must be determined and risk level identified. The purpose of identifying the risk level is to determine which operational events pose risk (and thus require additional evaluation) and those events which present negligible risk to the public and workers.

As waste is removed from the waste tanks during the closure process, the DSA requires controls on the waste tanks commensurate with the risk of the material remaining in the waste tank. These controls include engineering controls (e.g., physical isolation requirements on transfer lines and motive forces) and administrative controls (e.g., limits on waste transfers and equipment operation).

The DSA identifies hazards in the HA that could impact the public, facility workers and the environment during normal operations and accident conditions. The DSA also discusses summary descriptions of key SRS safety management programs.

In part, these administrative controls require: a facility manager be assigned who is accountable for safe operation and in command of activities necessary to maintain safe operation, personnel who carry out radiological controls functions have sufficient organizational freedom to ensure independence from operating pressure, that personnel receive initial and continuing training including radiological control training and an RPP shall be prepared consistent with 10 CFR 835. In addition, the design requirements implement 10 CFR 835 and, in particular, implement ALARA principles.

7.3.12.3 Radiological Design for Protection of Occupational Workers and the Public

The HTF radiological facilities and facility modifications are designed to meet the requirements of 10 CFR 835 Subpart K. The SRS Engineering Standard Number 01064 provides the requirements necessary to ensure compliance with 10 CFR 835. [WSRC-TM-95-1] The standard refers to 10 CFR 835, DOE Orders, DOE Standards, DOE handbooks, national consensus standards, SRS manuals, SRS engineering standards, SRS engineering guides and site operating experience in order to meet the 10 CFR 835 specific requirements and additional requirements to ensure the design provides for protection of the worker and the environment.

The standard covers the full spectrum of radiological design requirements and not just radiation exposure limits. The following are the specific areas addressed in the standard: radiation exposure limits; facility and equipment layout; area radiation levels; radiation shielding; internal radiation exposure; radiological monitoring; confinement; and ventilation.

The facility design also incorporates radiation zoning criteria to ensure exposure limits are met by providing adequate radiation shielding. Areas in which non-radiological workers are present are assumed to have continuous occupancy (2,000 hours/year) and are designed to a dose rate less than 0.05 mrem per hour to ensure the annual dose is less than 100 mrem. [WSRC-TM-95-1] Other zoning criteria are established to ensure radiological worker doses are ALARA and less than 1,000 mrem/year to meet the 10 CFR 835.1002 design requirements.

The design is also required to provide necessary radiological monitoring or sampling for airborne and surface contamination to ensure the engineered controls are performing their function and, in the event of a failure or upset condition, workers are warned and exposures avoided.

Radiological protection personnel ensure applicable requirements of the standard are addressed and presented in design summary documentation as needed. The incorporation of radiological design criteria in the engineering standard ensures the requirements of 10 CFR 835 are met and the design provides for the radiological safety of the workers and environment.

7.3.12.4 Regulatory and Contractual Enforcement

Any violation of the 10 CFR 835 requirements is subject to civil penalties pursuant to the Atomic Energy Act of 1954, Section 234A, as amended, 42 USC 2011 <u>et seq.</u>, as implemented by DOE regulations in 10 CFR Part 820. In addition, the requirements in 10 CFR 835 and all applicable DOE Orders are incorporated into all contracts with DOE contractors. The DOE enforces these contractual requirements through contract enforcement measures, including the reduction of contract fees. [48 CFR 970]

7.3.12.5 Access Controls, Training, Dosimetry and Monitoring

Training or an escort is required for individual members of the public for entry into controlled areas. In addition, use of dosimetry is required if a member of the public is expected to enter a controlled area and exceed 0.05 rem/yr to ensure no member of the public exceeds radiation exposure limits. [5Q Manual, Chapter 5, 5Q Manual, Chapter 6]

In addition, worker radiation exposure monitoring is performed for all workers expected to receive 100 mrem/yr from internal and external sources of radiation to provide assurance no worker exceeds radiation exposure limits and all radiation doses are maintained as far below the limits as is reasonably achievable. [5Q Manual, Chapter 5]

7.3.12.6 Occupational Radiation Exposure History for Savannah River Site

The effectiveness of the RPPs, including the effectiveness of oversight programs to ensure they are implemented properly, is demonstrated by the occupational radiation exposure results. The highest annual dose received by an SRS worker from 1995-2010 was 1,808 mrem TED and the highest total dose received by an HTF worker from 1995 – 2011 was 687 mrem compared to the DOE Administrative Control Limit of 2,000 mrem/yr and the 10 CFR 835 limit of 5,000 mrem/yr. [PIT-MISC-0062, SRR-CWDA-2012-00097]

In addition, for all work activities, the average TED exposure for workers receiving a TED dose at SRS has been 127 mrem/yr over the last five years, 2006-2010. [DOE_HSS_ORE_2010]

7.4 10 CFR 61.44

10 CFR 61.44 states:

> *The disposal facility must be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.*

This section outlines the relevant factors of HTF siting, design, use, operation and closure, which ensure compliance with 10 CFR 61.44 for the purpose of the Draft HTF 3116 Basis Document.

7.4.1 Siting

A site characteristics review of demography, geography, meteorology, climatology, ecology, geology, seismology, and hydrogeology is presented in Section 3.0 of the HTF PA [SRR-CWDA-2010-00128] and Section 2.0 of this Draft HTF 3116 Basis Document, and is briefly summarized below. The SRS is located in south-central South Carolina, approximately 100 miles from the Atlantic Coast. The major physical feature at SRS is the Savannah River, approximately 20 miles along the southwestern boundary of the site. The HTF is an active waste storage facility located within the GSA of SRS, approximately 5 miles from the boundary of SRS. The nearest towns are New Ellenton, South Carolina (5 miles), Jackson, South Carolina (5 miles), Snelling, South Carolina (5 miles) and the more populated areas include Aiken, South Carolina (12 miles) and Augusta, Georgia (15 miles). As of 2010, the region of influence population was over 570,000.

The general climate for the SRS region is a humid subtropical climate characterized by short mild winters and long warm and humid summers. The site experiences an average of 49 inches of rainfall each year and the average monthly temperature has a low of 46 degrees in the winter to 81 degrees in the summer. SRS supports an abundant terrestrial and semi-aquatic wildlife. The areas around HTF have grasses, forests, and swamps. An abundance of terrestrial, avian, wetlands, and aquatic wildlife live within SRS. HTF itself is a heavy industrial complex surrounded by fencing and covered in asphalt and, therefore, few animals are seen near the tanks; however burrowing animals in the surrounding areas are common. At closure, a cover is expected to be designed incorporating the latest barrier technologies to limit burrowing animals and growth of plants with taproot system; however, those are expected to infiltrate, in time, after a loss of institutional controls.

The principal geology of the region is characterized by unconsolidated soils. The vadose zone is comprised of cross-bedded, poorly sorted sands with clay lenses indicating fluvial deposition with occasional transitional marine influence. It is represented by wide differences in lithology and presents a very complex system of transmissive and confining beds.

The GSA is bounded by two surface waters: UTR and Fourmile Branch. These waters eventually feed into the Savannah River. The aquifers of primary interest for HTF are the UTRA and Gordon Aquifer. Other aquifers do not contribute to the potential dose to the workers, public or intruder and were not included in the models.

Because SRS is not located within a region of active plate tectonics characterized by volcanism, volcanology is not an issue of concern for SRS. The seismic history of the southeastern U.S. is dominated by the Charleston earthquake of 1886 with an estimated magnitude of 7.0. The most recent seismic event within a 50-mile radius of SRS was in March 2009 with a magnitude of 2.6. In the past approximately 30 years there have been four earthquakes with epicenter locations within SRS boundaries, all with a magnitude less than 3.0. [SRR-CWDA-2010-00128]

7.4.2 Design

The closure design of the HTF waste tanks and ancillary structures provide long-term stability, which is consistent with the performance objective.

There are multiple elements of the HTF design that will serve to minimize infiltration of water through the waste tanks and ancillary structures. The waste tank concrete vaults, steel tanks and secondary tanks or annular pans, where applicable, serve to significantly retard water flow through the waste tanks. The concrete structures, steel wall liners, if applicable, and transfer line encasements or outer jackets will serve to significantly retard water flow into ancillary structures. The HTF design features are described in detail in the HTF PA. In addition, the waste tanks and ancillary structures are expected to be covered with a closure cap,[108] which further limits the water infiltration into the waste tanks and ancillary structures.

[108] The closure cap design described in the HTF PA is based on the best information available at the time the HTF PA was developed. [SRR-CWDA-2010-00128] The design information utilized is for planning purposes sufficient to support evaluation of the closure cap as part of the integrated site conceptual model evaluated in the HTF PA. Any actual closure cap design will be finalized closer to the time of HTF closure in accordance to the FFA for SRS (e.g., Section IX.E.(2).) [WSRC-OS-94-42], to take advantage of possible advances in materials and closure cap technology that could be used to improve the design. The final closure cap design will minimize water infiltration into the waste tanks and ancillary structures, and the likelihood of intrusion into the waste.

Because the waste tanks will be filled with grout at closure, significant structural failure (i.e., collapse) is not likely. For tank types with an annulus, the annulus will also be grouted for stability and to minimize void spaces. The impact of potential waste tank degradation (e.g., cracking or corrosion leading to increased water infiltration) is considered in the HTF PA analysis. Ancillary structures such as diversion boxes, pump pits and pump tanks will be filled, as necessary, to prevent subsidence.

Multiple waste tank design elements will serve as inadvertent intruder barriers. The HTF closure cap, concrete tops on Type I, II, III and IIIA tanks, grout-filled domed roof of the Type IV waste tanks[109] and waste tank reducing grout are considered sufficient barriers to prevent drilling into the waste tanks, given regional well drilling practices and the presence of nearby land without underground rock or concrete obstructions. [SRR-CWDA-2010-00128]

7.4.3 Use/Operation

The use/operation of HTF waste tanks and ancillary structures will support long-term stability consistent with the performance objective. During operations, corrosion control and structural integrity programs are implemented to maintain design features utilized for waste containment (e.g., waste tanks and ancillary structures). These programs ensure that tanks are monitored for structural integrity via mechanisms such as a tank inspection program and a tank leak detection system. Programs such as these will be maintained throughout HTF use and operation. The HTF waste tanks and ancillary structures monitoring continues after closure via the site Groundwater Protection Program. [SRNS-TR-2009-00076]

7.4.4 Closure

Final HTF closure will support long-term stability consistent with this performance objective. In this context, long-term stability of the closed HTF site means that the stabilized residuals in the waste tanks and ancillary structures, the waste tanks, and the ancillary structures (including integral equipment) maintains structural integrity under the closure conditions for hundreds to thousands of years following closure. A stable closure system prevents subsidence of, and minimizes water intrusion into, the closed site and mitigates migration of residual material into the environment. In addition, a carefully designed closure site minimizes the likelihood of inadvertent intrusion into the system and disturbance of the stabilized residuals.

The waste tank systems (i.e., primary tank, secondary tank or annular pan, and concrete roofs and vaults, as applicable) and the ancillary structures themselves will provide the primary stability for the closed HTF site. Grouting of the waste tanks and backfilling of ancillary structures with an appropriate fill material, as necessary, will prevent subsidence and will minimize the migration of radioactive material into the environment over time, and will support long-term stability of both the tank structures and the residual waste.[110] Grout used to fill the domed roof of the Type IV waste tanks will have a minimum 2,000 psi nominal compressive strength at 28 days to deter intrusion. Type I, II, III and IIIA tanks have sufficient thicknesses of reinforced concrete roofs to deter such intrusion. Grouting of the waste tanks, filling of the ancillary structures, and grout chemical and mechanical characteristics are discussed in detail in the HTF PA. [SRR-CWDA-2010-00128]

A closure cap is expected to be designed and constructed over the the HTF site following grouting of the HTF waste tanks and backfilling of the ancillary structures, as necessary.[111] The closure cap design described in the HTF PA is based on the best information available at the time the HTF PA was developed. [SRR-CWDA-2010-00128] The design information utilized is for planning purposes sufficient to support evaluation of the closure cap as part of the integrated site conceptual model evaluated in the HTF PA. The actual closure cap design will be finalized closer to the time of HTF closure, to take advantage of possible advances in materials and closure cap technology that could be used to improve the design. The final closure cap design will minimize water infiltration into the waste tanks and ancillary structures, and the likelihood of intrusion into the waste. [SRR-CWDA-2010-00128]

[109] Grout used to fill the domed roof of the Type IV waste tanks will have a minimum 2,000 psi nominal compressive strength at 28 days.
[110] It may be shown through calculation and other means that backfilling certain ancillary structures will not be required for the purpose of long-term stability. For example, there are no current plans to grout or fill the HTF transfer lines.
[111] Final closure of HTF will be performed per the requirements of the FFA for SRS (e.g., Section IX.E.(2). [WSRC-OS-94-42]

The DOE will maintain GSA ownership, which includes the HTF. The SRS Land Use Plan requires federal ownership and control of the site well beyond 100 years after tank closure. [PIT-MISC-0041]

7.4.5 Conclusion

As previously discussed, the site conditions do not present hazards that impact HTF stability. In addition, the HTF closure methods will result in a facility closure that does not require ongoing maintenance. Therefore, closure of the HTF complies with 10 CFR 61.44 performance objective.

8.0 STATE-APPROVED CLOSURE PLAN

Section Purpose

The purpose of this section is to demonstrate removal from service and stabilizing of the HTF waste tanks and ancillary structures, as appropriate, will be performed pursuant to a State-approved closure plan.

Section Contents

This section discusses the State of South Carolina regulation of the waste tanks and ancillary structures and shows that removal from service of the HTF waste tanks and ancillary structures will be pursuant to State-approved Closure Modules, consistent with the HTF GCP.

Key Points

- The HTF waste storage and removal are governed, in part, by a SCDHEC industrial wastewater construction permit.
- The overall plan for removing from service and stabilizing the HTF waste tanks and ancillary structures, referred to as the HTF GCP, requires approval by SCDHEC.
- A specific Closure Module for each waste tank and ancillary structure, consistent with the requirements of the HTF GCP, will be developed and submitted to the SCDHEC for approval. The State must grant this approval before final stabilization activities may proceed.

The NDAA Section 3116(a) provides in pertinent part:

> *[T]he term "high-level radioactive waste" does not include radioactive waste resulting from the reprocessing of spent nuclear fuel that the Secretary of Energy..., in consultation with the Nuclear Regulatory Commission…, determines –*
>
> *(3)(A)(ii) [Will be disposed of] pursuant to a State-approved closure plan or State-issued permit, authority for the approval or issuance of which is conferred on the State outside of this section.*

8.1 State-Approved Closure Plan

The HTF waste storage and removal operations are governed by an SCDHEC industrial wastewater construction permit issued January 25, 1993. [DHEC_01-25-1993] The permit was issued under the authority of the South Carolina Pollution Control Act, S.C. Code Ann., Section 48-1-10, et seq. (1985) and all applicable regulations implementing the Act. The State of South Carolina has authority for approval of wastewater treatment facility operational closure under Chapter 61, Articles 67 and 82 of the SCDHEC Regulations. [SCDHEC R.61-67, SCDHEC R.61-82]

The HTF GCP addresses the State's regulatory authority relevant to removing the HTF waste tanks and ancillary structures from service. The GCP sets forth the general protocol by which DOE intends to remove from service the HTF waste tanks and ancillary structures to protect human health and the environment. The HTF GCP was approved by SCDHEC August 2, 2012. Prior to approval by SCDHEC, the HTF GCP was made available to the public for review and comment. [SRR-CWDA-2011-00022, DHEC_08-02-2012]

Before final stabilization activities commence,[112] individual waste tank and ancillary structure closure plans, referred to as Closure Modules, describing closure details will be developed and submitted to SCDHEC for approval.[113] Prior to approval, the Closure Modules will be made available to the public for review and comment as deemed appropriate by SCDHEC. The Closure Modules will describe the waste

[112] Final stabilization activities in this context refers to the addition of grout to the waste tanks, annulus, and cooling coils, or, in the case of ancillary structures, grout or other appropriate fill material, as necessary, for the purpose of stabilizing the structure.
[113] Each individual waste tank and ancillary structure is required to be covered by a Closure Module approved by SCDHEC. Closure Modules may be written for individual waste tanks and ancillary structures or for groupings of waste tanks and ancillary structures.

tank(s) or ancillary structure(s) being covered, waste removal activities performed and effectiveness, justification that additional waste removal is not technically practicable from an engineering perspective,[114] and characteristics of remaining residuals and the stabilization process. The Closure Modules will provide analysis for each waste tank or ancillary structure demonstrating conformance with the performance objectives set forth in the GCP.

8.2 Conclusion

As explained above, the HTF waste tanks and ancillary structures will be removed from service (operationally closed) and stabilized pursuant to State-approved Closure Modules, consistent with the HTF GCP. Thus, the HTF waste tanks, ancillary structures and the stabilized residuals "[will be disposed of] pursuant to a State-approved closure plan or State-issued permit, authority for the approval or issuance of which is conferred on the State outside of this section."

[114] Per the FFA, the waste tanks will be cleaned until DOE-SR, SCDHEC and EPA agree that waste removal may cease. The Closure Module provides the basis for agency agreement.

9.0 CONCLUSION

As demonstrated in the preceding sections of this Draft HTF 3116 Basis Document, the stabilized residuals within the waste tanks and ancillary structures, the waste tanks, and the ancillary structures (including integral equipment) located at HTF at the time of closure meet the criteria set forth in NDAA Section 3116(a).

This document demonstrates that the HTF waste tanks, ancillary structures and their associated stabilized residuals will have had HRRs removed to the MEP at the time of closure. Removal of HRRs to the MEP in HTF waste tanks and ancillary structures occurs through a systematic progression of waste removal and cleaning activities using proven technologies to a point where further removal of HRRs is not sensible or useful in light of the overall benefit to human health, safety and the environment.

The stabilized HTF wastes at closure are anticipated to meet concentration limits for Class C low-level waste as set out in 10 CFR 61.55. Nevertheless, DOE is also consulting with the NRC on DOE's disposal plans for HTF pursuant to the consultation process in NDAA Section 3116(a)(3)(B)(iii) to take full advantage of the consultation process established by NDAA Section 3116. In this regard, DOE is specifically requesting in this Draft HTF 3116 Basis Document that NRC identify what changes, if any, NRC would recommend to DOE's disposal plans as described in the Draft HTF 3116 Basis Document, and DOE intends to consider the NRC recommendations, as appropriate, in the development of DOE's plans.

This document demonstrates the stabilized residuals within the waste tanks and ancillary structures, the waste tanks, and the ancillary structures (including integral equipment) located at HTF at the time of closure will meet the 10 CFR 61, Subpart C performance objectives so as to provide for the protection of the public health and the environment. These performance objectives address protection of the general population from radioactivity releases, protection of individuals from inadvertent intrusion on the disposal site, protection of workers and the public during disposal facility operations and the stability of the disposal site after closure.

Through use of the performance assessment process, DOE has analyzed the possible methods by which a future member of the public or inadvertent intruder could be exposed to the HTF residuals. The results of the HTF PA show that there is reasonable assurance the annual peak doses for a future hypothetical member of the public and a hypothetical inadvertent intruder will remain below 25 mrem and 500 mrem, respectively, in compliance with the performance objectives at 10 CFR 61.41 and 10 CFR 61.42.

The DOE has programs in place to ensure protection of workers and the public during facility operations. As demonstrated in this document, the DOE requirements for occupational radiological protection and those for radiological protection of the public and the environment are equivalent to the requirements contained in the performance objectives at 10 CFR 61.43.

This document demonstrates that the HTF at closure meets the performance objective at 10 CFR 61.44, concerning long-term site stability. DOE reviewed the site characteristics, including demography, geography, meteorology, climatology, ecology, geology, seismology and hydrogeology. As demonstrated in this Draft HTF 3116 Basis Document, the site conditions do not present hazards that impact HTF stability. In addition, the HTF closure methods will result in a facility closure that does not require ongoing maintenance.

The HTF waste tanks and ancillary structures will be removed from service (operationally closed) and stabilized pursuant to State-approved Closure Modules, consistent with the HTF GCP that has been approved by SCDHEC. Per the SRS FFA, the waste tanks will be cleaned until DOE-SR, SCDHEC and EPA agree that waste removal may cease.

Furthermore, the stabilized residuals within the waste tanks and ancillary structures, the waste tanks, and the ancillary structures (including integral equipment) do not raise any unique considerations that, notwithstanding the demonstration that all other NDAA Section 3116(a) criteria have been met, require permanent isolation in a deep geologic repository.

As summarized above and as discussed more fully in the preceding sections, this Draft HTF 3116 Basis Document demonstrates that the HTF waste tanks, ancillary structures and residuals at closure meet the criteria in NDAA Section 3116(a). Moreover, DOE will consult with the NRC, as discussed previously.

This Draft HTF 3116 Basis Document will be finalized after DOE has completed consultation with NRC and, although not required by NDAA Section 3116, after public review and comment. DOE will fully consider any consultative recommendations that may be made by NRC during the consultation process, as well as public comments provided on the Draft HTF 3116 Basis Document in preparation of the final document. Accordingly, the final document will provide the basis for the Secretary of Energy, in consultation with the NRC, to determine that the NDAA Section 3116(a) criteria are met and, thus, the HTF waste is not high-level waste.

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Note 1: References identified as (Copyright) were used in the development of this document, but are protected by copyright laws. No part of those publications may be reproduced in any form or by any means, including photocopying or electronic transmittal in any form by any means, without permission in writing from the copyright owner.

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11.0 GLOSSARY

A	
Actinide	Group of elements of atomic number 89 through 103 including thorium, uranium, neptunium, plutonium, americium and curium.
Alternate Cases	In addition to the Base Case (i.e., Case A) which reflects the most probable and defensible waste tank configuration (i.e., expected conditions for the HTF closure system) other modeling cases which reflect alternate waste tank configurations were also considered in the HTF PA. The alternate cases reflect different modeling assumptions with respect to key modeling parameters so as to allow evaluation of sensitivities and uncertainties associated with Base Case modeling assumptions. The alternate waste tank configurations are described in detail in Section 4.4.2 of the HTF PA.
Ancillary Structures	Structures associated with the waste storage tanks, such equipment as transfer line piping, pump tanks or evaporators, which are used to distribute or control the transfer of waste from one storage point to another storage point, or are used to volume reduce the waste.
Air Content	Amount of air incorporated into the grout as the result of mixing and placement.
Annulus	Also referred to as the secondary containment of a waste tank, surrounds the primary tank of Types I, II, III and IIIA tanks, providing a location for collection of any leakage from the primary tank.
B	
Base Case	The waste tank system configuration modeling case within the HTF PA that represents the most probable and defensible estimate of expected conditions for the HTF closure system based on currently available information.
Basemat	Concrete pad upon which the waste tank is constructed. The pad has close tolerances for tank leveling and the concrete is quality controlled to ensure the structural integrity to tank foundation. The basemat is also referred to as floor slab or foundation.
Bleed Water	Water that separates from the grout as the result of solids settling.
C	
Calcareous Zone	Located within the Santee Formation and the lowermost part of the overlying Dry Branch Formation, zones consist of silty and clayey fine sands, fine-grained clays, and calcareous shell fragments deposited in nearshore and inner shelf environments. Soft zones within the calcareous zones near the General Separations Area, which includes the HTF, are not cavernous voids, but are small, isolated, poorly connected, three-dimensional features filled with loose, fine-grained, water-saturated sediment.
Chromate Cooling Water	Coolant comprised of chromate-inhibited water that circulates through the cooling coils of waste tanks to remove radioactive decay heat and other sources of heat (e.g., steam heat loads, ventilation heat loads or mechanical heat loads from pumping/mixing operations).
Closure Plan	Plan that presents the environmental regulatory standards and guidelines pertinent to the closure of the tanks and describes that process for evaluating and selecting the closure configuration (i.e., residual inventory and form).
Compressive Strength	Force per unit area required to break an unconfined grout or concrete sample.

Concentration	Amount (e.g., in grams or moles) per volume of a substance.
Conductivity Probes	A simple electrical device that works on the principle that liquids conduct electricity more readily than air. If a liquid comes in contact with the probe it will complete an electrical circuit and send a signal for indication or alarm purposes.
Cooling Coils	Coils installed in the tanks to remove the decay heat that is generated by the waste in the tanks. Arrangements and designs of cooling coils differ, depending on the type of tank. Type I and II tanks, in addition to having vertical cooling coils, also have cooling coils across the bottom of the tank to provide a means for cooling the bottom of the tank.
Contamination	In the context of this Draft HTF 3116 Basis Document, contamination refers to radioactive materials that have been projected to migrate from the closed HTF.
Core Pipe	Internal pipe of transfer line that comes into contact with the waste materials. The core pipe is usually located within a jacket pipe.
Curie	A unit of radioactivity - the quantity of nuclear material that has 3.7E+10 disintegrations per second.
D	
Diffusion	Movement of contaminants from an area of higher concentration to an area of lower concentration.
Diversion Box	A shielded reinforced concrete structure containing transfer line nozzles to which jumpers are connected in order to direct waste transfers to the desired location.
E	
Eh	The symbol for reduction/oxidation (redox) potential in millivolts.
Evaporator	Steam-heated, water-cooled system installed in the tank farms to concentrate underground waste storage tank contents, in order to reduce the liquid waste volume.
Exposure	Being exposed to ionizing radiation or to radioactive material.
F	
Federal Facility Agreement	Agreement between EPA, DOE and SCDHEC that directs the comprehensive remediation of the Savannah River Site. It contains requirements for (1) site investigation and remediation of releases and potential releases of hazardous substances and (2) interim status corrective action for releases of hazardous wastes or hazardous constituents.
Fly Ash	A mineral admixture used in grout to enhance finishing characteristics, make the mix more economical and to improve pumping. It is finer in consistency than cement and its particles are round. These fine particles make the mix finish and pump more easily.

G	
General Separations Area	Centralized area of SRS including, E, F, H, J, S and Z Areas that are the heavily industrialized areas of SRS.
Grout	A cement mixture, sufficiently fluid, which can be pumped into waste tanks and equipment cavities creating a watertight bond and increasing the strength of the existing structural foundation. Capable of slowing the vertical movement or migration of water.
H	
H-Modified Process	The modified PUREX process used in H-Canyon for separation and recovery of enriched uranium from used reactor fuel.
High-Heat Waste	Waste streams from the first cycle extractions from F-Canyon and H-Canyon Separations Facilities.
Hydraulic Conductivity	Velocity of water flow through saturated materials (e.g., concrete, grout, soil).
I	
Institutional Control	A 100-year period in which DOE retains ownership and control of HTF such that HTF facility maintenance and controls will be performed to prevent inadvertent intrusion and protect public health and the environment.
L	
Leak Detection Boxes	Structures that provide for the collection and detection of leakage from the transfer lines.
Line Encasement (Sealed Concrete Trench)	Enclosed core pipes in a covered reinforced concrete encasement below ground. Any core pipe leakage into the encasement and in-leakage of groundwater into the encasement will gravity drain to a catch tank.
Low-Heat Waste	Waste streams from the second cycle extractions from F-Canyon and H-Canyon Separations Facilities.
N	
NDAA Section 3116	The Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 Section 3116 was passed by Congress on October 9, 2004 and signed by the President on October 28, 2004. NDAA Section 3116 specifies that the term “high-level radioactive waste” does not include radioactive waste that results from reprocessing spent nuclear fuel if the Secretary of Energy determines, in consultation with the NRC, that the waste meets certain criteria.
O	
Oxalic Acid	A relatively strong organic acid, about 10,000 times stronger than acetic acid.

P	
Permeability	Capability of a material to let pass other molecules or particles.
pH	A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity.
Pitting	Localized corrosion of a metal surface, confined to a point or small area that takes the form of cavities.
Porosity	Grout porosity is generally defined as the percentage of total volume of cured grout that is not occupied by the starting cementitious materials and the products that result from reaction of these cementitious materials with water.
Primary Tank	The primary tank, sometimes referred to as the “shell” or “primary liner”, is the component of the waste tank that actually contains the liquid waste. The primary tank is contained within the secondary containment, if any.
Progeny	Decay products or descendants of specific radionuclides.
Pump Pit	Shielded reinforced concrete structures located below grade at the low points of transfer lines, contain pump tanks and are usually lined with stainless steel.
Pump Tank	All HTF pump pits (except HPP-1) house a pump tank with the pump pits providing secondary containment for pump tanks. The pump tanks have a nominal capacity of 7,200 gallons each. The pump tanks installed in HTF are all of the same basic size (8.5 feet tall, 12 feet in diameter) and are lined with stainless steel.
PUREX Process	The Plutonium Uranium Extraction process used in the F-Canyon and H-Canyon to extract special nuclear material from aluminum-clad, depleted uranium targets which had been irradiated in the site’s nuclear production reactors. H-Canyon utilized the PUREX process from 1955 to 1959 prior to conversion to the HM process.
R	
Residuals	For the purposes of this Draft HTF 3116 Basis Document, the residual waste remaining in a waste tank or ancillary structure - following successful completion of waste removal activities and removal of highly radioactive radionuclides to the maximum extent practical - is referred to as “residuals”.
Riser	The risers are openings through the tank tops providing access to the tank and annulus interiors. Risers are used primarily to provide for the installation of equipment such as pumps and cooling equipment; instrumentation such as level probes and leak detection; ventilation; and to provide access to the tank interior for sampling, depth measurement and inspection.
S	
Saltcake	Saltcake located in waste tanks consists of crystallized salts with interstitial void space and small quantities of entrained insoluble solids (assumed to be partially sludge solids).
Saltstone Production	A process in which low-activity salt solution is mixed with dry chemicals (cement, slag and fly ash) to form a homogeneous grout mixture.
Sand Layer	All Type II waste tanks have a one-inch thick primary sand layer between the primary tank and secondary liner and a one-inch thick secondary sand layer between the secondary liner and basemat. These sand layers are also commonly referred to as "Sand Pads".

Secondary Containment	Also referred to as an annulus of a waste tank. The secondary containment surrounds the primary tank of Types I, II, III and IIIA tanks, providing a location for collection of any leakage from the primary tank.
Segregation	Separation of sand from binder as the result of impact and separation of water from grout as the result of gravity settling of the solids from the grout slurry.
Set Time	Time after mixing at which the grout responds as a solid.
Shotcrete	Concrete conveyed through a hose and pneumatically projected at high velocity onto a surface. Shotcrete undergoes placement and compaction at the same time due to the force with which it is projected from the nozzle. Shotcrete was used in the construction of Type IV tanks.
Slag	Slag was introduced into the design mixes which in addition to its hydraulic activity, also provides chemical reducing power to the mix. Slag has been shown to possess chemically reducing properties that are favorable for technetium reduction and for plutonium and selenium.
Solubility	The ability of a substance to dissolve in a solvent. Solubility may also refer to the measure of this ability for a particular substance in a particular solvent, equal to the quantity of substance dissolving in a fixed quantity of solvent to form a saturated solution under specified temperature and pressure. The extent of the solubility of a substance in a specific solvent is measured as the saturation concentration, where adding more solute does not increase the concentration of the solution. The extent of solubility ranges widely, from infinitely soluble, such as ethanol in water, to poorly soluble, such as silver chloride in water. The term *insoluble* is often applied to poorly or very poorly soluble compounds.
Source Term	The amount and type of radioactive material released into the environment.
Stabilized Contaminant	Grouted waste remaining in the waste tanks or ancillary equipment after system closure.
Stochastic	A probabilistic distribution of parameters.
Supernate	Liquid salt solution found above the sludge layer after settling of solids in waste tanks has occurred as a result of a liquid waste transfer to one of the waste processing facilities or receipt tanks. Also referred to, generally, as supernatant.
U	
Underliner Sump	An engineered feature that collects any leakage through the concrete or stainless steel liners beneath waste tanks.
Unit Weight	Weight of a unit volume, typically one cubic foot.
V	
Valve Boxes	Transfer valve boxes facilitate specific waste transfers that are conducted frequently. The valves are generally manual ball valves in removable jumpers with flush water connections on the transfer piping. The valve boxes provide containment of, and access to, the valves.
Vault	Term used to describe the underground concrete floor, walls and roof that enclose the steel primary tank and secondary liner, if applicable, in the waste tank system.
Viscosity	Rheological quality of fluids describing the resistance to flow.

W	
Waste Characterization System	Computer-based system designed to integrate historical information, current sample data, and physical properties of constituents to develop predictions of concentrations and inventory.
Working Slab	Concrete surface usually placed to create a level construction surface. This concrete is normally lower quality without reinforcement and is either broken up after or cracked during construction activities between the tanks, thus is not considered a barrier to vertical water migration.

APPENDIX A: LIQUID WASTE SYSTEM DESCRIPTION

Appendix Purpose

The purpose of this appendix is to provide a brief overall description of the SRS Liquid Waste System.

Appendix Contents

This appendix briefly describes the history of the SRS underground radioactive waste storage tanks and their contents, and describes the methods used to treat and dispose of this waste.

Key Points

- SRS has 51 waste tanks within two tanks farms, FTF and HTF, which entered service between 1954 and 1986.
- There are four basic types of waste tanks, designated Types I, II, III/IIIA and IV.
- The 27 Type III/IIIA tanks meet current EPA requirements for full secondary containment and leak detection; the other 24 do not meet these requirements.
- As of April 2, 2012, approximately 37,200,000 gallons of radioactive waste were stored in the waste tanks, most of this from separation and recovery of special nuclear materials and enriched uranium in the two SRS nuclear materials processing facilities known as F-Canyon and H-Canyon.
- The high-level waste fraction removed from the waste tanks (including the sludge waste) is being converted into borosilicate glass by the vitrification process that takes place in the DWPF, with the solidified glass contained in stainless steel canisters.
- Salt waste removed from the waste tanks is pretreated with the resultant low-volume, high-activity fraction being sent to DWPF and the high-volume, low-activity fraction (referred to as decontaminated salt solution) being treated and disposed of as a non-hazardous, cementitious waste form (i.e., saltstone) in the SDF.

A.1 Background

The SRS is an approximately 310 square mile site located in the state of South Carolina and bordering the Savannah River. Since it became fully operational in 1954, it has produced nuclear material for national defense, research, medical, and space programs. The separation of nuclear material from irradiated targets and used fuels resulted in the generation of large quantities of radioactive liquid waste, which is currently stored on-site in large underground radioactive waste storage tanks.

Most of the waste tank inventory currently stored at SRS is a complex mixture of chemical and radioactive waste generated during the separation of special nuclear materials and enriched uranium from irradiated targets and used fuel using the PUREX process in F-Canyon and the HM process in H-Canyon. Waste generated from the recovery of Pu-238 in H-Canyon for the production of heat sources for space missions is also included. The variability in both nuclide and chemical content in this liquid radioactive waste is due, in part, to the fact that waste streams from the first cycle (high-heat) and second cycle (low-heat) extractions from each canyon were typically stored in separate waste tanks to better manage waste heat generation.

When these acidic streams were pH-adjusted with caustic to form a high alkaline solution and transferred to a waste tank in one of the two tank farms, the resultant precipitate settled into four characteristic sludge consistencies. Typically, this sludge waste can still be found in the waste tanks where it was originally deposited beginning in 1954. Historically, new waste receipts into the tank farms have been segregated into four general categories in the SRS tank farms: PUREX high activity waste (HAW), PUREX low activity waste (LAW), HM HAW and HM LAW. Because of this segregation, settled sludge solids contained in waste tanks that received new waste are readily identified as one of these four categories. Fission product concentrations are about three orders of magnitude higher in both PUREX and HM HAW sludge than the corresponding LAW sludge.

The soluble portions of the first and second cycle waste were similarly partitioned but have, and continue to undergo, blending in the course of waste transfer and staging of salt waste for evaporative concentration. Beginning in 1964, large evaporator systems were used to volume reduce the liquid salt waste to form two distinct waste types: concentrated supernate and saltcake. Combining and blending salt solutions has tended to reduce soluble waste into blended PUREX salt and concentrate and HM salt and concentrate, rather than maintaining four distinct salt compositions. Continued blending and evaporation of the salt solution deposits crystallized salts with overlying and interstitial concentrated salt solution in salt tanks located in both FTF and HTF. More recently, with transfers of sludge slurries to sludge washing tanks, removal of saltcake to support salt waste pretreatment, receipts of DWPF recycle, and space limitations restricting full evaporator operations, salt solutions have been transferred between the two tank farms. Intermingling of PUREX and HM salt waste will continue through the life of the program. [SRR-LWP-2009-00001]

A.2 Liquid Waste System

The Liquid Waste System is the integrated series of facilities at SRS that safely manage the storage of existing waste inventory in the SRS waste tanks, support the transfer and waste reduction of this waste, perform the pretreatment of waste in preparation for eventual waste disposal, and provides for the permanent disposal of the high-volume, low-activity decontaminated salt solution, as well as other smaller low-level waste liquid streams, in the SDF. Key facets of the Liquid Waste System are briefly described in the text that follows.

A.2.1 Waste Tank Storage

The SRS has a total of 51 waste tanks located within two tank farms, FTF (22 waste tanks) and HTF (29 waste tanks). These waste tanks were placed into operation between 1954 and 1986. There are four distinct waste tank designs, Types I through IV. Type III/IIIA tanks are the newest waste tanks and were placed into operation between 1969 and 1986. There are a total of 27 Type III/IIIA tanks. Figure A.2-1 shows Type III tanks during construction. These waste tanks meet current EPA requirements for full secondary containment and leak detection. The remaining 24 waste tanks do not meet EPA requirements for secondary containment. The twelve Type I tanks are the oldest waste tanks and were constructed in the early 1950s. The four Type II waste tanks were constructed between 1955 and 1956. There are eight Type IV waste tanks that were constructed between 1958 and 1962. Two of these Type IV waste tanks, Tanks 17 and 20, were removed from service and filled with grout in 1997 under SCDHEC approved GCP. [PIT-MISC-0002, PIT-MISC-0004] Two additional Type IV tanks, Tanks 18 and 19, were removed from service and filled with grout in 2012 under the SCDHEC approved FTF GCP. [LWO-RIP-2009-00009] Two FTF Type I tanks, Tanks 5 and 6, have completed cleaning activities and are awaiting completion of final closure documentation.

Figure A.2-1: Waste Tanks Under Construction

Thirteen SRS waste tanks have a history of leakage. These waste tanks include Type I, Type II and Type IV designs. No Type III or IIIA tanks have developed leak sites. Eight of the 13 waste tanks with a history of leakage are located in HTF (Tank 9, Tank 10, Tank 11, Tank 12, Tank 13, Tank 14, Tank 15 and Tank 16). [SRR-STI-2012-00346] Sufficient waste has been removed from these waste tanks such that there are currently no active leak sites. [SRR-LWP-2009-00001] Only once has waste leaking from a primary waste tank reached the environment. This event occurred in September 1960 and was associated with Tank 16 in HTF when tens of gallons of waste reached the surrounding soils. [DPSOX-5954] In all other cases, leakage from a primary waste tank has been confined within the secondary containment annuli and has not reached the surrounding soils.

Although outside the scope of this determination, waste did reach the soil from a spill associated with Tank 8. In 1961, Tank 8 was inadvertently over-filled and waste escaped along the junction area where a transfer line entered Tank 8. The majority of the liquid was contained within the secondary encasement associated with the transfer lines for Tanks 1 through 8 in FTF, but an estimated 1,500 gallons spilled into the surrounding soil. [DPSPU 75-11-8]

A.2.2 Waste Tank Space Management

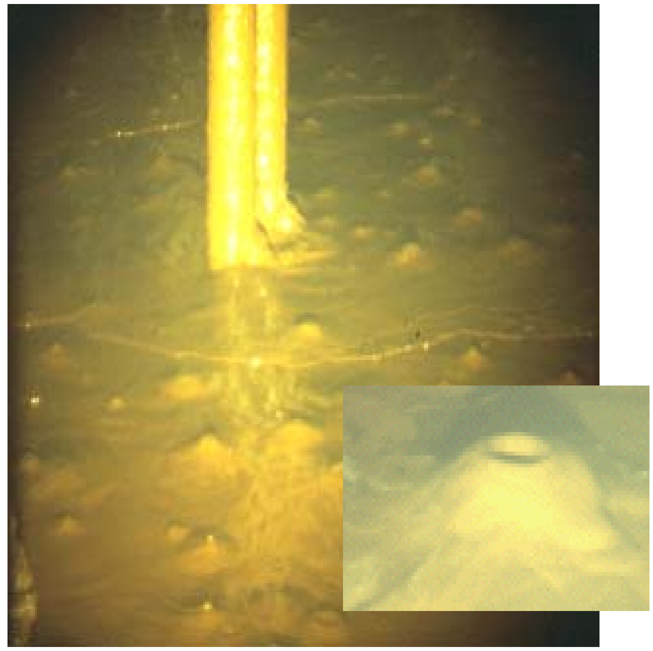
To make better use of available waste tank storage capacity, incoming liquid waste is evaporated to reduce its volume. Since 1951, the tank farms have received over 140,000,000 gallons of liquid waste, of which over 100,000,000 gallons have been evaporated. As of April 2, 2012, approximately 37,200,000 gallons of liquid radioactive waste was stored in the waste tanks. Projected available waste tank space is carefully tracked to ensure that the tank farms do not become “water logged,” a term meaning that so much of the usable Type III/IIIA tank space, the waste tanks that have full secondary containment systems, has been filled that normal operations, waste removal, and waste processing operations cannot continue. A portion of the Type III/IIIA tank space must be reserved as contingency space should a new waste tank leak be realized. [SRR-LWP-2012-00029]

Waste receipts and transfers are normal tank farm activities as the tank farms receive new waste from the H-Canyon legacy material stabilization program, liquid waste from DWPF processing (typically referred to as “DWPF recycle”), and wash water from sludge washing. The tank farms also make routine transfers to and from waste tanks and evaporators. Currently, there is very little waste that has not had the water evaporated from it to its maximum extent. The working capacity of the tank farms has steadily decreased and this trend will continue until sufficient salt waste has been treated and disposed of in SDF. Three evaporator systems are currently operating at SRS, the 2H, 3H, and 2F systems. Evaporator operations are currently impacted due to limited salt waste storage space. [SRR-LWP-2009-00001]

Figure A.2-2: Supernate (Top) and Saltcake (Bottom)

As of April 2, 2012, approximately 308,000,000 curies of radioactivity were stored in the SRS tank farms. This waste is a complex mixture of insoluble metal hydroxide solids, commonly referred to as sludge, and soluble salt supernate. The supernate volume is reduced by evaporation which also concentrates the soluble salts to their solubility limit. The resultant solution either crystallizes as salts or remains as a concentrated supernate solution (Figure A.2-2). The resulting crystalline solids are commonly referred to as saltcake. [SRR-LWP-2012-00029]

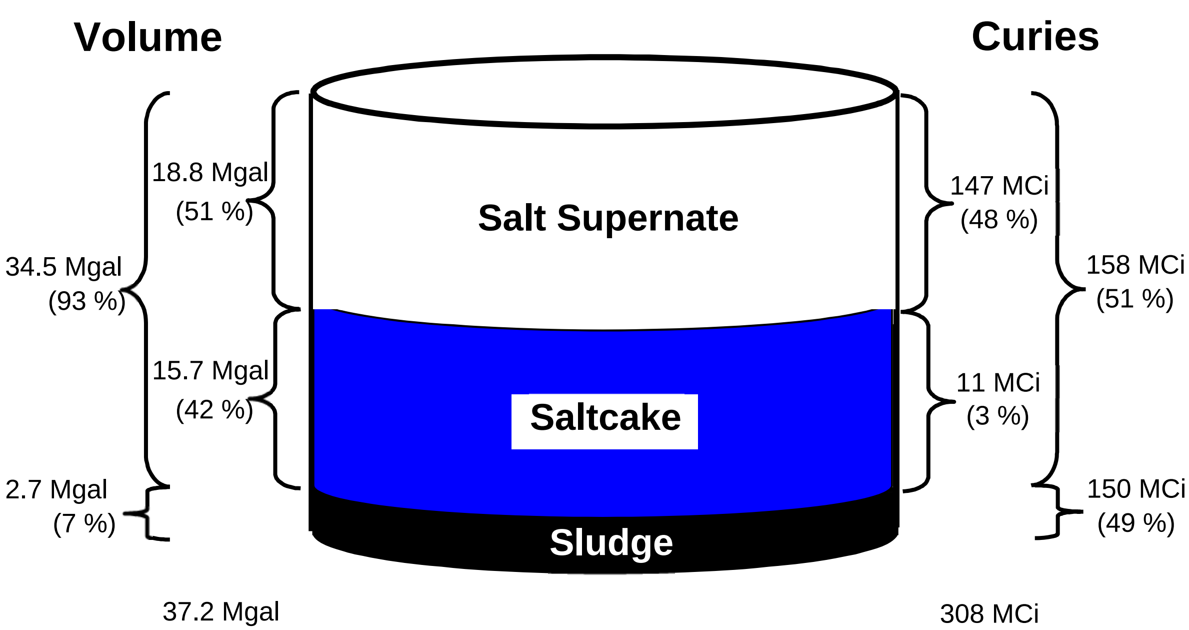
Figure A.2-3: Sludge Component of Radioactive Waste



The sludge component (Figure A.2-3) of the radioactive waste represents approximately 2,700,000 gallons (7 % of total) of waste volume but contains approximately 150,000,000 curies (49 % of total) of the radioactivity. The salt waste makes up the remaining 34,500,000 gallons (93 % of total) of waste and contains approximately 158,000,000 curies (51 % of total) of the radioactivity. Of that salt waste, the supernate accounts for approximately 18,800,000 gallons and 147,000,000 curies of the 158,000,000 curies total salt waste related activity. The saltcake accounts for approximately 15,700,000 gallons and 11,000,000 curies of the remaining salt waste. The sludge contains the majority of the long-lived (half-life greater than 30 years) radionuclides (e.g., actinides) and strontium. Figure A.2-4 shows the breakdown of this waste. [SRR-LWP-2012-00029]

Radioactive waste volumes and radioactivity inventories reported herein are based on the WCS database, which includes the chemical and radionuclide inventories on a tank-by-tank basis. The WCS is a dynamic database frequently updated with new data from ongoing operations, such as decanting and concentrating of free supernate via evaporators, preparation of sludge batches for DWPF feed, waste transfers between waste tanks, waste sample analyses, and influent receipts such as H-Canyon waste and DWPF recycle. Volumes and curies referenced in this appendix are current as of April 2, 2012. [SRR-LWP-2012-00029]

Figure A.2-4: FTF and HTF Waste Tank Composite Inventory



Inventory values as of April 2, 2012
[SRR-LWP-2012-00029]

Note: Due to rounding, inventory values may differ slightly from those contained in the *4/02/2012 – April 2012 Curie and Volume Inventory Report*. [SRR-LWP-2012-00029]

Approximately 95 % of the salt waste radioactivity is short-lived (half-life 30 years or less) Cs-137 and its daughter product, Ba-137m, along with lower levels of actinide contamination. Depending on the particular waste stream (e.g., canyon waste, DWPF recycle waste), the cesium concentration may vary. The precipitation of salts following evaporation can also change the cesium concentration. The concentration of cesium is significantly lower than non-radioactive salts in the waste, such as sodium nitrate and nitrite; therefore, the cesium does not reach its solubility limit and only a small fraction precipitates. [SRR-LWP-2009-00001] As a result, the cesium concentration in the saltcake is much lower than that in the liquid supernate and interstitial liquid fraction of the salt waste.

A.3 Safe Disposal of the Waste

In the 1980s, waste removal operations were initiated in the SRS tank farms. Ultimately, the goal is remove and treat the waste, safely closing the waste tanks and disposing of the waste in one of two final waste forms: glass, which will contain greater than 99 % of the radioactivity, and saltstone, which will contain the vast amount of volume but less than one percent of the radioactivity. Both the salt waste and the sludge waste must be uniquely treated to prepare these two waste forms for disposal. The sludge must be washed to remove non-radioactive salts that would interfere with glass production. The washed sludge can then be sent to DWPF for vitrification. The salt must be treated to separate the bulk of the radionuclides from the non-radioactive salts in the waste. This separation will be accomplished in SWPF. However, until the startup of the SWPF, additional salt treatment processes, known as Interim Salt Processing, will be used to accomplish this separation on a limited amount of the lower activity salt waste.

A.3.1 Salt Processing

A final DOE technology selection for salt processing was completed and a Salt Processing EIS ROD was issued in October 2001. [DOE/EIS-0303 ROD] The ROD designated Caustic Side Solvent Extraction (CSSX) as the preferred alternative to be used to separate cesium from the salt waste. Based on the current *Liquid Waste System Plan*, DOE anticipates using a two-phase, three-part process to treat salt waste. [SRR-LWP-2009-00001]

During the initial Interim Salt Processing phase, relatively small volumes of the lower activity will be treated using the following two salt waste treatment processes:

- **Deliquification, Dissolution and Adjustment (DDA):** For salt waste in Tank 41 as of June 9, 2003, the treatment of deliquification (i.e., extracting the interstitial liquid) was sufficient to produce a salt waste that met the SPF WAC. Deliquification is an effective decontamination process because the primary radionuclide in salt is Cs-137, which is highly soluble. To accomplish the process, the saltcake is first deliquified by draining and pumping. The deliquified saltcake is dissolved by adding water and pumping out the salt solution. The resulting salt solution is given time to allow additional insoluble solids to settle prior to being sent to the SPF feed tank. If necessary, the salt solution may be aggregated with other Tank Farm waste to adjust batch chemistry for processing at SPF.
- **Actinide Removal Process (ARP)/Modular CSSX Unit (MCU):** For salt waste in selected waste tanks (e.g., Tank 25), further decontamination is performed. Salt waste from these waste tanks first will be sent to ARP. In ARP, monosodium titanate is added to the waste as a finely divided solid. Actinides are sorbed on the monosodium titanate and then filtered out of the liquid to produce a stream that is sent to MCU. The salt solution is further treated to reduce the concentration of Cs-137 using the CSSX process.

Interim Salt Processing will be utilized pending the construction and start-up of the SWPF, the second and more robust phase of salt processing. The SWPF is a large, high-capacity facility that incorporates both the ARP and CSSX processes in a full-scale shielded facility capable of handling and effectively decontaminating salt waste with high levels of radioactivity.

In addition, DOE is exploring the viability of augmenting salt processing capabilities using rotary microfilters and ion exchange columns installed in Type IIIA tank risers. The salt solution would be struck with monosodium titanate similar to the actinide removal processes associated with Interim Salt Processing and SWPF, and the insoluble solids and monosodium titanate would be filtered using rotary microfiltratrion technology. This clarified salt solution would then pass through ion exchange column(s) designed to target the removal of cesium at decontamination factors similar to SWPF design valves.

Figure A.3-1: Vitrification Canister Prior to Use

A.3.2 Sludge Processing

Sludge is "washed" to reduce the amount of soluble salts remaining in the sludge slurry. The processed sludge is called "washed sludge." During sludge processing, large volumes of wash water are generated and must be volume-reduced by evaporation. Over the life of the waste removal program, the sludge currently stored in SRS waste tanks will be blended into separate sludge "batches" to be processed and fed to DWPF for vitrification.

Final processing for the washed sludge and the high-activity fraction of the salt waste occurs at DWPF. This waste includes monosodium titanate sludge from ARP or SWPF, the cesium strip effluent from MCU or SWPF, and the washed sludge slurry. In a complex sequence of carefully controlled chemical reactions, this waste is blended with glass frit and melted to vitrify it into a borosilicate glass form. The resulting molten glass is poured into stainless steel canisters (Figure A.3-1). As the filled canisters cool, the molten glass solidifies (Figure A.3-2), immobilizing the radioactive waste within the glass structure. After the canisters have cooled, they are permanently sealed, and the external surfaces are decontaminated to meet United States Department of Transportation requirements. The canisters are then ready to be stored on an interim basis, on-site, in the Glass Waste Storage Building (GWSB). A low-level recycle waste stream from DWPF is returned to the tank farms. DWPF has been fully operational since 1996. [SRR-LWP-2009-00001]

Figure A.3-2: Sample of Vitrified Radioactive Glass

A.3.3 Saltstone: On-Site Disposal of Low-Level Waste

The Saltstone Facility, located in Z Area, consists of two facility segments: SPF and SDF. The SPF is permitted as a wastewater treatment facility per SCDHEC Regulations. SPF receives and treats the decontaminated salt solution to produce saltstone by mixing the low-level waste liquid stream with cementitious materials (cement, flyash, and slag). A slurry of the components is pumped into the disposal cells located in SDF, where the saltstone grout solidifies into a monolithic, non-hazardous, solid low-level waste form called saltstone. SDF is permitted as an Industrial Solid Waste Landfill Facility (ISWLF). [SRR-LWP-2009-00001]

The SDF will be comprised of many large disposal units. Each of the disposal units will be filled with saltstone. The saltstone itself provides primary containment of the waste, and the walls, floor, and roof of the disposal units provide additional engineered barriers.

The current active disposal unit (Vault 4) dimensions are approximately 200 feet wide, 600 feet long and 30 feet high. The disposal unit is divided into two units which are 200 feet wide and 300 feet long, with a three-inch separation gap between the units. Each unit is further divided into six cells, with each cell measuring approximately 100 feet x 100 feet. Thus, Vault 4 is comprised of 12 cells each approximately 100 feet x 100 feet. The original SDF disposal unit (Vault 1) dimensions are approximately 100 feet wide, 600 feet long and 27 feet high. The disposal unit is divided into two units which are 100 feet x 300 feet with a three-inch separation gap between units. Each unit is further divided into three cells, with each cell measuring approximately 100 feet x 100 feet. Thus, Vault 1 is comprised of six cells each approximately 100 feet x 100 feet. [SRR-CWDA-2009-00017]

Future disposal cells are currently planned to be nominally 150 feet diameter by 22 feet high each and will be designed in compliance with provisions contained in the *Consent Order of Dismissal in Natural Resources Defense Council, et al. v. South Carolina Department of Health and Environmental Controls, et al. (South Carolina Administrative Law Court, August 7, 2007)*. [SRR-CWDA-2009-00017] Construction of the first of the future disposal units, comprised of Disposal Cells 2A and 2B, is complete in the SDF, and additional disposal units are under construction (Figure A.3-3). DOE is also evaluating other disposal cell designs for potential future use.

Figure A.3-3: Saltstone Facility (April, 2012)

Closure operations will begin near the end of the active disposal period in the SDF, i.e., after most or all the disposal units have been constructed and filled. Backfill of native soil will be placed around the disposal units. The present closure concept includes an erosion barrier, two drainage layers along with backfill and a vegetative cover. [SRR-CWDA-2009-00017]

Construction of the Saltstone Facility and the first two disposal units was completed between February 1986 and July 1988. The Saltstone Facility started radioactive operations June 12, 1990. Future disposal cells will be constructed on an as-needed basis in coordination with salt processing production rates. [SRR-CWDA-2009-00017]

APPENDIX B: APPROACH TO DOCUMENTING REMOVAL OF RADIONUCLIDES TO SUPPORT DOE CLOSURE AUTHORIZATION

Appendix Purpose

The purpose of this appendix is to outline the approach used by DOE for the SRS waste tanks and ancillary structures to document removal of radionuclides, with emphasis on HRRs.

Appendix Contents

This appendix briefly describes DOE's closure approach leading to DOE Closure Authorization and provides details on each phase of DOE's radionuclide removal process to support Closure Authorization.

Key Points

- In order to proceed with closure of the HTF, DOE Manual 435.1-1, DOE Guide 435.1-1 and DOE practice requires that DOE issue Tier 1 Closure Authorization specifying the requirements necessary to achieve closure.
- DOE Manual 435.1-1, DOE Guide 435.1-1 and DOE practice require that subsequent DOE Tier 2 Closure Authorization to proceed with permanent stabilization of a specific waste tank or ancillary structure be based on Tier 2 closure documentation.
- DOE's approach to radionuclide removal consists of the following phases: Initial Technology Selection, Technology Implementation, Technology Execution, Technology Effectiveness Evaluation and Additional Technology Evaluation.
- For each waste tank or ancillary structure, documentation or information collected from each phase of the process eventually contributes to a final removal report supporting Tier 2 Closure Authorization.

B.1.0 Executive Summary

The discussions presented in this Appendix outline and describe the approach used by the DOE for each of the SRS waste tanks or ancillary structures to document removal of radionuclides, with emphasis on HRRs. This approach consists of the following phases: initial technology selection, technology implementation, technology execution, technology effectiveness evaluation and additional technology evaluation. For each waste tank or ancillary structure, documentation or information collected from each phase of the process eventually contributes to a removal report describing removal of radionuclides, with emphasis on HRRs, for that particular waste tank or ancillary structure. In some instances a report may be written to capture more than one tank or ancillary structure if several are removed from service at the same time. The removal report further integrates into documentation supporting removal from service and stabilization of waste tanks and ancillary structures in support of eventual closure of the SRS tank farms. The information documented in the removal report is utilized by the DOE-SR to support Tier 2 Closure Authorization.

B.2.0 Closure Approach

In order to proceed with closure of the FTF and the HTF at the SRS, DOE Manual 435.1-1, DOE Guide 435.1-1 and DOE practice requires that DOE issue Tier 1 Closure Authorization specifying the requirements necessary to achieve closure. The Tier 1 closure documentation defines the parameters, approach and plans by which tank farm closure activities will be accomplished. Once the specified documentation has been approved, an Authorization to Proceed will be issued. [DOE M 435.1-1, DOE G 435.1-1] At SRS, separate Tier 1 closure documentation will be issued for FTF[115] and HTF. The tank

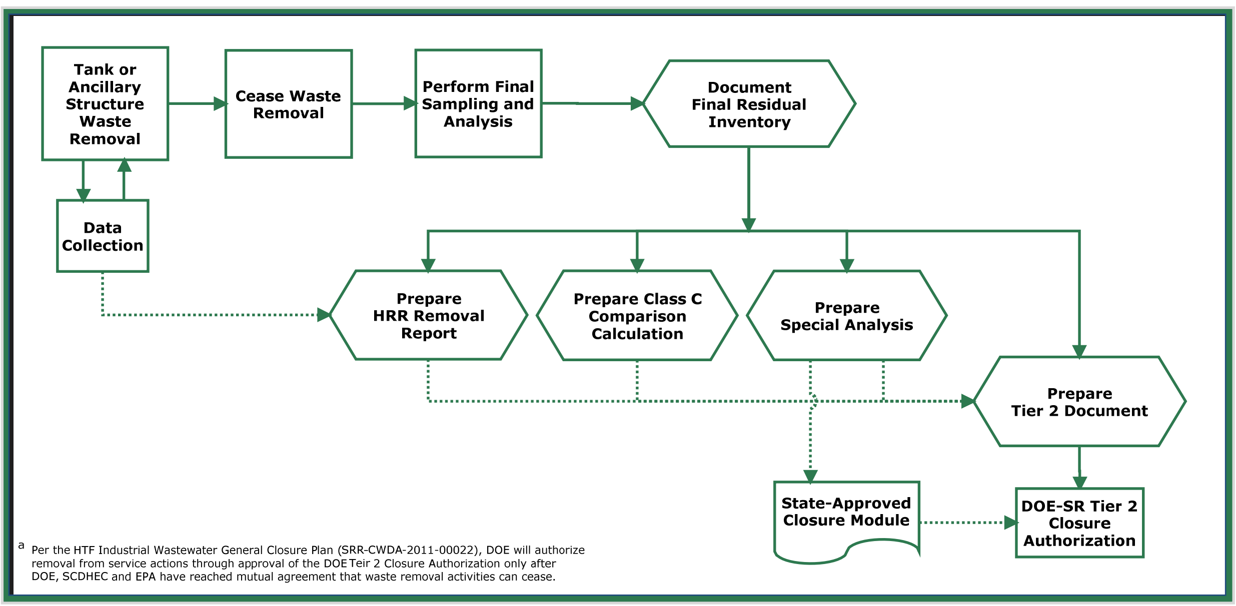
[115] In March 2012, DOE issued Tier 1 closure documentation for FTF.

farm-specific Tier 1 closure documentation requirements are anticipated to include the following documentation:

- Appropriate NEPA documentation
- Tank Farm specific (FTF or HTF) performance assessment
- SRS CA
- Tank Farm specific (FTF or HTF) NDAA 3116 Determination by the Secretary, and its supporting 3116 Basis Document
- State-approved Tank Farm specific (FTF or HTF) Industrial Wastewater GCP

At the completion of waste removal activities for a specific waste tank or ancillary structure, the individual tank or structure is removed from service. As required by DOE Manual 435.1-1, DOE Guide 435.1-1 and DOE practice, approval to proceed with permanent stabilization of the specific waste tank or ancillary structure will be based on Tier 2 closure documentation. [DOE M 435.1-1, DOE G 435.1-1] This Tier 2 closure documentation provides the waste tank-specific or ancillary structure-specific information demonstrating that the process described in the Tier 1 closure documentation has been implemented and the criteria required by the Tier 1 closure documentation have been met. Figure B.2-1 shows the documentation pathway that leads to Tier 2 Closure Authorization. Tier 2 Authorization to proceed with closure (e.g., stabilization activities) will be issued by the Manager for DOE-SR.

Figure B.2-1: Tier 2 Closure Authorization



B.3.0 Radionuclide Removal Process to Support Tier 2 Closure Authorization

B.3.1 General Approach

The following section describes the progression of defined stages that must be utilized to support Tier 2 Closure Authorization. The process presented begins following the bulk removal of the solids and liquid from a waste tank or ancillary structure. This final waste removal phase is typically referred to as "heel removal." Waste removal will continue per the progression described in the following section. Proceeding with operational closure activities, e.g., stabilization, must be authorized through the Tier 2 approval process.

It should be noted that in some ancillary structures it may not be practical to undertake further removal of HRRs following bulk waste removal efforts. As a general matter, such a situation may arise if HRRs are present in such low quantities that they make an insignificant contribution to potential doses to workers, a hypothetical future member of the public, and the hypothetical future human intruder.

The contamination remaining in a waste tank or ancillary structure following successful completion of heel removal is referred to as “residuals.”

B.3.2 Activities and Steps

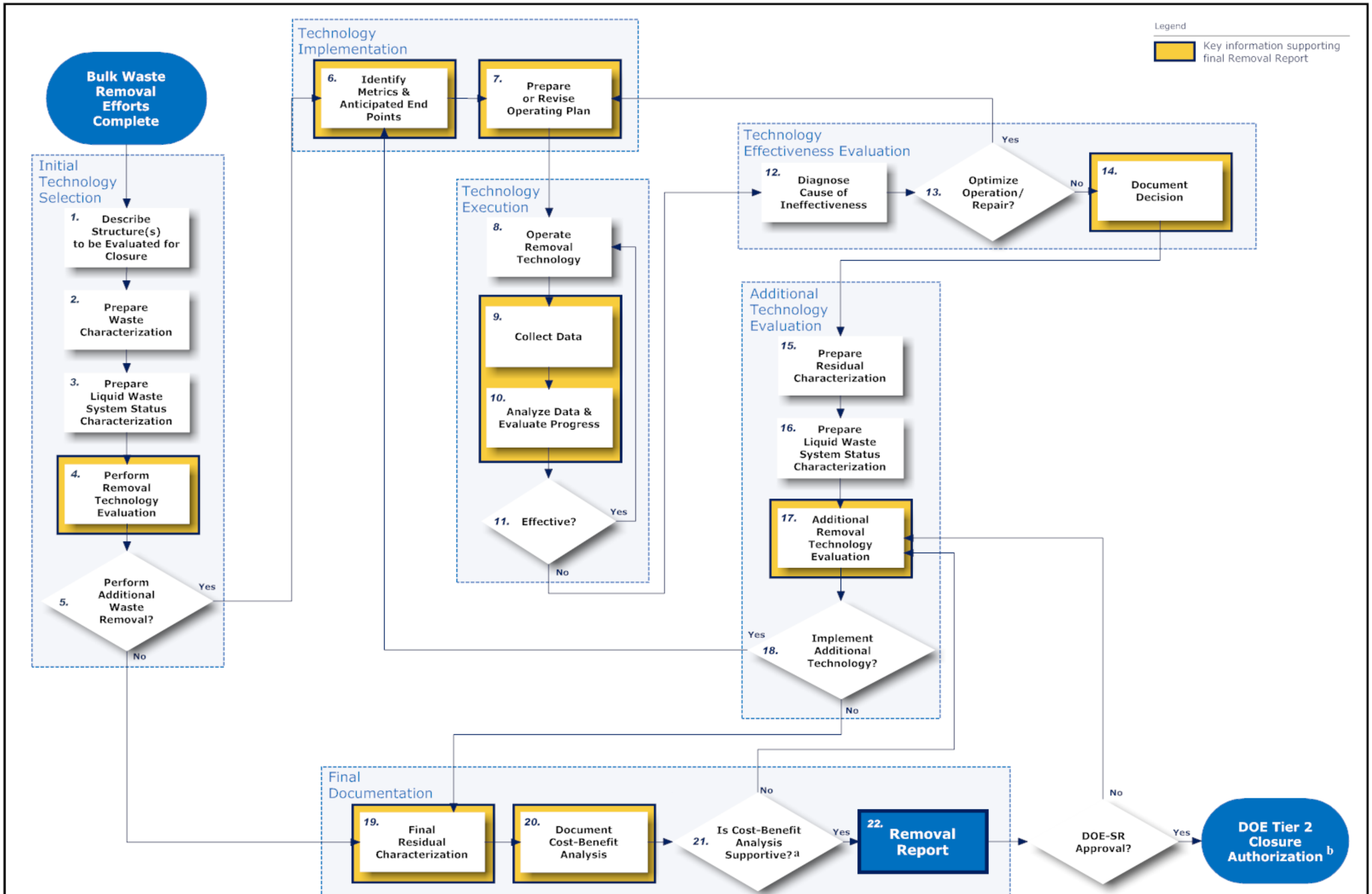
The approach is outlined in Figure B.3-1 and consists of the following phases, which are described in more detail in subsequent sections of this document:

- Initial Technology Selection
- Technology Implementation
- Technology Execution
- Technology Effectiveness Evaluation
- Additional Technology Evaluation

Throughout the waste tank or ancillary structure cleaning process various reports, evaluations, analyses, data, operational documents, and presentations are developed to support DOE’s final documentation supporting Tier 2 Closure Authorization. The level of specific data collection or documentation for each waste tank or ancillary structure will vary depending upon the attributes of the waste tank or ancillary structure and the technologies being implemented. For example, the documentation may be as simple as a memo to file when the planned technology is the same as the baseline (e.g., use of mixing pumps for mechanical heel removal) due to similar waste characteristics as a previously completed tank. However, a more formal report or documented systems engineering evaluation may be conducted if it is expected that the deployment of a new type of technology is needed.

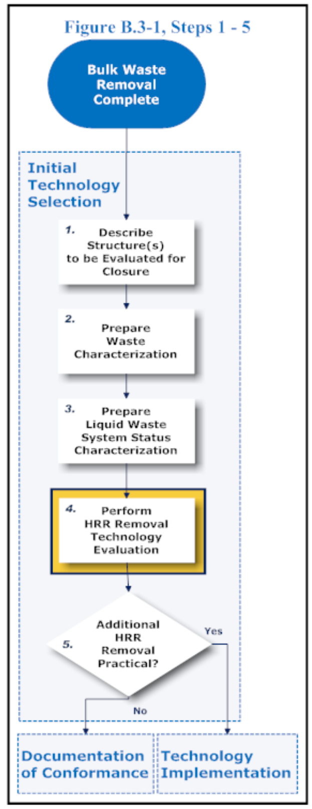
For each waste tank or ancillary structure, documentation or information collected from each phase of the process eventually contributes to a final removal report supporting Tier 2 Closure Authorization. In some instances a report may be written to capture more than one tank or ancillary structure if several are removed from service at the same time.

Figure B.3-1: Approach



[a] In this context, DOE is assessing the practicability of additional radionuclide removal with emphasis on HRRs.

[b] Per the HTF Industrial Wastewater General Closure Plan (SRR-CWDA-2011-00022), DOE will authorize removal from service actions through approval of the DOE Tier 2 Closure Authorization only after DOE, SCDHEC and EPA have reached mutual agreement that waste removal activities can cease.



B.3.2.1 Initial Technology Selection (Figure B.3-1, Steps 1-5)

This section outlines the technology selection methodology that DOE will utilize to choose the optimal technology for radionuclide removal, with emphasis on HRRs, given the conditions at the time of evaluation. This process requires an initial systematic, documented evaluation of the options available, with a quantitative analysis arriving at the optimal technology choice. The specific methodology that DOE utilizes for choosing a removal technology and the formality of the associated documentation can vary (see Section B.3.2) depending on the waste properties, waste location and timing of the waste removal, but will include the following activities, which are described in subsequent sub-sections:

1. Clear description of the structure, or structures, being evaluated for closure (i.e., waste tanks or ancillary structure) (see Section B.3.2.1.1)
2. Characterization of waste remaining in the structure (see Section B.3.2.1.2)
3. Characterization of associated Liquid Waste System status and the impact to this overall system posed by waste removal actions for the structure (see Section B.3.2.1.3)
4. Systematic evaluation of removal technologies and selection of best available technology (see Section B.3.2.1.4)
5. Assessment of whether to perform additional removal utilizing the selected technology (see Section B.3.2.1.5)

B.3.2.1.1 Description of Structure to be Evaluated (Figure B.3-1, Step 1)

The components associated with the specific structure (or structures) that are to be evaluated for radionuclide removal and eventual stabilization pending closure will be described. These structures could include either a waste tank or ancillary structure. In all cases, waste tank refers to the entire structure including both primary tank and annulus.[116] The description of the structure could include assembly of engineering drawings, schematics, maps of obstructions to cleaning efforts, lists of components, operating status and location of integral equipment, boundaries between the tank or structure and tank farm system, photographs, and other pertinent documentation.

B.3.2.1.2 Waste Characterization (Figure B.3-1, Step 2)

With a clear description of the structure that is undergoing waste removal, DOE will prepare a characterization of the waste to be removed. The purpose of this characterization is to provide the baseline of radionuclide content, with an emphasis on HRRs, to ensure selection of optimal waste removal technologies. This characterization will take into consideration the specific HRRs within the tank or ancillary structure and may include:

- Photographs and video of waste inside the waste tank or ancillary structure
- Sample results from internal surface area and mounds
- Estimated volumes
- Historical information related to radionuclides present and associated concentrations
- Analysis from similar waste tanks or ancillary structures
- Physical properties (e.g., density, rheology, viscosity, particle size, yield strength)
- Waste composition (e.g., HRRs present, non-radioactive materials present, concentrations)
- Maps of waste locations within a waste tank or structure (e.g., layers, mounds)
- Documentation of past removal activities and their relative success
- Worker dose records for sampling activities
- Waste removal history (e.g., relative success of cleaning efforts, progress photographs, equipment used)
- Cooling coil sample analysis

[116] An exception to this is the Type IV tanks, which do not have an annulus.

- Annulus condition (e.g., leak history, photographs)
- Leak detection system historical data

Information on waste characterization will be collected from applicable lab analysis reports, drawings, mapping diagrams and other pertinent reports. This evaluation may be documented as a stand-alone document or may be included with other documentation within the Initial Technology Selection phase.

B.3.2.1.3 Liquid Waste System Status Characterization (Figure B.3-1, Step 3)

In addition to the characterization of the waste inside the structure, DOE will characterize the Liquid Waste System status associated with the further waste removal activities for the structure. The purpose of the system characterization is to understand and document the status and condition of the Liquid Waste System, in total, at the time of the proposed waste removal evolutions. These considerations of status, at a minimum, will include:

- Available tank storage space capacity for applicable waste tanks required to support waste removal efforts
- Compatibility of potential waste, waste removal streams, or agents added to the waste to aid in waste removal (e.g., oxalic acid) with other waste stored
- Downstream processing impacts (e.g., impact of oxalates, waste volumes)
- Status of salt waste and sludge batch processing and preparation
- Impact on future waste removal activities in waste receipt tanks
- Available equipment (e.g., explanation of resources used or not used)

This status determination will either document these considerations or, in cases of similar time and circumstances, refer to previous documentation that remains valid for the current configuration and systems being evaluated. This evaluation may be documented as a stand-alone document or may be included with other documentation within the Initial Technology Selection phase.

B.3.2.1.4 Radionuclide Removal Technology Evaluation (Figure B.3-1, Step 4)

A technology selection evaluation will be performed based on the structure undergoing waste removal, the initial waste characterization, and the system characterization outlined in Sections B.3.2.1.1, B.3.2.1.2 and B.3.2.1.3 respectively. This evaluation will focus on removal of radionuclides, with emphasis on HRRs, as well as other closure considerations related to DOE Manual 435.1-1 and other requirements. The formality of the associated documentation of the evaluation can vary (see Section B.3.2) depending on the waste properties, waste location and timing of the removal activities.

When performing a technology evaluation, DOE will take one of two paths: rely on a previously performed evaluation where conditions for a waste tank or ancillary structure are similar to previously completed waste removal evolutions; or initiate a new technology evaluation, particularly where the tank structure or wastes are different than previously evaluated tanks. The “Alternative Studies” method is an example of a technology selection process that has been used successfully at the SRS. [WSRC-IM-98-00033] The “Alternatives Studies” method uses a formal analysis based on a set of weighted decision criteria. The depth of detail required by the technology selection will depend on specific conditions associated with the waste tank or ancillary structure under evaluation. A sensitivity analysis may be included in the analysis to aid in proper selection of a preferred technology. The technology selection process generally follows the “Alternative Studies” methodology and typically includes the assembly of a small but diverse group of knowledgeable individuals with experience that is relevant to the evaluation, and typically includes activities similar to the following steps:

1. Identification of the communities of practice to be surveyed for viable technologies – In addition to the removal technologies that have previously been used at SRS, technologies from other DOE sites, DOE-sponsored technical exchanges, the industrial sector, the international sector and other relevant organizations may also be considered.
2. Identification of removal technologies – A wide range of current technologies will be considered, at a minimum, including sluicing, mixing, chemical cleaning, vacuum retrieval techniques, mechanical manipulators and robotic vehicles. Any relevant future developments in removal technologies will also be considered at the time. The DOE will consider targeted HRR-specific

removal technologies as well as overall volume reduction technologies. Additionally, pertinent combinations of removal technologies will be taken into account.

3. Identification of criteria that will be used to compare the various removal technologies – Criteria will include, at a minimum, the technologies' expected radionuclide removal capability, with emphasis on HRRs, likelihood to meet the desired results effectively, costs, technical maturity, technical complexity and reusability. Furthermore, some examples of costs that will be considered are dose to workers, dose to public, financial costs, system-wide impacts (e.g., effects on downstream systems, generation of secondary waste streams), impacts to DOE's mission and schedule and radiological control requirements.
4. Evaluation of technologies against the selected criteria – Each technology is evaluated against each criterion and will be assigned a comparative ranking.
5. Selection of a preferred technology – A scoring methodology will be used to select the optimum technology from among the set of technologies.

The anticipated result of this process will be the identification of the optimal technology, or technologies, to remove radionuclides, with emphasis on HRRs, from the defined structure accounting for the specific characterization of the waste, surrounding Liquid Waste System status, schedule, and current technological maturity at the time the evaluation is performed.

B.3.2.1.5 Assessment of Additional Removal (Figure B.3-1, Step 5)

The activities described in Section B.3.2.1.4, will identify which available technology, or technologies, is the most viable option for additional radionuclide removal. The progression advances to the implementation of the technology as discussed in Section B.3.2.2 (Figure B.3-1, Steps 6 and 7). However, if it is not obvious that the technology can be and should be implemented to continue waste removal efforts (beyond bulk waste removal efforts previously completed), data for a cost-benefit analysis should be collected. The types of data supporting a cost-benefit analysis are described in Section B.3.2.6 (Figure B.3-1, Steps 19-22). If, during the course of collecting this information, it appears probable that implementation and execution of any additional waste removal technology (beyond bulk waste removal efforts previously completed) is not practical, then a qualitative analysis will be performed and documented. As required by the HTF GCP (SRR-CWDA-2011-00022), DOE will review this information with the SCDHEC and the EPA and, if the three agencies (DOE, SCDHEC, EPA) concur, DOE would suspend waste removal activities and move into final sampling and analysis (Figure B.3-1, Step 19).

The Technology Evaluation and Assessment steps will be documented or, if the current technology has not changed significantly, referenced to a previous report. For example, when two similar tanks (in construction and waste type) are undergoing similar waste removal processes at the same time, it is not necessary to undertake a selection and determination process for the second tank if the assumptions and parameters of the first still apply and no new technology has become available. This decision, however, will be documented. As discussed in Section B.3.2, the formality of the associated documentation can vary depending on the waste properties, waste location and timing of the removal activities.

Examples of documentation/information that support this step are:

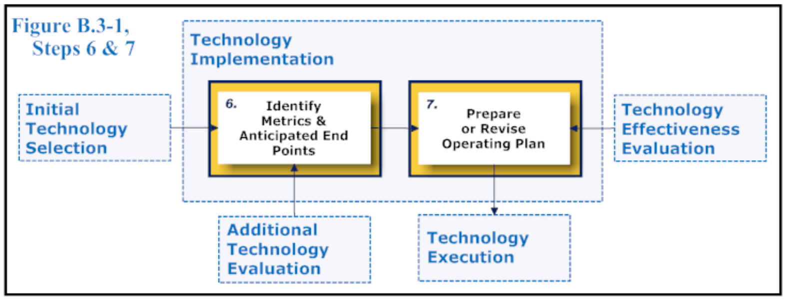
- Operational history
- Selection, operational performance and effectiveness of cleaning technologies used during each cleaning phase
- Rationale for suspending use of each cleaning technology
- Effectiveness in removing overall waste volume
- Cost-benefit analysis of continuing waste removal efforts

B.3.2.2 Technology Implementation (Figure B.3-1, Steps 6-7)

An Operating Plan will be developed on how best to implement the selected technology safely for the particular waste tank or ancillary structure. An Operating Plan is a document that describes the cleaning process to be implemented, the methods of implementation, identification of anticipated end states and identification of specific metrics that ideally provide real-time indication of effectiveness.

These tailored metrics, which are necessary to track progress in waste removal evolutions, will be defined in the Operating Plan. Such metrics are dependent on the technology being implemented and structure undergoing waste removal but are expected to include such things as:

- Monitoring radiation levels on transfer line
- Waste removal equipment operating parameters (e.g., current drawn by a mixer pump, transfer rates)
- Monitoring density readings for a solution
- Monitoring solids concentration being removed

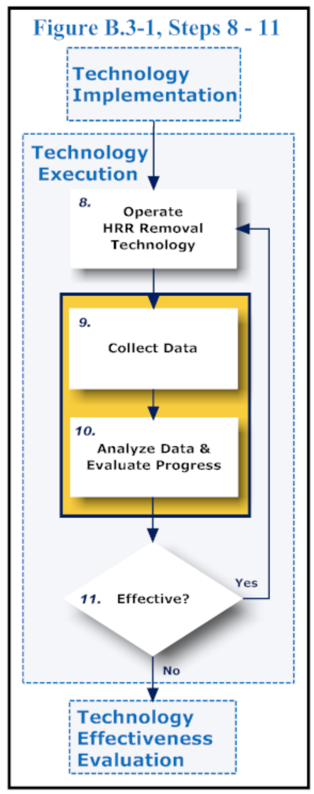


- Waste volume reduction achieved by comparing pictures, video and mapping results
- Effective cleaning radius of mixing devices

The Operating Plan will reference estimated end states and metrics, and detail how the data will be obtained. The Operating Plan will also reflect any planned chemical cleaning flow sheets, include the projected mixing strategy (e.g., hours of operation, orientation, mode of operation, liquid level, mixer speed), and incorporate lessons learned from earlier waste removal efforts. If modifications to the equipment operation and/or the Operating Plan can result in greater technology effectiveness, then DOE will revise the Operating Plan to reflect this advantage.

B.3.2.3 Technology Execution (Figure B.3-1, Steps 8-11)

DOE will execute the technology until it is no longer considered an effective means of radionuclide removal, with an emphasis on HRR removal. Effectiveness will be assessed based on the technical data (i.e., metrics) outlined in the Operating Plan and captured throughout the execution of the removal technology.



Data collection during this phase is expected to include such things as:

- Photographs of any tank modification required for waste removal installation
- Video mapping and high quality digital still photographs (before and after cleaning photographs from the same location) inside the primary tank and annulus
- High quality photographs of obstructions to mixing
- Records of daily operational decisions and their underlying reasons (e.g., logbooks, memos)
- Solids volume reduction for each cleaning phase
- Process sample analysis results
- Volume and radionuclide concentration reductions
- Weight percent solids in slurry
- Tank temperature and pH
- Impact of high efficiency particulate air (HEPA) filter loading
- Liquid additions to the system
- Secondary waste generation
- Activities to address equipment issues
- Costs of modifications, installation and operation
- Mixer and transfer pump amps
- Effective cleaning radius
- Transfer line radiation dose rate data
- Worker dose data

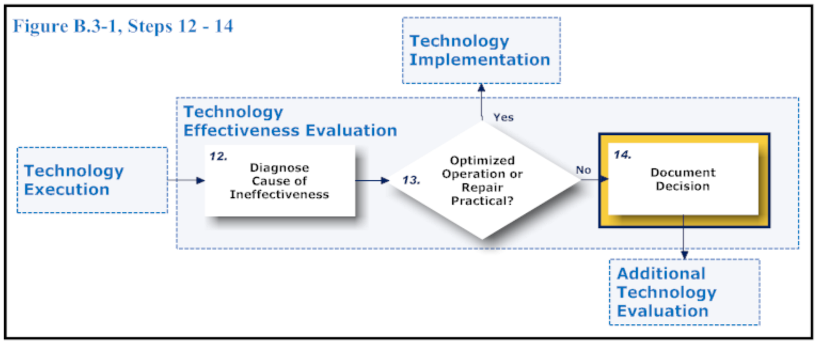
- Historical timeline of events
- Documentation of each cleaning phase and reasons for proceeding to the next phase

This data will be analyzed on an ongoing basis and used to determine whether the technology has reached the point of diminished effectiveness. Actual results will be compared with the expected results to support the evaluation of effectiveness. If the technology continues to be effective (Figure B.3-1, Step 11), then DOE will continue to execute the technology (Figure B.3-1, Steps 8-10). If the technology is determined to be at the point of diminished effectiveness, the technology will be evaluated to determine whether to further deploy this technology.

B.3.2.4 Technology Effectiveness Evaluation (Figure B.3-1, Steps 12-14)

If a technology is no longer effective, the reason must be diagnosed and recorded. Examples for diminished effectiveness include:

- Technology limitation (i.e., the inability of the current configuration to clean any further due to physical limitations of equipment)
- Deterioration or failure of the equipment utilized by the technology
- An outside factor that decrease effectiveness



The diagnosed reason for diminished effectiveness determines what assessment will be done to establish whether to stop further execution of this technology or to modify the system or system parameters and continue execution (Figure B.3-1, Step 12). If the technology is no longer yielding effective results due to a technological limitation, DOE will assess whether it is practical to optimize the existing system to increase effectiveness. Optimization could include such things as adjusting pump indexing, altering flow rates, changing cleaning patterns or changing the concentration of a cleaning agent such as oxalic acid. Major modifications of equipment, such as identification and installation of an alternative transfer or mixing pump, are not considered optimization of the existing system.

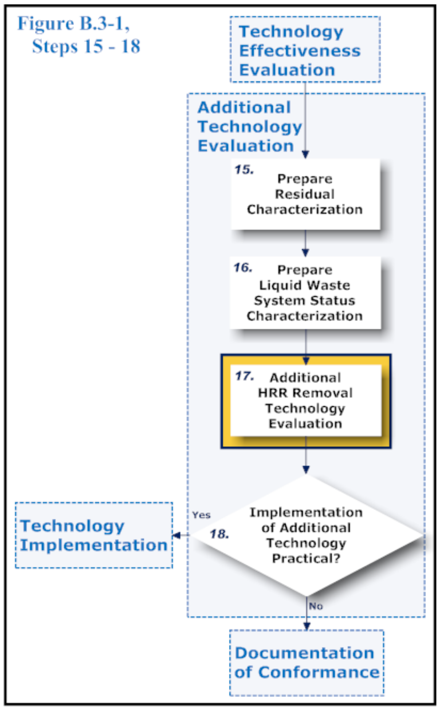
If effectiveness is reduced due to deterioration or failure of equipment, DOE will evaluate repairing or replacing the component. Likewise, if the technology is no longer effective due to an outside factor such as a constraint in the Liquid Waste System beyond the structure undergoing waste removal (see Section B.3.2.1.3), DOE will evaluate whether or not resolving that factor would be a means of increasing effectiveness.

If DOE is making optimization adjustments, repairing/replacing equipment, or resolving an outside factor, (Figure B.3-1, Step 13), the appropriate changes in the Operating Plan as described in Section B.3.2.2 (Figure B.3-1, Step 7) will be made and DOE will continue to execute the removal technology. If effecting these changes is not believed to be practical based on sound engineering judgment and the knowledge gained during the initial technology selection process, DOE will document (Figure B.3-1, Step 14) that the implemented technology will no longer be used based on earlier documented metrics and move into the next phase of the progression (i.e., Additional Technology Evaluation, Figure B.3-1, Steps 15-18). Although a formal cost-benefit analysis will not be performed at this stage, the underlying principles of such an evaluation will be included in the documentation supporting this decision.

B.3.2.5 Additional Technology Evaluation (Figure B.3-1, Steps 15-18)

This section outlines the technology evaluation methodology that DOE will employ to determine whether it is practical to continue removal operations with an additional technology. The specific methodology can vary depending on the waste properties, waste location and timing of the removal at this stage, and will include the following considerations:

- Characterization of remaining residuals to be removed (see Section B.3.2.5.1)
- Characterization of potential impact to the Liquid Waste System during the scheduled time required for the evolution (see Section B.3.2.5.2)
- Evaluation of alternative radionuclide removal technologies and selection of best available option (see Section B.3.2.5.3)
- Assessment of whether to perform additional removal utilizing the selected technology (see Section B.3.2.5.4)



The process is described in the following subsections.

B.3.2.5.1 Residual Characterization (Figure B.3-1, Step 15)

Because the removal operations may have altered the waste form, previously excluded alternative technologies may be viable at this point. The DOE will use the waste characterization methodology discussed in Section B.3.2.1.2 (Figure B.3-1, Step 2) to re-evaluate the remaining waste and build a basis for the subsequent alternative selection. Once again, DOE will, at a minimum, consider the quantity, physical properties, composition, location of residual waste and the success of past removal activities. It may be necessary to collect actual samples of the residual material (typically referred to as “process samples”) and perform some sort of limited analysis suite to determine key characteristics.

B.3.2.5.2 Liquid Waste System Status Characterization (Figure B.3-1, Step 16)

Changes to the Liquid Waste System status could have occurred since earlier evaluations. DOE will re-evaluate the status of the Liquid Waste System using the methodology discussed in Section B.3.2.1.3 (Figure B.3-1, Step 3) to consider any changes that might affect the subsequent technology selection. These characterizations will consider the information collected in the previous characterization steps as well as the operational data collected in previous technology operation steps, discussed in Section B.3.2.3 (Figure B.3-1, Steps 8-11). At a minimum, DOE will consider waste tank storage space capacity, compatibility of waste, downstream processing impacts and the impacts on other risk-reducing evolutions within the Liquid Waste System.

B.3.2.5.3 Additional Radionuclide Removal Technology Evaluation (Figure B.3-1, Step 17)

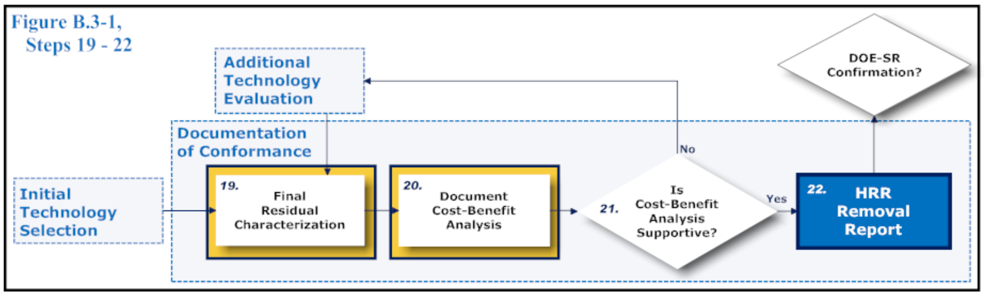
DOE will perform an additional technology selection evaluation utilizing the residual and Liquid Waste System evaluations outlined in Section B.3.2.5.1 and Section B.3.2.5.2 (Figure B.3-1, Steps 15 and 16). This analysis will review available waste removal technologies to determine if a viable technology could be practically implemented to remove additional quantities of radionuclides, with emphasis on HRRs. The alternative removal technology selection methodology will resemble the methodology discussed in Section B.3.2.1 (Figure B.3-1, Steps 1-5). If the residual waste has not changed greatly from the previous characterization and the Liquid Waste System status characterization is similar, previous technology selection data may be used to inform the present technology selection. Technological advances since the previous technology selection will be considered.

This methodology uses a structured approach for the identification and comparison of viable technologies to determine the most practical option for additional radionuclide removal, with an emphasis on HRR removal. This will include activities similar to those outlined in Section B.3.2.1.4 (Figure B.3-1, Step 4). The level of detail and formality will align with the extent the waste and the Liquid Waste System as a whole changed during the previous removal operations. The result of this selection methodology will be the identification of the best available alternative technology, or technologies, that could potentially be deployed to remove additional radionuclides, with emphasis on HRRs, from the defined structure accounting for current conditions.

B.3.2.5.4 Assessment of Additional Removal (Figure B.3-1, Step 18)

As DOE evaluates the actions necessary to implement the potential new technology, or technologies, a qualitative evaluation will be performed to assess its implementation. This evaluation will consider: Liquid Waste System constraints; ratio of implementation costs per gallon of waste potentially removed or total curies, with emphasis on HRRs, potentially removed; potential worker exposure for technology installation; and execution. At this stage, if it is not obvious that the selected technology can be or should be implemented to continue waste removal efforts, data for a cost-benefit analysis should be collected. The types of data supporting a cost-benefit analysis are described in Section B.3.2.6 (Figure B.3-1, Steps 19-22). If, during the course of collecting this information, it appears probable that implementation and execution of the technology is not practical, then a qualitative analysis will be performed and documented. As required by the HTF GCP (SRR-CWDA-2011-00022), DOE will review this information with SCDHEC and the EPA. If the three agencies (DOE, SCDHEC, EPA) concur, DOE will suspend waste removal and move into final sampling and analysis (Figure B.3-1, Step 19).

B.3.2.6 Final Documentation of Radionuclide Removal (Figure B.3-1, Steps 19-22)



The DOE will proceed to the sampling and analysis stage of the waste tank system operational closure process (Figure B.3-1, Step 19) and perform a final characterization of the residuals with emphasis on the curies and locations of remaining HRRs. To support waste tank residual characterization, DOE will develop and document a sampling plan that minimizes uncertainty through representative sampling of the residuals. In some cases, process knowledge and historical sampling may be used to support final characterization of residuals. The process knowledge and historical sampling will be properly referenced. If process knowledge is used as a basis to support final characterization, the specific basis for the process knowledge will be identified and documented. Final characterization includes a volume determination as well as radionuclide concentrations. This information is used to develop a final radionuclide inventory.

A cost-benefit analysis will be performed, informed, in part, by the qualitative dose impact results and conclusions of the associated performance assessment with the final radionuclide inventory considered.[117] In this analysis, cost examples may include financial costs, increased risks to workers and members of the public, generation of secondary waste streams, schedule delays and associated impacts on other risk reduction activities, and downstream Liquid Waste System impacts. Typically, the cost-benefit analyses will be relatively simple and will focus on the financial costs for implementation of new technologies versus the decrease in potential future doses resulting from the closure actions. [NUREG-1854] If the development of the characterization data or the cost-benefit analysis demonstrates that it may be practical to remove additional radionuclides, with emphasis on HRRs, then additional removal technologies, or optimization of existing technologies, will be evaluated for possible additional removal.

When final residual characterization and the cost-benefit analysis are complete, a removal report (Figure B.3-1, Step 22) will be prepared. This documentation will detail the design, construction and operational service histories of each tank. It will document all waste removal activities, including bases and

[117] To support Tier 2 Closure Authorization at the completion of waste removal activities for each waste tank and ancillary structure, DOE will prepare a special analysis utilizing the final residual characterization information. The special analysis process is consistent with DOE Manual 435.1-1 and DOE Guide 435.1-1 and is a systematic process for determining the impact on the results and conclusions of a performance assessment when parameter values, such as radionuclide inventory, change. For each waste tank and ancillary structure, DOE will prepare a special analysis to evaluate the known actual inventories to date, for waste tanks and ancillary structures which have had final residual characterization completed, and projected future inventories, for waste tanks and ancillary structures yet to be cleaned, to determine the impacts of the final residual characterization values on the conclusions of the HTF PA. The results of these special analyses will be used to support the cost-benefit analyses and subsequent removal reports generated for each of the waste tanks and ancillary structures.

justifications for proceeding from one phase to another. The removal report will also document the selection, operational performance and effectiveness of technology used and will include the effectiveness of removing overall waste volume and specific HRRs. The report will combine documentation from the entire process to provide the complete demonstration of radionuclide removal to support Tier 2 Closure Authorization.

B.3.2.7 DOE Tier 2 Closure Authorization

The Tier 2 closure documentation, which includes, among other documentation (see Section B.2.0), the removal report discussed in the preceding subsection, must be approved by the Manager for DOE-SR authorizing the cessation of waste removal activities and removal from service and stabilization of the waste tank or ancillary structure.

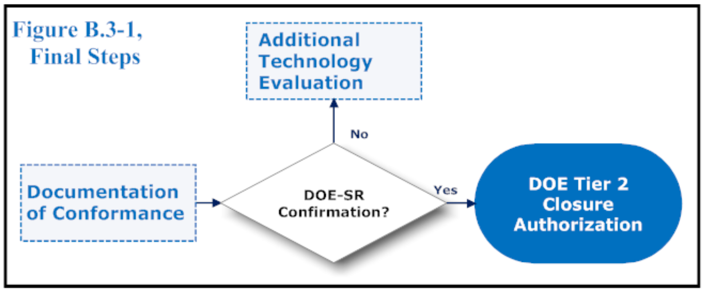


Figure B.3-1, Final Steps

APPENDIX C: H-TANK FARM PERFORMANCE ASSESSMENT DOSE SUMMARY

Appendix Purpose

The purpose of this appendix is to provide a brief discussion on dose results provided in the HTF PA.

Appendix Contents

This Appendix provides a summary of doses provided in the HTF PA.

Key Points

- The Base Case (i.e., Case A) represents the waste tank system configuration modeling case within the HTF PA that represents the most probable and defensible estimate of expected conditions for the HTF closure system based on currently available information.
- In addition to the Base Case, other modeling cases which reflect alternate waste tank configurations were also considered in the HTF PA. The alternate cases reflect different modeling assumptions with respect to key modeling parameters so as to allow evaluation of sensitivities and uncertainties associated with Base Case modeling assumptions.
- Table C.1-1 provides a summary of doses, for the Base Case and Alternate Cases, provided in the HTF PA.
- A summary of the alternate waste tank configurations as compared to the Base Case is provided in Table C.1-2. A detailed description of the alternate waste tank configurations is provided in Section 4.4.2 of the HTF PA.
- For the purposes of demonstrating reasonable assurance that the performance objective at 10 CFR 61.41 will be met, DOE utilizes the peak all-pathways dose at or outside of the 100-meter buffer zone.[118]
- For the purposes of demonstrating reasonable assurance that the performance objective at 10 CFR 61.42 will be met, DOE considers a 500 mrem/yr peak intruder dose.

Table C.1-1: HTF PA Dose Summary Table

	Protection of the General Population 10 CFR 61.41	Notes
10 CFR 61.41 Conclusion	Performance objective of 25 mrem/yr is met	DOE's conclusion that there is reasonable assurance this performance objective is met is based on doses associated with the Base Case (Case A), taking into account other cases (i.e., alternate configurations) and additional sensitivity analyses. In addition, additional sensitivity cases (described in Section 5.6 of the HTF PA) further support DOE's conclusions.

[118] See Section 7.0 of this Draft HTF 3116 Basis Document for additional discussion.

Table C.1-1: HTF PA Dose Summary Table (Continued)

	Protection of the General Population 10 CFR 61.41		Notes
Deterministic (Case A)	0.3 mrem/yr	Within 1,000 years	Deterministic modeling of Case A in the HTF PA results in a peak dose well below the performance objective within 1,000 years and 10,000 years after HTF closure. The Case A dose results peak at approximately year 91,000 with a dose equivalent to approximately 20 percent of the 620 mrem average annual dose received by the average United States citizen. [NCRP-160]
	4.0 mrem/yr	Within 10,000 years	
	120 mrem/yr	Peak dose within 100,000 years	
Deterministic (Alternative or Sensitivity Cases)	12, 2.1 mrem/yr	Case B, C (Within 1,000 years)	Deterministic modeling of Case B and Case C shows that the dose results remain below the performance objective within 1,000 years and 10,000 years after HTF closure even assuming alternative tank failure scenarios.
	14, 16 mrem/yr	Case B, C (Within 10,000 years)	
	12 mrem/yr	Case D (Within 1,000 years)	Deterministic modeling of Case D shows that dose results remain below the performance objective within 1,000 years and 10,000 years after HTF closure even assuming a fast flow path exists though the entire closed system for each waste tank. The fast flow configuration (Case D, described in Section 4.4.2.4 of the HTF PA) sensitivity analysis results were presented in Section 5.6.7.4 of the HTF PA to assess the impact of input variability on the groundwater pathways.
	18 mrem/yr	Case D (Within 10,000 years)	
	3.7 mrem/yr	Case E (Within 1,000 years)	Deterministic modeling of Case E shows that dose results remain below the performance objective within 1,000 years after HTF closure even assuming multiple “failed” barriers. The Case E results are higher within 10,000 years after HTF closure due to Case E simultaneously and non-mechanistically simulating multiple “failed” barriers (e.g., a fast flow path exists though the entire closed system and the tank grout imparts no reducing capacity upon the tank waste). The Case E results within 10,000 years are less than the 620 mrem average annual dose received by the average United States citizen. [NCRP-160]
	240 mrem/yr	Case E (Within 10,000 years)	
	0.7 mrem/yr	No Closure Cap (Within 1,000 years)	Deterministic modeling of the Case A waste tank configuration shows that dose results remain within the performance objective for 1,000 years and 10,000 years after HTF closure even assuming no closure cap is placed over the HTF.
	4.7 mrem/yr	No Closure Cap (Within 10,000 years)	

Table C.1-1: HTF PA Dose Summary Table (Continued)

	Protection of the General Population 10 CFR 61.41		Notes
Deterministic (Alternative or Sensitivity Cases) (Continued)	2.7 mrem/yr	Synergistic Case (Within 1,000 years)	This non-mechanistic synergistic sensitivity analysis (Case F) is presented to address uncertainty related to three Base Case key modeling parameters. The three parameters analyzed further are gas transport impacts on reducing grout, liner failure times, and solubility controlling phases. The synergistic case evaluates the combined results of altering these three key modeling parameters. The relatively low resultant peak doses despite the synergistic case reflecting multiple modified assumptions further provides reasonable assurance that the performance objectives would be met.
	5.7 mrem/yr	Synergistic Case (Within 10,000 years)	
	13 mrem/yr	Synergistic Case (Within 20,000 years)	
Probabilistic Modeling (peak of mean) Dose Statistics			The “peak of the mean” analysis is based on the time at which the average annual dose (averaged over all samples) is maximum. The Uncertainty Analysis results are described in Section 5.6.4 of the HTF PA. The HTF probabilistic model is not intended to predict future potential doses, rather the goal is to characterize the context of uncertainty and sensitivity surrounding the PA calculations to further inform closure discussions.
Probabilistic (peak of mean)	13 mrem/yr	Case A (Within 10,000 years)	Probabilistic modeling of Case A results in a peak of the mean dose below the performance objective within 10,000 years after HTF closure. The fact that the peak of the means dose is higher than the deterministic peak dose is not unexpected, since many of the stochastic distributions used in the probabilistic modeling are, by design, reasonably conservative, driving the peak of the means higher.
	35 mrem/yr	Case D (Within 10,000 years)	Probabilistic modeling of Case D results in a peak of the mean dose slightly above the performance objective within 10,000 years after HTF closure. In the Case D probabilistic modeling, a fast flow path is assumed to exist through the entire closed system for each waste tank. These modeling runs are intended to provide insight into the sensitivity of the HTF model to specific assumptions. The relatively low resultant peak doses for an alternative waste tank configuration with failed barriers provides further reasonable assurance that the performance objective would be met. The maximum results are less than the 620 mrem average annual dose received by the average United States citizen. [NCRP-160]

Table C.1-1: HTF PA Dose Summary Table (Continued)

	Protection of the General Population 10 CFR 61.41		Notes
Probabilistic (peak of mean) (Continued)	15 mrem/yr	All Cases (Within 10,000 years)	The peak of the mean dose for all cases is below the performance objective within 10,000 years after HTF closure. While the probabilistic modeling that encompasses all of the alternative waste tank configurations results in a peak of the mean dose above the performance objective well beyond 10,000 years, the resultant peak dose (at approximately 67,000 years) is approximately an order magnitude higher than the performance objective value. The impact of individual modeling realizations can have a more pronounced impact on the peak of the mean dose as the modeling time period expands. The maximum results are less than the 620 mrem average annual dose received by the average United States citizen. [NCRP-160]
	205 mrem/yr	All Cases (Within 100,000 years)	
	Protection of the Inadvertent Intruder 10 CFR 61.42		**Notes**
10 CFR 61.42 Conclusion	Performance objective of 500 mrem/yr is met		DOE's conclusion that there is reasonable assurance this performance objective is met is based on doses associated with the Base Case (Case A), taking into account other cases (i.e., alternate configurations) and additional sensitivity analyses. In addition, additional sensitivity cases (described in Section 5.6 of the HTF PA) further support DOE's conclusion.
Deterministic (Case A)	1.3 mrem	Acute Dose (Within 1,000 and 10,000 years)	Deterministic modeling of the Case A Intruder Dose in the HTF PA results in a peak acute dose well below a 500 mrem/yr dose within 1,000 years and 10,000 years after HTF closure.
	40 mrem/yr	Chronic Dose (Within 1,000 years)	Deterministic modeling of the Case A Intruder Dose in the HTF PA results in a peak chronic dose well below a 500 mrem/yr dose within 1,000, 10,000 and 20,000 years after HTF closure.
	50 mrem/yr	Chronic Dose (Within 10,000 years)	
	260 mrem/yr	Chronic Dose (Within 20,000 years)	
Probabilistic (Case A peak of mean)	760 mrem/yr	Within 10,000 years	The peak of the mean dose of 760 mrem/yr is higher than the median peak dose of 500 mrem/yr, and illustrates that the mean is greater than the median indicating that a few realizations sampled at the tail of the parameter distributions can cause the mean to be high. As explained in Section 6.5.2 of the HTF PA, the GoldSim model intruder results were conservative (e.g., about three times higher than the deterministic PORFLOW results) due to differences in the models.

Table C.1-2: HTF Waste Tank Case Comparison Versus Base Case (Case A)

		Alternate Cases					
		B	**C**	**D**	**E**	**No Closure Cap**	**Synergistic**
Barriers	**Closure Cap**	NC	NC	NC	NC	No Closure Cap	NC
	Waste Tank Top	Tank Top Fast Flow	Tank Top Fast Flow	Tank Top Fast Flow	Tank Top Fast Flow	NC	Tank Top Fast Flow
	Waste Tank Liner	Early liner degradation	Early liner degradation	Early liner degradation	Early liner degradation	NC	Early liner degradation
	Waste Tank Grout	Early grout degradation	NC	Early grout degradation	NC	NC	NC
	Contamination Zone Reducing Capacity	NC	Grout monolith reducing capacity impact minimized	NC	Grout monolith reducing capacity impact minimized	NC	Grout monolith reducing capacity impact minimized
	Contamination Zone Solubility Limits	NC	NC	NC	NC	NC	Solubility Limits higher for Dose Drivers
	Waste Tank Basemat	NC	NC	Basemat Fast Flow	Basemat Fast Flow	NC	NC
	Vadose Zone Beneath Waste Tanks	NC	NC	NC	NC	NC	NC

NC - No Change from Base Case