241-C-102, 241-C-104, 241-C-107, 241-C-108, and 241-C-112 Tanks Waste Retrieval Work Plan

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Abstract: This document establishes the 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tanks Waste Retrieval Work Plan required by the Hanford Federal Facility Agreement and Consent Order

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3B	Replace pg 4-5 and add new pgs G-6 and G-7 per ECN 724748	DB Parkman 5/25/07	WT Thompson 6/5/07
3C	Replace TOC, old section 3 with new section 3 and add new pgs G-8 through G-17 per ECN 725187	DB Parkman 10/30/07	WT Thompson 10/30/07
3D	Replace pgs 4-10 and 9-7 and add new pgs G-18 and G-19 per ECN 725483	DB Parkman 4/11/08	WT Thompson JR Bellomy for, 5/15/08
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4B	Revised per ECN 726643 to incorporate Ecology approved mod notice on volume displacement measurement	DB Parkman 9/16/09	MJ Sutey 9/14/09
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6	Revised per ECN 11-002029 to identify 1st and 2nd retrieval technologies for each tank, limit of technology for modified sluicing, nitrite concentration in AN-106, annulus leak detection and associated Ecology approved change notice and	AR Olander 11/17/11	DG Baide 11/28/11

Tank Farm Contractor (TFC) **RECORD OF REVISION**	(1) Document Number: Error! Reference source not found.	Page 2

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7 RS	Changed as described on DRF	AR Olander ARO 10/28/13	RA Burk 11/18/13

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Revision 7

241-C-102, 241-C-104, 241-C-107, 241-C-108 AND 241-C-112 TANKS WASTE RETRIEVAL WORK PLAN

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Terms

High Pressure Water in the context of this document means any water supplied at a higher pressure than the raw water supply pressure.

Abbreviations and Acronyms

1C	bismuth phosphate first-cycle decontamination
ALARA	as low as reasonably achievable
BBI	best-basis inventory
CH2M HILL	CH2M HILL Hanford Group, Inc.
COPC	constituent of potential concern
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERSS	Extended Reach Sluicing System
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
HI	hazard index
HIHTL	hose-in-hose transfer line
HRR™	high-resolution resistivity
IH	Industrial Hygiene
ILCR	incremental lifetime cancer risk
LDM™	leak detection and monitoring
ORP	Office of River Protection
PrHA	Process hazards analysis
PUREX	plutonium-uranium extraction
RCRA	*Resource Conservation and Recovery Act of 1976*
RMS	retrieval monitoring system
SST	single-shell tank
TBP	tributyl phosphate
TOC	tank operations contractor
UPR	unplanned release
WMA	waste management area
WRS	waste retrieval system

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™ Leak Detection and Monitoring (LDM) is a trademark of hydroGEOPHYSICS, Inc., Tucson, Arizona

Units

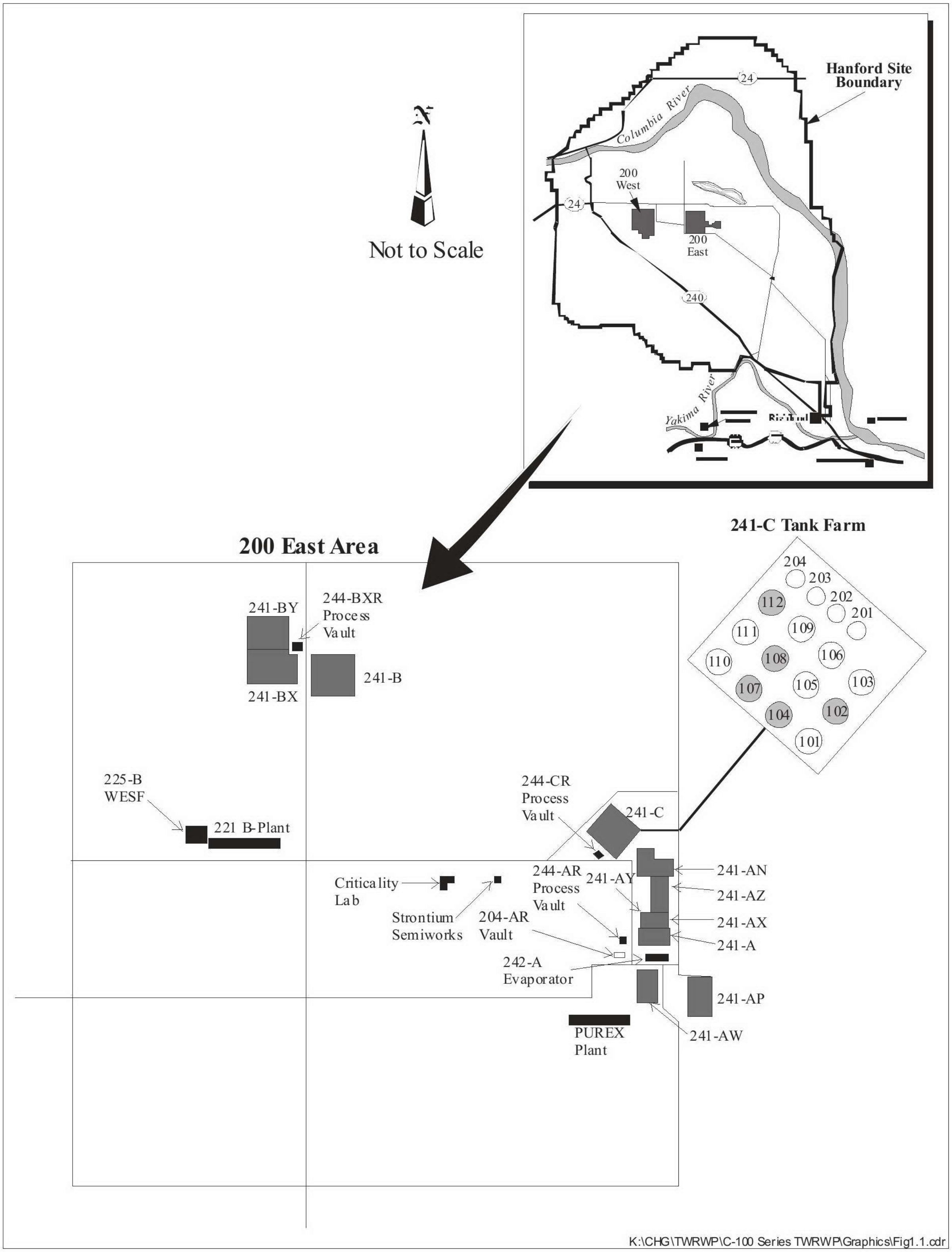
%	percent
Ci/kg	curies per kilogram
Ci	curie
Ci/L	curies per liter
°F	degrees Fahrenheit
ft	foot
ft^3	cubic feet
gal.	gallon
gal/min	gallons per minute
in.	inch
kg	kilogram
kg/m^3	kilograms per cubic meter
kgal	1,000 gallons
m	meter
m^3	cubic meters
μCi/mL	microcuries per milliliter
mg/L	milligrams per liter
mL/g	milliliters per gram
mm/yr	millimeters per year
mrem	millirem
pCi/g	picocuries per gram
pCi/L	picocuries per liter
vol%	volume percent
wt%	weight percent

1.0 INTRODUCTION

The U.S. Department of Energy (DOE), Office of River Protection (ORP) River Protection Project mission includes storage, retrieval, immobilization, and disposal of radioactive mixed waste presently stored in underground tanks located in the 200 East and 200 West Areas of the DOE Hanford Site. The 241-C-102 (C-102), 241-C-104 (C-104), 241-C-108 (C-108), and 241-C-112 (C-112) single-shell tanks (SSTs), located in the 200 East Area (Figure 1-1), are scheduled for waste retrieval using the modified sludge sluicing system retrieval technology. Tank 241-C-107 (C-107) is scheduled to be the first tank using the Mobile Arm Retrieval System for sluicing (MARS-S) for waste retrieval. These tanks are classified as sound tanks per HNF-EP-0182, *Waste Tank Summary Report for Month Ending February 28, 2005*, and are suitable for deployment of existing modified sluicing waste retrieval technology.

This document was originally developed to meet the requirements identified in Hanford Federal Facility Agreement and Consent Order (HFFACO) for Tank Waste Retrieval Work Plans (TWRWP). As of 10/25/10 Consent Decree No. 08-5085-FVS (Decree) became the regulating direction for TWRWPs for tanks retrieved as Project B-1 and Project B-4 of the Decree. The purpose of this document is to provide the Washington State Department of Ecology (Ecology) information on the planned approach for retrieving waste from tanks C-102, C-104, C-107, C-108, and C-112 to allow Ecology to approve the waste retrieval activity in Project B-1. Where information regarding treatment, management, and disposal of the radioactive source, byproduct material, and/or special nuclear components of mixed waste (as defined by the *Atomic Energy Act of 1954*) has been incorporated in this document, it is not incorporated for the purpose of regulating the radiation hazards of such components under the authority of this tank waste retrieval work plan or Chapter 70.105 RCW, "Hazardous Waste Management Act."

Figure 1-1. Location Map of C Tank Farm and Surrounding Facilities in the 200 East Area.



2.0 TANKS AND/OR ANCILLARY EQUIPMENT CONDITION AND CONFIGURATION AND WASTE CHARACTERISTICS

2.1 RETRIEVAL START DATES

The planned start date for C-102 waste retrieval operations is November 2012. C-104 waste retrieval operations began in January 2010 and are planned to restart in April 2012. The planned start date for C-107 waste retrieval operations is September 2011. C-108 began waste retrieval operations in December 2006 and retrieval was halted in April 2007 when a hard-to-remove heel was reached. A heel removal for C-108 is planned to start in October 2011. The planned start date for C-112 waste retrieval operations is November 2011.

These dates are subject to change depending on priorities and availability of resources. Completion dates are specified in the Decree, Appendix B. The completion date for Project B-1, complete retrieval from the remaining SSTs in WMA-C, is 9/30/14.

2.2 TANK HISTORY

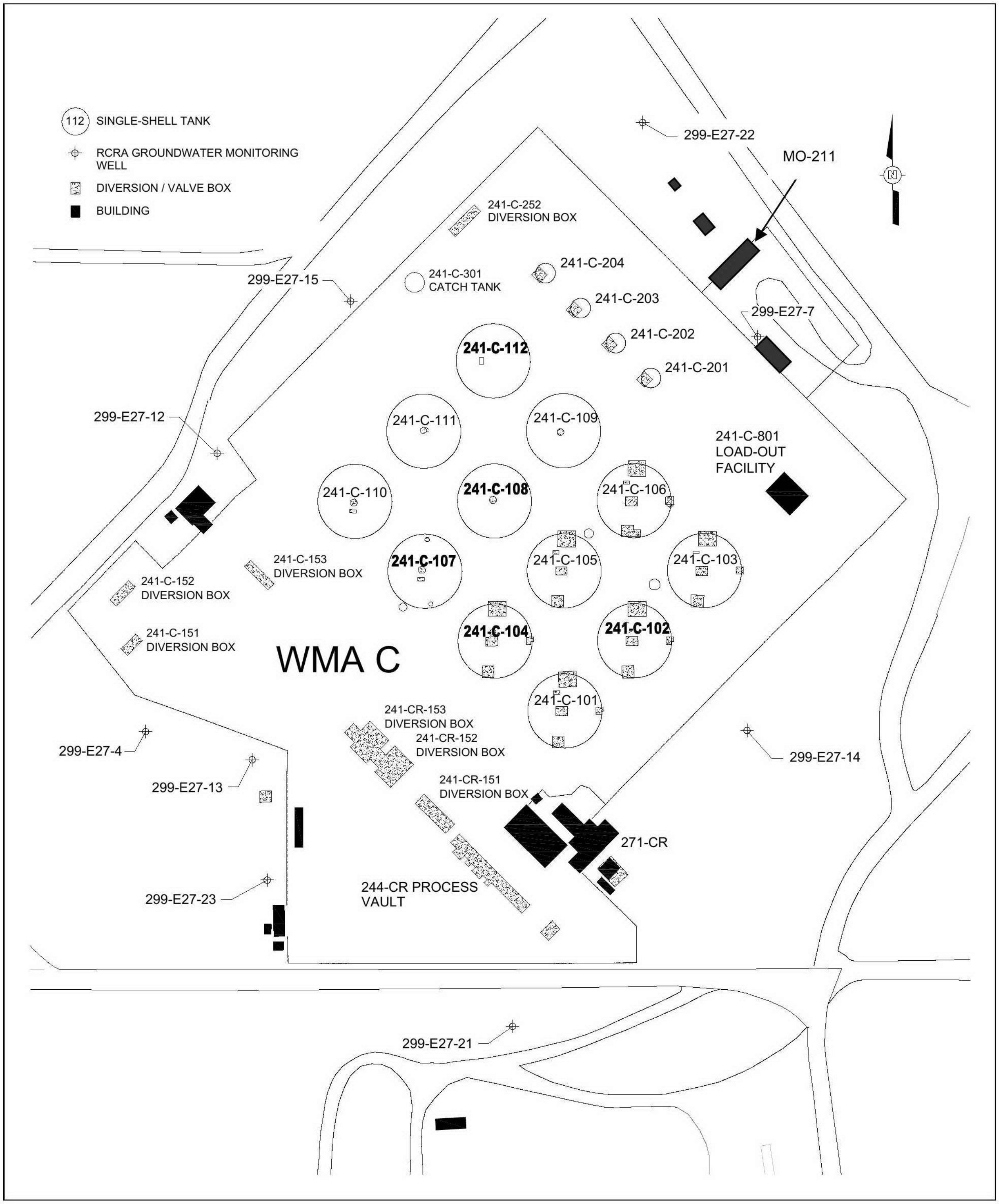
This TWRWP addresses waste retrieval from five 100-series tanks, C-102, C-104, C-107, C-108, and C-112, located in the C tank farm in the 200 East Area (Figure 2-2). Summary-level historical data related to the configuration and operating history for these five tanks are provided in Table 2-1.

Each of these tanks is designated as sound in HNF-EP-0182. The designation of sound is based upon tank surveillance data that indicates no loss of liquid attributed to a breach of integrity. See Section 2.4 for a discussion of the basis for tank designation.

The C farm 100-series tanks are 75 ft in diameter and 32 ft tall. The tanks have a 16-ft operating depth and an operating capacity of 530,000 gal. each. The tanks sit below grade with soil cover to provide shielding from radiation exposure to operating personnel.

Figure 2-1. Figure deleted.

Figure 2-2. Location of Tanks C-102, C-104, C-107, C-108, and C-112.*



* RPP-13774, 2004, *Single-Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

Table 2-1. Summary-Level Tank Data.

Tank	C-102	C-104	C-107	C-108	C-112
Constructed	1943-44	1943-44	1943-44	1943-44	1943-44
In service	1946	1946	1946	1947	1946
Diameter (ft)	75	75	75	75	75
Operating depth (in.)	185	185	185	185	185
Design capacity (gal.)	530,000	530,000	530,000	530,000	530,000
Bottom shape	Dish	Dish	Dish	Dish	Dish
Ventilation	Passive	Passive	Passive	Passive	Passive
Nominal burial depth (ft)	6	6	6	6	6
Declared inactive	1977	1980	1978	1977	1976
(Row Deleted)					
Interim stabilized	9/85	9/89	9/95	3/84	9/90

Note: Best-basis inventory AutoTCR documents (2-1-2005) from TWINS, Web Site - http://twinsweb.pnl.gov/twins.htm.
TWINS = Tank Waste Information Network System.

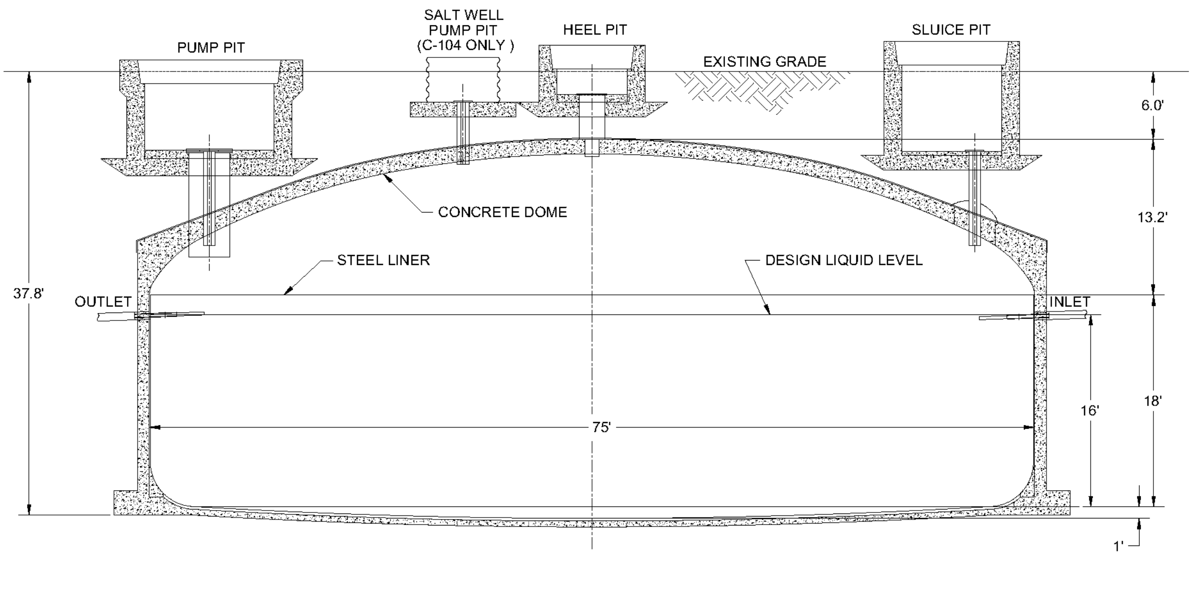
The SSTs were constructed in place with a carbon steel lining on the bottom and sides, and a reinforced concrete shell. The welded liners are independent of the reinforced concrete tanks and were designed to provide leak-tight containment of the liquid radioactive wastes and to protect the reinforced concrete from waste contact. All other loads (e.g., surface live loads, static and dynamic soil loads, dead loads, hydrostatic loads, and hydrodynamic loads) are carried by the reinforced concrete tank structure. The tanks have concave bottoms (center of tanks lower than the perimeter) and a curving intersection of the sides and bottom. Inlet and outlet lines are located near the top of the liners. These lines are also referred to as ‘cascade’ lines because they allowed transfer of fluids between tanks using gravity flow to support the transfer and storage of waste within a series of three 100-series SSTs.

Tanks C-101 through C-106 were modified after initial tank construction to add pits at the tank farm surface. Tanks C-107 through C-112 were also subsequently modified to add central saltwell pump pits. Because of these modifications, the configuration of tanks C-102 and C-104 is different than tanks C-107, C-108, and C-112 as described in the following sections.

2.2.1 Tanks C-102 and C-104 Configuration

The existing configurations of tanks C-102 and C-104 are similar as depicted in the cross-section view in Figure 2-3.

Figure 2-3. Tanks C-102 and C-104 Cross-Section View.*



* Adapted from RPP-13774, 2004, *Single-Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

Tanks C-102 and C-104 both have three reinforced concrete process pits that were installed after initial tank construction to facilitate waste retrieval. These pits are constructed of reinforced concrete and extend abovegrade. The pits provide secondary containment for the primary transfer piping within, and have removable cover blocks or plates that allow entry into the pits. The pit floors were constructed with drains that direct any liquid back into the tank through a tank riser located in the pit. For the purpose of retrieval of these two tanks, if the pit drains are plugged, any liquid (intrusion, tank waste, or other) will be pumped back to the associated SST. Pit pumping into the associated SST will occur so that the pit liquids may be removed before retrieval completion. The condenser hatchway (not shown in Figure 2-3) located above the outside edge of the tank provided an indirect access path into the tank for ventilation.

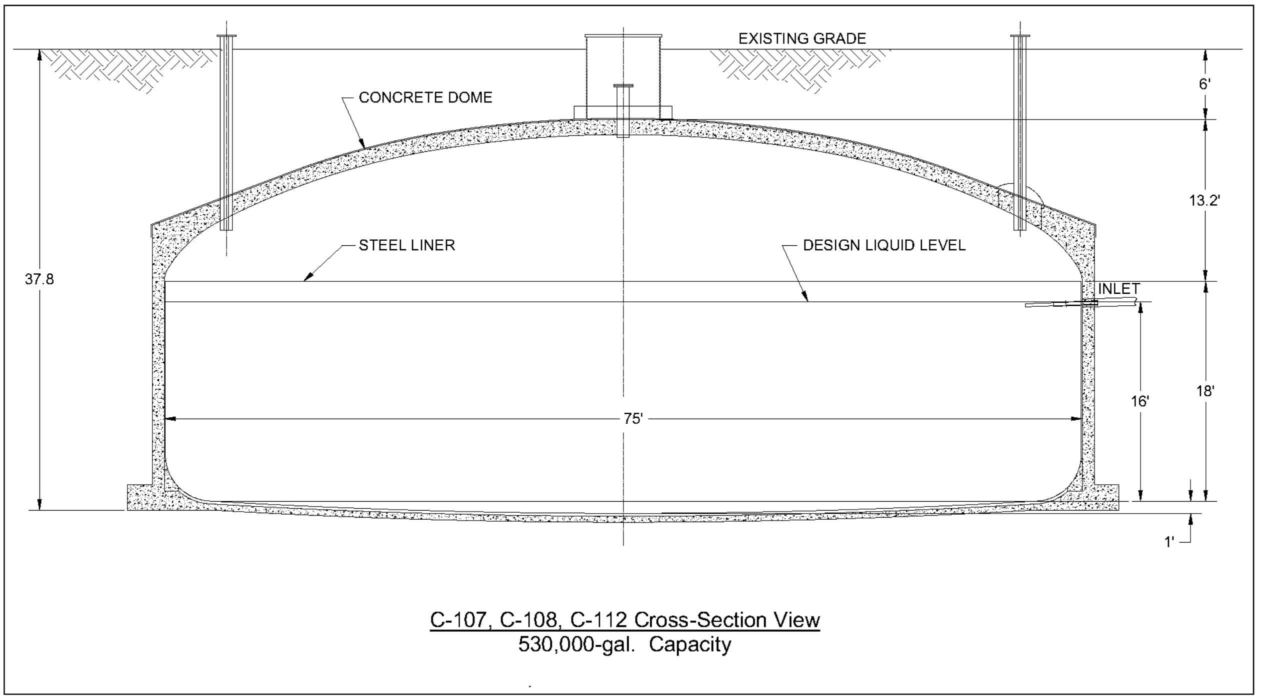
In addition, tank C-104 has a caisson made from a corrugated pipe embedded in a concrete base. The concrete base was sloped to a drain that connected to the tank riser so any leakage within the caisson would drain back into the tank. The caisson extends abovegrade and is closed off on the top with a coverplate. This caisson and the associated 12-in. riser were added to the tank to support saltwell pumping.

Each pit or caisson used for waste retrieval will have a leak detector probe.

2.2.2 Tanks C-107, C-108, and C-112 Configuration

The configuration of tanks C-107, C-108, and C-112 is depicted in the cross-section view in Figure 2-4.

Figure 2-4. Tanks C-107, C-108, and C-112 Cross-Section View.*



Note: The cascade line configuration in these three tanks varies. Tank C-107 has only an outlet line. Tank C-108 has both an inlet and an outlet, and tank C-112 has only an inlet.

* Adapted from RPP-10435, 2002, *Single-Shell Tank System Integrity Assessment Report*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

Tanks C-107, C-108, and C-112 do not have any concrete pits, but do have a caisson that was installed over the center riser after initial tank construction to facilitate waste retrieval. The caissons are constructed of a section of corrugated pipe embedded in a concrete base. The concrete base was sloped to a drain that connected to the tank riser so any leakage within the caisson would drain back into the tank. The caisson extends abovegrade and is closed off on the top with a coverplate.

Drawing H-2-38597, *Salt Well Pump Pit Assembly for Std. 12" Riser*, shows the original installation of the corrugated caisson. The caisson was installed in a groove in the concrete bottom of the pit and sealed with grout. A drain, flush with the bottom of the pit, previously routed drainage to the 12-in. riser. Drawing H-14-106599, *241-C Sluice Retrieval Mechanical Equipment Installation*, shows the equipment installation to be used during SST retrieval using the caisson. A leak detector probe will be used in the pit. A sump pump is used to pump leakage into the tank.

Each pit or caisson used for waste retrieval will have a leak detector probe.

2.3 TANK RISER AND FILL/CASCADE LINE INFORMATION

This section identifies the 'as is' configuration of the risers and fill/cascade lines. Table 2-2 provides the size and current use/contents of tanks C-102 and C-104 risers and fill/cascade lines, and Figure 2-5 provides the tanks C-102 and C-104 riser plan view. Table 2-3 provides the size and current use/contents of tanks C-107, C-108, and C-112 risers and fill/cascade lines. Figure 2-6 provides the tanks C-107, C-108, and C-112 riser plan view. Use of the risers for waste retrieval is described in Section 3.0.

2.4 TANK CLASSIFICATION

Tanks C-102, C-104, C-107, C-108, and C-112 are classified as 'sound' in HNF-EP-0182. Sound classification is assigned to a tank when surveillance data indicates no loss of liquid attributed to a breach of integrity. A description of the 100-series tanks is provided in RPP-13774, *Single-Shell Tank System Closure Plan*, Appendix C, Section C2.0.

WHC-SD-WM-ER-313, *Supporting Document for The Historical Tank Content Estimate for C-Tank Farm*, discusses all the past level (and other) data used to provide an estimate of the tank contents in the mid-1990s. No unexplained level drops are mentioned for any of these tanks. The document states no significant occurrence reports (related to tank leakage) were found for tanks C-102, C-104, and C-112. The document states that an occurrence report was issued for tank C-108 in 1974 because of increasing activity in a drywell that was attributed to migration of existing contamination. The document states that an occurrence report was issued in 1992 for tank C-107 because of increasing activity monitored from the top 20 ft of a drywell, but the activity was caused by residual waste in the tank C-110 saltwell transfer line and the readings returned to the previous level when the line was flushed.

RPP-14430, *Subsurface Conditions Description of the C-A-AX Waste Management Area,* provides an evaluation of the available drywell logging information for each tank in Section 3.3 and Appendix E. No significant indications of unexplained gamma radiation are evident in the drywells surrounding tanks C-102, C-104, C-107, C-108, or C-112 that indicate a leak occurred in that tank. Additional references for drywell monitoring results are provided in Section 4.1.1.

RPP-10435, *Single-Shell Tank System Integrity Assessment Report*, was prepared and issued in response to HFFACO Milestone M-23-24. This document provides an integrity assessment for the SSTs and some ancillary equipment used with the tanks. Appendix D of RPP-10435 discusses tank leak history. There is no mention in Appendix D of RPP-10435, or anywhere else in the document, of any known leaks from these tanks nor is there any wording that would indicate any of these five tanks should not be classified as sound.

Table 2-2. Tanks C-102 and C-104 Riser and Fill/Cascade Line Descriptions.

Riser Number	Diameter (in.)	Use Description	
		Tank C-102	**Tank C-104**
R1	4	Unused temperature probe	Liquid level well, belowgrade
R2	12	Level gauge (ENRAF) [a]	Breather filter and benchmark
R3	12	Observation port/breather filter in weather covered pit (02-C pit)	Observation port in weather covered pit (04-C pit)
R4	4	Recirculating dip leg in weather covered pit (02-C pit)	Recirculating dip leg in weather covered pit (04-C pit)
R5	4	Recirculating dip leg in weather covered pit (02-A pit)	Recirculating dip leg in weather covered pit (04-A pit)
R6	12	Sluicing access riser in weather covered pit	Sluicing access riser in weather covered pit
R7	12	Temperature probe in riser through pit wall, flange weather covered pit (02-A pit)	Temperature probe in riser through pit wall (04-A pit)
R8	4	blind flange (obstruction)	Level gauge (ENRAF)
R9	36	sludge pump access riser in weather covered pit (02-A pit)	Sludge pump access riser in weather covered pit (04-A pit)
R13	12	Saltwell screen in weather covered pit (02-B pit)	Heel jet in 04-B pit
R14	4	NA	Blind flange
R15	12	NA	Empty
A [b]	3	Cascade overflow line to tank C-103	Cascade overflow line to tank C-105
B [b]	3	Cascade inlet line from tank C-101	NA
C1 [b]	3	Spare inlet, capped	Fill line V150
C2 [b]	3	Spare inlet, capped	Fill line V149, sealed in diversion box 241-C-153
C3 [b]	3	Spare inlet, capped	Fill line V148, sealed in diversion box 241-C-153
C4 [b]	3	Spare inlet, capped	Spare, capped

Note: Reference documents from TWINS, Web Site - http://twinsweb.pnl.gov/twins.htm and H-14-010613, 2003, *Waste Storage Tank (WST) Riser Data*, Sheet 2, Rev. 6, CH2M HILL Hanford Group, Inc., Richland, Washington (with ECNs).

ECN = engineering change notice.
NA = not applicable.
TWINS = Tank Waste Information Network System.

[a] Enraf is the supplier of the identified level gauges; ENRAF is a trademark of Enraf, Inc., Enraf B.V., Delft, The Netherlands.

[b] Cascade and/or fill line, not a riser.

Figure 2-5. Tanks C-102 and C-104 Riser and Fill/Cascade Line Plan View.

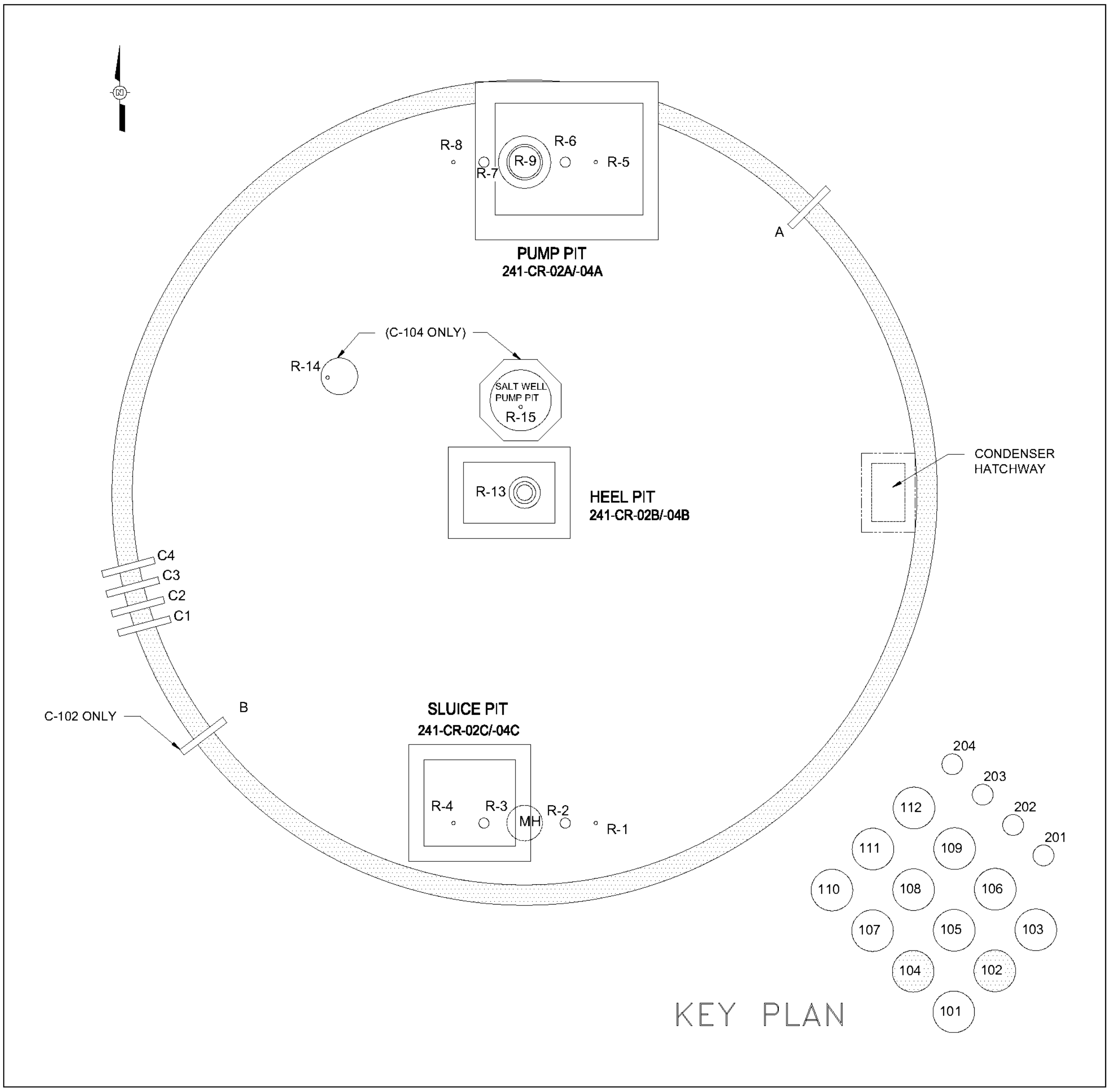
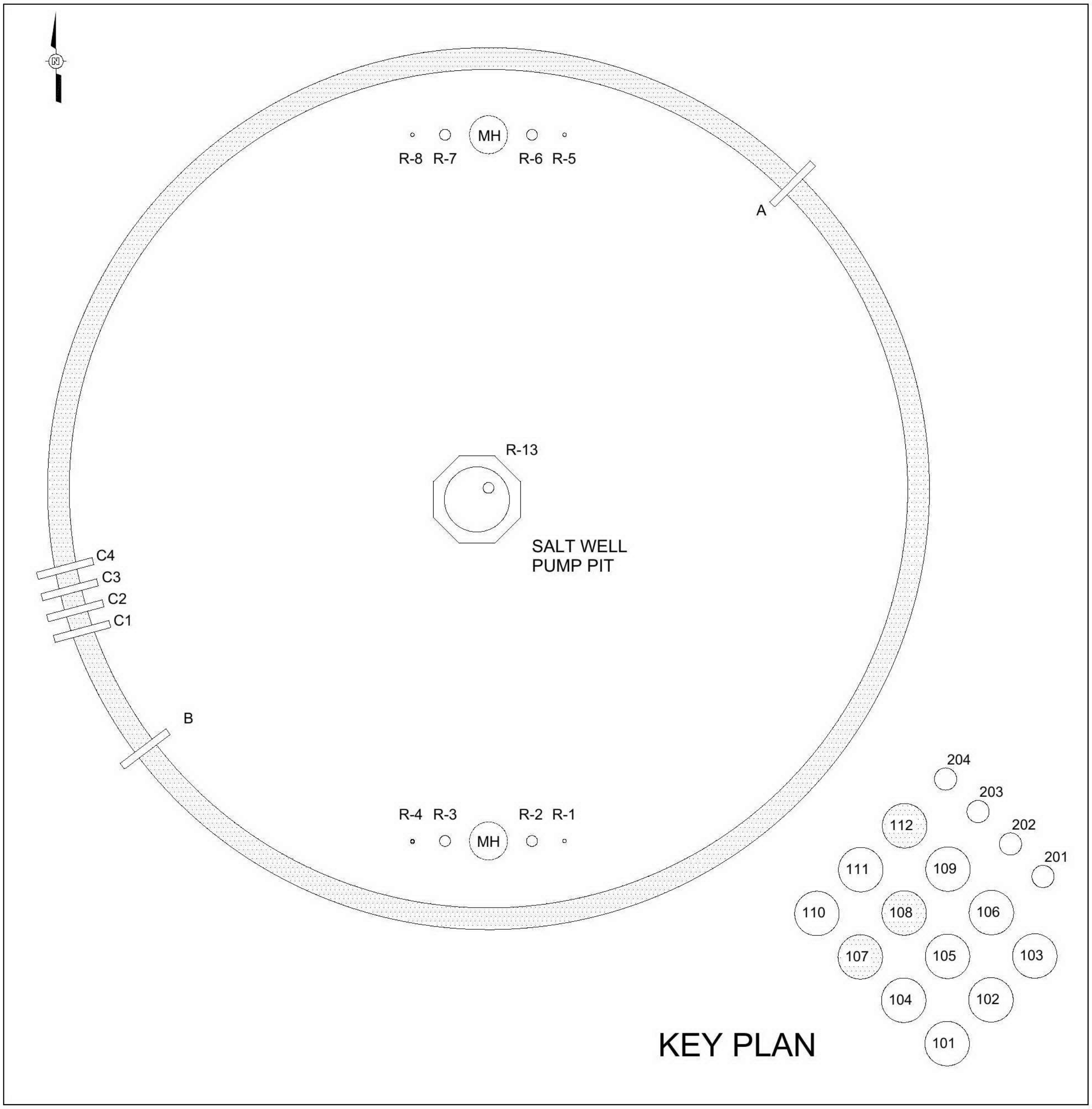


Table 2-3. Tanks C-107, C-108, and C-112 Riser and Fill/Cascade Line Descriptions.

Number	Diameter (in.)	Use Descriptions		
		Tank C-107	Tank C-108	Tank C-112
R1	4	Spare	Thermocouple	Temperature probe
R2	12	Spare	Multi-port adapter with benchmark	Blind flange with benchmark
R3	12	Multi-port adapter / standard hydrogen monitoring system vapor probe (on 4-in. adapter)	Spare	Spare
R4	4	Breather filter	Breather filter with offset adapter	Breather filter with offset adapter
R5	4	Temperature probe	Temperature probe	Level gauge (ENRAF [a]) with thermocouple
R6	12	Spare	Spare	Spare
R7	12	Spare	Observation port	Observation port
R8	4	Level gauge (ENRAF)	Level gauge (ENRAF) with benchmark	Multi-function instrument tree
R13	12	Saltwell pump	Saltwell screen in weather covered pit	Saltwell pump pit weather covered pit
A [b]	3	Cascade line overflow to tank C-108	Cascade overflow line to tank C-109	NA
B [b]	3	NA	Cascade inlet line from tank C-107	Cascade inlet line from tank C-111
C1 [b]	3	Fill line, sealed in diversion box 241-C-153	Spare, capped	Spare, capped
C2 [b]	3	Fill line, sealed in diversion box 241	Spare, capped	Spare, capped
C3 [b]	3	Fill line, sealed in diversion box 241	Spare, capped	Spare, capped
C4 [b]	3	Spare, plugged	Spare, capped	Spare, capped

Note: Best-basis inventory documents from TWINS, Web Site - http://twinsweb.pnl.gov/twins.htm.
NA = not applicable.
TWINS = Tank Waste Information Network System.
[a] Enraf is the supplier of the identified level gauges; ENRAF is a trademark of Enraf, Inc., Enraf B.V., Delft, The Netherlands.
[b] Cascade and/or fill line, not a riser.

Figure 2-6. Tanks C-107, C-108, and C-112 Riser and Fill/Cascade Line Plan View.



2.5 TANK WASTE VOLUME/CHARACTERISTICS

The waste volume and physical properties of the waste currently stored in tanks C-102, C-104, C-107, C-108, and C-112 and awaiting retrieval are summarized in Table 2-4.

Table 2-4. Waste Volume and Physical Properties Summary.

Waste Property	Unit	Tank C-102	Tank C-104	Tank C-107	Tank C-108	Tank C-112
Solids volume [a]	gal.	316,000	259,000	247,000	66,000	104,000
Supernate volume [a]	gal.	0	0	0	0	0
Interstitial liquid volume [a]	gal.	62,000	29,000	30,000	4,000	6,000
Sludge density [b]	kg/L	1.68	1.68	1.55	1.48	1.6
Sludge percent water [b]	%	43	48	48	38	52

[a] HNF-EP-0182, 2005, *Waste Tank Summary Report for Month Ending February 28, 2005*, Rev. 203, CH2M HILL Hanford Group, Inc., Richland, Washington.

[b] Source: Best-basis inventory download from http://twinsweb.pnl.gov/twins.htm, dated February 1, 2005.

The tank waste inventory data extracted from the best-basis inventory (BBI) (http://twinsweb.pnl.gov/twins.htm) is provided in Appendix F (Tables F-1 through F-5 for tanks C-102, C-104, C-107, C-108, and C-112, respectively). There are varying degrees of uncertainty associated with the waste inventory. The inventory uncertainty is a combination of the uncertainty associated with measurements of waste volume and concentration. Inventory uncertainty estimates have been completed for some but not all constituents and for some but not all waste types. The available inventory and inventory uncertainty data for tanks C-102, C-104, C-107, C-108, and C-112 are provided in Appendix F (Tables F-1 through F-5). The standard deviation is calculated from the variation in the sample analysis results. Details of the methodology used for developing inventory uncertainty values reported in the BBI are provided in RPP-7625, *Best Basis Inventory Process Requirements*. The inventory uncertainty data associated with the contaminants that drive the long-term risk (e.g., technetium-99) can be used for tanks C-104, C-107, C-108, and C-112 to provide insight to the uncertainty in the long-term human health risks presented in Section 7.0. Indicator contaminants identified in Section 7.1.1.1 are noted in Tables F-1 through F-5.

Although there are uncertainties associated with contaminant inventories in the tanks, the following items show that there is sufficient information on the characteristics that affect waste retrieval, transfer, and storage in the double-shell tanks (DSTs) to proceed with waste retrieval:

- DOE (2003), *Dangerous Waste Permit Application—Single-Shell Tank System* (Part A Permit) list of constituents contains constituents not found in the BBI because of 'protective filing.' The constituents listed in the BBI (25 chemicals and 46 radionuclides) account for approximately 99 wt% of the chemical inventory (not including water and hydroxide) and over 99% of the activity in terms of short- and long-term risk, based on estimates developed using the Hanford Defined Waste (HDW) Model (RPP-19822, *Hanford Defined Waste Model – Revision 5.0).*

- The above meets the requirement in Section 2.1.3 of Appendix I of the HFFACO that requires those contaminants accounting for at least 95% of the impact to groundwater risk be addressed.

- The BBI is the best available data; however, the Part A Permit provides a list of constituents that may or may not be present in the SSTs. To address this uncertainty, a post-retrieval sample will be taken of the residual waste for all constituents identified in the Ecology-approved sampling and analysis plan, pursuant to the requirements of that sampling and analysis plan.

There are currently no plans to perform additional characterization (e.g., sampling and analyses) of the waste in tank C-102, C-104, C-107, C-108, or C-112 to support waste retrieval and transfer. Sampling and analyses of the waste from each of the tanks will be performed at or near the end of waste retrieval activities in support of component closure activity actions. Sampling and analysis activities associated with component closure actions will be defined through the planned component closure data quality objectives process and described in the associated waste sampling and analysis plans yet to be developed and to be approved by Ecology.

Meeting the informational requirements for waste transfers meets the substantive requirements of WAC 173-303-300, "General Waste Analysis." Compliance with the following documents is required before initiating a waste transfer:

1. RPP-29002, *Double-Shell Tank Waste Analysis Plan*. SST transfers into the DSTs for any reason must meet the waste acceptance criteria presented in this plan. This plan is written pursuant to WAC 173-303-300(5) and U.S. Environmental Protection Agency (EPA) guidance document OSWER 9938.4-03, *Waste Analysis at Facilities That Generate, Treat, Store and Dispose of Hazardous Waste.*

2. Waste Stream Profile Sheet (RPP-29002). The sheet addresses the applicable sections of WAC 173-303-300; 40 CFR 761, "Polychlorinated Biphenyls (PCBs). Manufacturing, Processing, Distribution, Commerce, and Use Prohibitions"; 40 CFR 268, "Land Disposal Restrictions"; and WAC 173-303-140, and also requires a waste compatibility assessment pursuant to HNF-SD-WM-DQO-001, *Data Quality Objectives for Tank Farms Waste Compatibility Program*, to meet WAC 173-303-395(1).

2.5.1 Tank C-102 Operating History

The following information is taken from HNF-SD-WM-ER-651, *Preliminary Tank Characterization Report for Single-Shell Tank 241-C-102: Best-Basis Inventory*. The purpose of HNF-SD-WM-ER-651 is to summarize the information on the historical uses, current status, and sampling and analysis results of waste stored in tank C-102.

Tank C-102 began receiving bismuth phosphate first-cycle decontamination (1C) waste from tank C-101 through the cascade line in 1946 and stored 1C waste until the second quarter of 1953. Tank C-102 cascaded waste into tank C-103 from 1946 until 1953. In 1953, the 1C waste in the tank was sluiced to a sludge heel in an effort to recover uranium. The tank received uranium recovery waste from the third quarter of 1953 until the fourth quarter of 1954. During the second quarter of 1957, the tank was scavenged.

During the third quarter of 1960, tank C-102 received waste water, and from the third quarter of 1960 until the fourth quarter of 1969, the tank received plutonium-uranium extraction (PUREX) cladding waste. The tank received waste from the 1966 thorium campaign during the second quarter of 1966 and PUREX organic wash waste from the second quarter of 1968 until the first quarter of 1969.

A maximum waste volume of approximately 530,000 gal. of waste in tank C-102 was reached in the first quarter of 1952 and remained at that level until the third quarter of 1952. The same amount of 530,000 gal. was reached in the first quarter of 1954 and remained at that level until the fourth quarter of 1956 (WHC-SD-WM-ER-313).

A saltwell pump was installed in tank C-102 in November 1975; saltwell pumping was completed in June 1978. The tank was declared inactive in 1977 and was partially isolated in December 1982. In November 1991, the tank was saltwell pumped again (GJ-HAN-86, *Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-102*).

2.5.2 Tank C-104 Operating History

The following information is taken from HNF-SD-WM-ER-679, *Tank Characterization Report for Single-Shell Tank 241-C-104*. The purpose of HNF-SD-WM-ER-679 is to summarize the information on the historical uses, current status, and sampling and analysis results of waste stored in tank C-104.

Tank C-104 went into service in 1946 when it began to receive 1C waste from B Plant (LA-UR-97-311, *Waste Status and Transaction Records Summary [WSTRS]*). The 1C waste began to cascade to tank C-105 in the first quarter of 1947. Waste additions continued until November 1947, when the tank and the cascade series were full. The tank remained full until 1953, when waste retrieval actions were initiated for uranium recovery. The tank was effectively emptied in early 1955. The tank remained empty until the fourth quarter of 1955 when it received tributyl phosphate (TBP) waste supernate and metal waste from tank C-112. Cladding waste was received from PUREX and was transferred to tanks C-101 and C-105 in 1956, and PUREX cladding waste was received again and cascaded to tank C-105 in 1957.

Tank C-104 received numerous transfers of different waste types. The tank currently contains only sludge consisting primarily of five waste types:

- Zirconium cladding waste (CWZr1)
- Organic wash waste (OWW3)

- Cladding waste (CWP2)
- Thorium waste (TH2)
- Cladding waste (CWP1).

From 1976 to 1980, tank C-104 exchanged supernate with tank A-102. Supernate was sent to tanks AZ-101 and AX-102 in 1978. The tank received supernate waste from tank C-103 in 1979. Tank C-104 was removed from service in 1980 and was declared interim stabilized in 1989.

2.5.3 Tank C-107 Operating History

The following information is taken from HNF-SD-WM-ER-474, *Tank Characterization Report for Single-Shell Tank 241-C-107*. The purpose of HNF-SD-WM-ER-474 is to summarize the information on the historical uses, current status, and sampling and analysis results of waste stored in tank C-107.

Tank C-107 was placed into service in 1946 when it began receiving 1C waste through diversion box 241-C-153. From the second quarter of 1946 until the third quarter of 1948, tank C-107 received 1C waste from the B and/or T Plants. In September 1947, tank C-107 was declared full and began cascading to tank C-108. Between 1947 and 1978, when it was declared inactive, numerous waste transfers were made into and out of tank C-107. Tank C-107 received 1C waste generated from the bismuth phosphate process, TBP (UR/TBP) liquid waste, PUREX cladding removal waste (CWP2), hot semiworks waste, waste from 244-CR (CR vault) and site laboratories, and strontium-rich sludge (SRR).

Two liquid-pumping campaigns have taken place since 1976. The tank was saltwell pumped from the third quarter of 1976 until the second quarter of 1977. Approximately 18,000 gal. were removed by jet pumping from November 1991 to January 1992 (HNF-SD-WM-ER-474).

The tank currently contains sludge consisting of three waste types: (1) 1C waste, (2) PUREX cladding removal waste, and (3) strontium-rich sludge. In general, 1C waste exhibits high concentrations of aluminum, bismuth, fluorine, iron, silicon, phosphate, and sulfate; PUREX cladding removal waste exhibits high concentrations of aluminum; and strontium-rich sludge exhibits high concentrations of sodium, iron, and strontium.

2.5.4 Tank C-108 Operating History

The following information is taken from WHC-SD-WM-ER-503, *Tank Characterization Report for Single-Shell Tank 241-C-108*. The purpose of WHC-SD-WM-ER-503 is to summarize the information on the historical uses, current status, and sampling and analysis results of waste stored in tank C-108.

Tank C-108 was placed into service in 1947 when it began receiving waste via the cascade line from tank C-107. Tank C-108 received 1C waste from the bismuth phosphate process, uranium recovery waste (UR) from the TBP process, in-farm ferrocyanide scavenging waste (TFeCN), and PUREX cladding waste (CWP). During the same period, supernate was transferred from tank C-108 to tanks BY-101 and BY-105. Other wastes received include Hot Semiworks Plant waste, PUREX organic wash waste, ion exchange waste, reduction oxidation waste, N Reactor waste, decontamination waste, and laboratory waste.

Between 1952 and 1976, when it was removed from service, numerous waste transfers were made into and out of tank C-108. The tank currently contains sludge consisting primarily of three waste types: (1) 1C waste, (2) TBP process waste, and (3) in-farm ferrocyanide scavenging waste. In general, 1C waste sludge exhibits high concentrations of aluminum, bismuth, fluorine, iron, silicon, phosphate, and sulfate; TBP sludge exhibits high concentrations of chromium, iron, sodium, phosphate, and sulfate; and in-farm ferrocyanide scavenging waste exhibits high concentrations of calcium, iron, nickel, phosphate, and cesium-137.

Saltwell pumping was completed in 1978, and intrusion prevention was completed on December 15, 1982 (WHC-SD-WM-TI-356, *Waste Storage Tank Status and Leak Detection Criteria*). The tank was designated as interim stabilized on March 9, 1984. This tank was added to the Ferrocyanide Watch List in January 1991 and was removed in June 1996.

2.5.5 Tank C-112 Operating History

The following information is taken from HNF-SD-WM-ER-541, *Tank Characterization Report for Single-Shell Tank 241-C-112*. The purpose of HNF-SD-WM-ER-541 is to summarize the information on the historical uses, current status, and sampling and analysis results of waste stored in tank C-112.

Tank C-112 was placed into service in 1946 when it began receiving 1C waste from the other two tanks in the cascade (tanks C-110 and C-111). The 1C waste originated from the bismuth phosphate separations process used at B Plant. Because tank C-112 is the final tank in a cascade series, most of the metal waste solids would have settled in the first two tanks. Supernate from tank C-112 was transferred to tank B-106 in 1952, leaving a 17,000-gal. heel in the tank. Tank C-112 was refilled with unscavenged uranium recovery waste in 1954. From late 1955 until 1958, the tank was used for settling scavenged ferrocyanide waste.

Between 1961 and 1976, when it was removed from service, numerous waste transfers were made into and out of tank C-112. The tank was saltwell pumped in 1983, resulting in the transfer of 5,000 gal. of waste from tank C-112 to DST 241-AN-103 (HNF-SD-WM-ER-541).

The tank currently contains sludge consisting primarily of three waste types: (1) 1C waste, (2) in-farm ferrocyanide scavenging waste, and (3) cladding waste (CWP1). In general, 1C waste sludge exhibits high concentrations of aluminum, bismuth, fluorine, iron, silicon, phosphate, and sulfate; in-farm ferrocyanide scavenging waste exhibits high concentrations of calcium, iron, nickel, phosphate, and cesium-137; and cladding waste (CWP1) exhibits high concentrations of aluminum.

2.6 TANK ANCILLARY EQUIPMENT

There is a complex waste transfer system of pipelines (transfer lines), diversion boxes, vaults, valve pits, and other miscellaneous structures that are collectively referred to as ancillary equipment. The routing of liquid waste to and from the tanks was accomplished using this transfer system. The diversion boxes provide the means for routing waste from one transfer line to another via jumper assemblies. The diversion boxes are belowground, reinforced concrete boxes that were designed to contain any waste that leaked from the waste transfer line connections and route it to a collection tank.

One valve pit, 241-C (a corrugated structure with a concrete floor), also served the C tank farm and is located southwest of tank C-103. This pit was installed as part of the saltwell pumping program to allow multiple saltwells to pump to the 244-CR vault receiver tank, 003, through a single transfer line, SN-275.

Table 2-5 provides a summary of the C tank farm ancillary equipment connected to tanks C-102, C-104, C-107, C-108, and C-112.

The existing buried waste transfer lines routed to tanks C-102, C-104, C-107, C-108, and C-112 have been isolated to prevent the inadvertent transfer of waste or intrusion of water into the tanks following retrieval with the exception of the cascade lines and saltwell transfer lines. With these isolation measures in place, the process lines are in a stable configuration and do not represent pathways for water or additional waste to enter the tanks.

Table 2-5. C Tank Farm Components Associated with Tanks C-102, C-104, C-107, C-108, and C-112. (2 Sheets)

Single-Shell Tanks			
Tank 241-	**Constructed**	**Declared Inactive**	**Constructed Operating Capacity (gal.)**
C-102	1943 – 1944	1977	530,000
C-104	1943 – 1944	1980	530,000
C-107	1943 – 1944	1978	530,000
C-108	1943 – 1944	1977	530,000
C-112	1943 – 1944	1976	530,000
Diversion Boxes			
Unit 241-	**Constructed**	**Removed from Service**	**Description**
C-151	1946	1985	Interconnected 241-C-152, -153, and CR-151 diversion boxes
C-153	1946	1985	Interconnected 241-C-151 and -152 diversion boxes
CR-152	1946	1985	Interconnected 241-C-151 diversion box and C farm
CR-153	1946	1985	Interconnected 241-CR-151 and -152 diversion boxes and C farm
C-252	1946	1985	Interconnected 241-C-151 diversion box and C farm

Valve Pits	
Facility Number	**Description**
241-C	Valve pit
Tank Pits	
Facility Number	**Description**
241-C-02A	Pump pit
241-C-02B	Heel pit
241-C-02C	Sluice pit
241-C-04A	Pump pit
241-C-04B	Heel pit
241-C-04C	Sluice pit
241-C-07	No pit, covered saltwell caisson
241-C-08	No pit, covered saltwell caisson
241-C-012	No pit, covered saltwell caisson

Transfer Lines		
Line Number	**Connecting Facilities**	
8006	241-C-102-02A-U1	241-CR-152-L12
8038	241-C-102-02A-U2	241-CR-152-U4
8037	241-C-102-02A-U3	241-CR-152-L15
8063	241-C-102-02B-U2	Line 8006
Unknown	241-C-102-02B-U3	241-C-valve pit-L1
8017	241-C-102-02C-U1	241-CR-152-L7
8041	241-C-102-02C-U2	241-CR-152-U3
V843	241-C-102	241-CR-151-L9
V844	241-C-102	241-CR-151-L8/241-CR-152-L8 via 8107
8210	241-C104-04A-U1	241-CR-153-L11
8244	241-C-104-04A-U2	241-CR-153-U2
8231	241-C-104-04A-U3	241-CR-153-L14
V101	241-C-104-04A-U4	241-C-151-L2
8270	241-C-104-04B-U2	Line 8210
Unknown	241-C-104-04B-U3	241-C-valve pit-L2
8220	241-C-104-04C-U1	241-CR-153-L9
8247	241-C-104-04C-U2	241-CR-153-U1
8253	241-C-104-04C-U6	241-CR-153
V050	241-C-104	241-A-152-L7
V051	241-C-104	241-A-152-L8
V148	241-C-104	241-C-153-L13
V149	241-C-104	241-C-153-L14
V150	241-C-104	241-C-153-L15
Drain Line	241-C-107-U1	241-C valve pit-L3
V142	241-C-153-L7	Capped
V143	241-C-107	241-C-153-L8
V144	241-C-107	241-C-153-L9
V145	241-C-107	241-C-153-L10
V172	241-C-252-U1	241-C-109/241-C-112
Unknown	241-C-108	241-C-valve enclosure
M5	241-C-108 saltwell pump pit	241-C valve pit
M5	241-C-112	241-C valve pit-L5

Note: From RPP-13774, 2004, *Single-Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

Unplanned releases (UPRs) from the ancillary equipment that are attributed to ancillary equipment leaks include the following:

- **UPR-200-E-16** – In 1959, the transfer line between tanks C-105 and C-108 leaked and contaminated the soil near the tank C-105 pit.
- **UPR-200-E-81** – In 1969, a transfer line leaked at the 241-C-151 diversion box resulting in a surface puddle (approximately 6 ft by 40 ft) a few feet west of 241-C-151 diversion box. Waste was being transferred from the 202-A building to tank C-102 via the 241-C-151 diversion box at time of leak discovery.
- **UPR-200-E-82** – In 1968, a transfer line leaked near the 241-C-152 diversion box resulting in an approximately 1,000-gal. surface pool of waste. Waste was being transferred from tank C-105 to the 221-B building via the 241-C-152 diversion box at the time of leak discovery.
- **UPR-200-E-86** – In 1971, transfer line 812 leaked outside the southwest corner of the tank farm fence. Waste was being transferred from the 244-AR vault to the C tank farm at time of leak discovery.

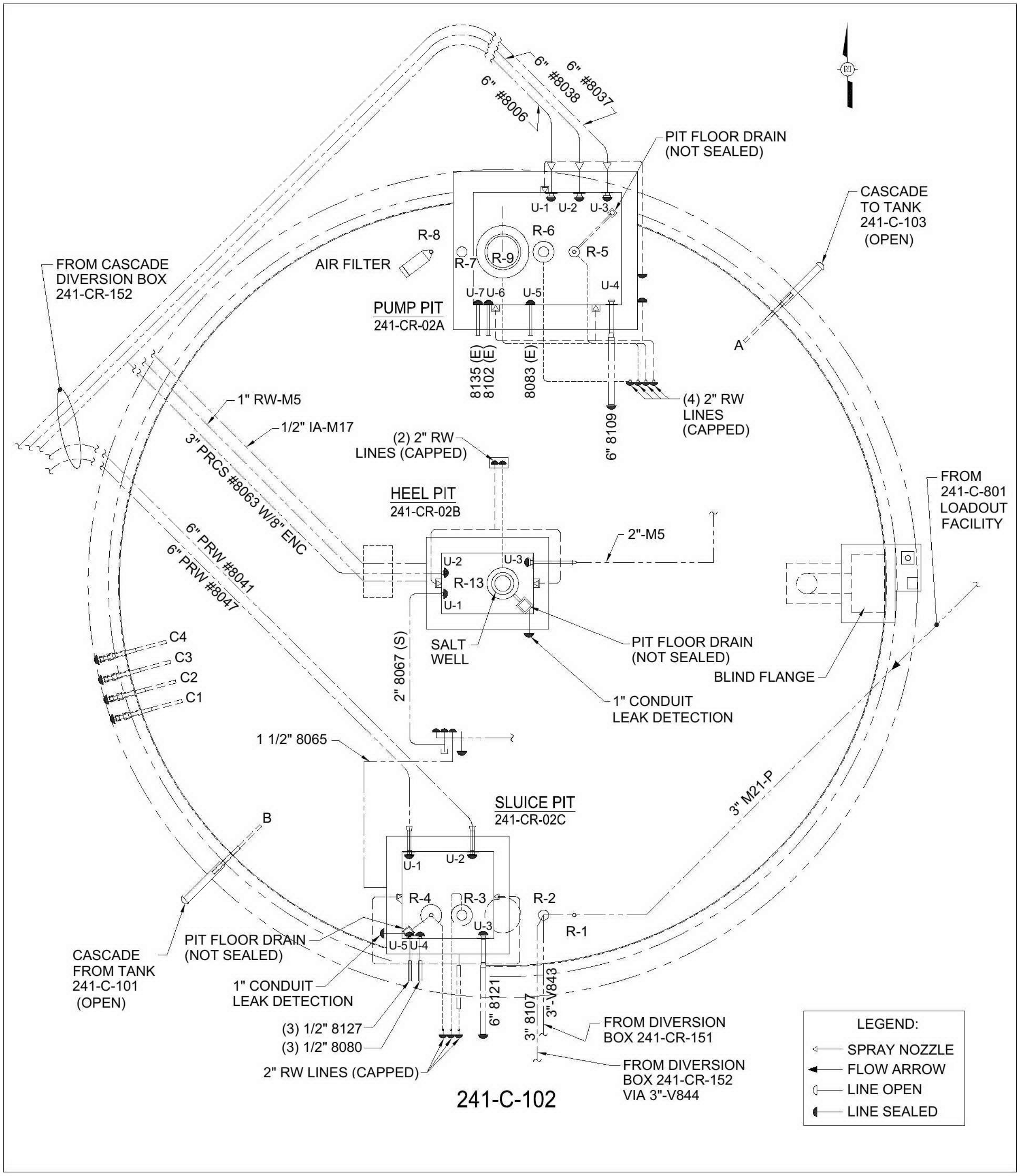
Based on the historical information presented in Sections 2.2 and 2.5, the abandoned process lines used for previous waste transfers will be internally contaminated through contact with the waste. These abandoned lines were constructed with a positive slope to facilitate drainage (a design requirement). Where possible, these lines were either flushed following use or were used for dilute waste transfers that should have minimized significant solid and/or liquid waste buildup in the lines.

There is no available information on the current condition or on the volume/characteristics of any waste associated with piping and other ancillary equipment. For the purpose of assessing the long-term human health risk for the overall waste management area (WMA), an ancillary equipment source-term was defined to include the residual waste in the C farm piping components, 244-CR vault tanks, and the 241-C-301 catch tanks. UPRs (UPR-200-E-81, UPR-200-E-82, and UPR-200-E-86) associated with known transfer line leaks are also included in the long-term human health risk for the overall WMA plan. There are no known leaks from cascade lines associated with the tanks. Additional details on the methodology used to estimate the inventory associated with the ancillary equipment are provided in Section 7.0.

2.6.1 Tank C-102 Ancillary Equipment

Tank C-102 is connected to tank C-101 and tank C-103 by 3-in.-diameter cascade lines. Tank C-102 has 10 risers of varying diameters and lengths of protrusion into the tank. The risers provide access to various in-tank equipment. Table 2-2 identifies the purpose of each riser. A cross-section view of tank C-102 is shown in Figure 2-3. Figure 2-7 illustrates the line and riser locations into and around tank C-102 along with their current uses.

Figure 2-7. Tank C-102 Plan View.



Twenty-seven pathways enter tank C-102 or its associated pits. The pathways include lines, risers, pit drains, weep holes, and ventilation ducts. Twenty-two pathways into tank C-102 have already been isolated, as shown on Table 2-6. Current plans for isolation of all remaining pathways are shown in Table 2-7. This work will be accomplished in accordance with the tank closure plan.

2.6.2 Tank C-104 Ancillary Equipment

Tank C-104 is connected to tank C-105 by a 3-in.-diameter cascade line. Tank C-104 has 11 risers of varying diameters and lengths of protrusion into the tank. The risers provide access to various in-tank equipment. Table 2-2 identifies the purpose of each riser. A cross-section view of tank C-104 is shown in Figure 2-3. Figure 2-8 illustrates the line and riser locations into and around tank C-104 along with their current uses.

Twenty-six pathways enter tank C-104 or its associated pits. The pathways include lines, risers, pit drains, weep holes and ventilation ducts. Twenty-three pathways into tank C-104 have already been isolated, as shown on Table 2-8. Current plans for isolation of all remaining pathways are shown in Table 2-9. This work will be accomplished in accordance with the tank closure plan.

2.6.3 Tank C-107 Ancillary Equipment

Tank C-107 is connected to tank C-108 by a 3-in. diameter cascade line. Tank C-107 has nine risers of varying diameters and lengths and lengths of protrusion into the tank. The risers provide access to various in-tank equipment. Table 2-3 identifies the purpose of each riser. A cross-section view of tank C-107 is shown in Figure 2-4. Figure 2-9 illustrates the line and riser locations into and around tank C-107 along with their current uses.

Nine pathways enter tank C-107 or its associated pit. The pathways include lines, risers, a pit drain, and ventilation ducts. Eight pathways into tank C-107 have already been isolated, as shown on Table 2-10. Current plans for isolation of all remaining pathways are shown in Table 2-11. This work will be accomplished in accordance with the tank closure plan.

2.6.4 Tank C-108 Ancillary Equipment

Tank C-108 is connected to tanks C-107 and C-109 by a 3-in.-diameter cascade line. Tank C-108 has nine risers of varying diameters and lengths of protrusion into the tank. The risers provide access to various in-tank equipment. Table 2-3 identifies the purpose of each riser. A cross-section view of tank C-108 is shown in Figure 2-4. Figure 2-10 illustrates the line and riser locations into and around tank C-108 along with their current uses.

Table 2-6. Tank C-102 Previously Isolated Lines. (2 Sheets)

Intrusion path	Description	Tank waste transfer line?	Isolation technique and status	Verification*
C1	Spare tank nozzle	No	Capped during tank construction, never used	H-2-73342
C2	Spare tank nozzle	No	Capped during tank construction, never used	H-2-73342
C3	Spare tank nozzle	No	Capped during tank construction, never used	H-2-73342
C4	Spare tank nozzle	No	Capped during tank construction, never used	H-2-73342
8006	Transfer line	Yes	Isolation blank at 241-CR-152, L12	H-2-73342 and H-14-104175
8038	Transfer line	Yes	Isolation blank at 241-CR-152, U4	H-2-73342 and H-14-104175
8037	Transfer line	Yes	Isolation blank at 241-CR-152, L15	H-2-73342 and H-14-104175
8109	Spare transfer line	No	Capped outside pit during tank construction, never used	H-2-73342
8083	Electrical conduit	No	Conduit sealed	Detail 6, H-2-73450
8102	Electrical conduit	No	Conduit sealed	Detail 6, H-2-73450
8135	Electrical conduit	No	Conduit sealed	Detail 6, H-2-73450
8067	Steam line from gang valve	No	Line cut and capped when gang valve was removed	H-2-73342 and H-2-71842
8063	Transfer line	Yes	Line T's into 8006 which has isolation blank at 241-CR-152, L12	H-2-73338, H-2-73342 and H-14-104175
M5	Saltwell transfer line	Yes	Isolation blank at 241-C, L1	H-2-73338, H-2-73342 and H-14-104175
8047	Transfer line	Yes	Isolation blank at 241-CR-152, L7	H-2-73342 and H-14-104175
8041	Transfer line	Yes	Isolation blank at 241-CR-152, U3	H-2-73342 and H-14-104175
8121	Spare transfer line	No	Capped outside pit during tank construction, never used	H-2-73342
8080	Air line	No	Cut and capped outside pit	H-2-73342 and H-2-73453
8127	Spare air line	No	Capped outside pit during tank construction, never used	H-2-73342
V843	Transfer line	Yes	Isolation blank at 241-CR-151, L9	H-14-104175

Table 2-6. Tank C-102 Previously Isolated Lines. (2 Sheets)

Intrusion path	Description	Tank waste transfer line?	Isolation technique and status	Verification*
V844/8107	Transfer line	Yes	Isolation blank at 241-CR-151, L8	H-14-104175
M-21-P	Transfer line to valve on tank C-103, then to loadout building	Yes	Valve has been disabled; lines to Loadout building have been cut and capped	H-2-73338, and H-2-73342
Undesignated	Raw water	No	(5) 2-in. lines capped above grade	H-2-73342
Undesignated	Conduit	No	Sealed	H-2-73342

Note: Raw water, steam, and air lines have been cut and capped.

* Verification documents reference information is provided in Section 9.0 of this document.

Table 2-7. Tank C-102 Currently Open Lines.

Line	Description	Tank waste transfer line?	Planned isolation technique
B	Cascade line from tank C-101	Yes	No action until closure fill in tank C-101 or C-102 blocks this line
A	Cascade line to tank C-103	Yes	No action until closure fill in tank C-102 or C-103 blocks this line
--	02A pit drain	No	To be left open
--	02B pit drain	No	To be left open
--	02C pit drain	No	To be left open

Figure 2-8. Tank C-104 Plan View.

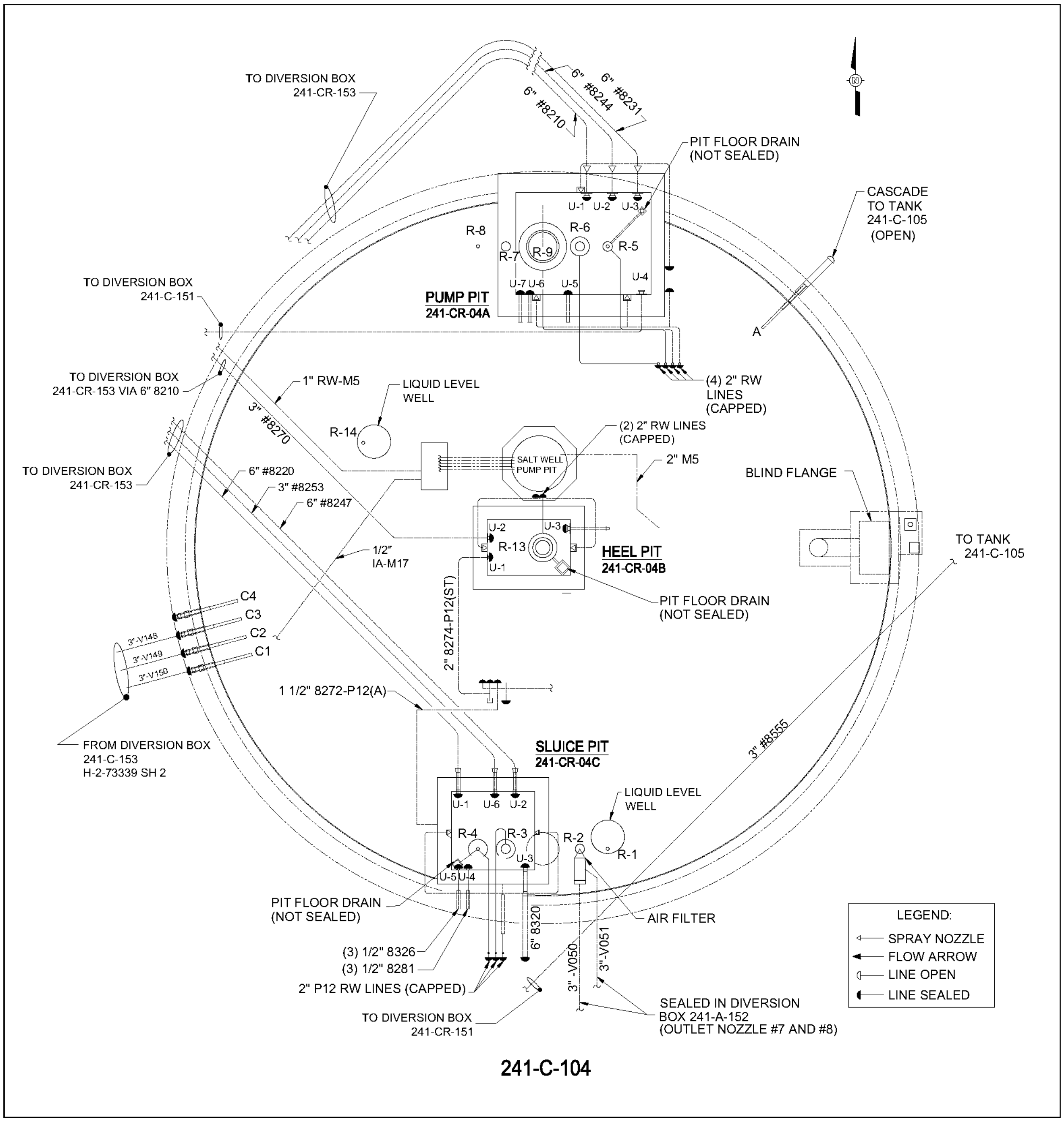


Table 2-8. Tank C-104 Previously Isolated Lines.

Intrusion Path	Description	Tank Waste Transfer Line?	Isolation Technique and Status	Verification*
C1(V150)	Fill line	No	Sealed in diversion box 241-C-153	H-2-73344/ H-2-73339
C2 (V149)	Fill line	No	Sealed in diversion box 241-C-153	H-2-73344/ H-2-73339
C3 (V148)	Fill line	No	Sealed in diversion box 241-C-153	H-2-73344/ H-2-73339
C4	Spare	No	Capped during tank construction, never used	H-2-73344
8210	Transfer line	Yes	Capped in diversion box 241-CR-153	H-2-73344/ H-2-73339
8231	Transfer line	Yes	Capped in diversion box 241-CR-153	H-2-73344/ H-2-73339
8244	Transfer line	Yes	Capped in diversion box 241-CR-153	H-2-73344/ H-2-73339
8270	Transfer line	Yes	Connected to line 8210 – Capped in diversion box 241-CR-153	H-2-73344/ H-2-73339
8220	Transfer line	Yes	Capped in diversion box 241-CR-153	H-2-73344/ H-2-73339
8253	Drain line	Yes	Capped in diversion box 241-CR-153	H-2-73344/ H-2-73339
8247	Transfer line	Yes	Capped in diversion box 241-CR-153	H-2-73344/ H-2-73338
8326	Raw water	No	Sealed in 241-CR-04C at U5	H-2-73344
8281	Raw water	No	Sealed in 241-CR-04C at U4	H-2-73344
8320	Raw water	No	Sealed in 241-CR-04C at U3	H-2-73344
8274	Steam line	No	Capped below grade per H-2-71842	H-2-73344
8272	Air line	No	Capped per H-2-73344	H-2-73344
V050	Transfer line	Yes	Sealed in diversion box 241-A-152	H-2-73344
V051	Transfer line	Yes	Sealed in diversion box 241-A-152	H-2-73344
V101	Transfer line	Yes	Capped in diversion box 241-CR-152	H-2-73338
Unknown	Raw water	No	(9) 2-in. lines capped above grade	H-2-73344
M5	Saltwell pump line	Yes	Capped	H-2-73973
--	04B pit drain	No	Plugged based on pit viper entry	RPP-13194

* Verification documents reference information is provided in Section 9.0 of this document.

Table 2-9. Tank C-104 Currently Open Lines.

Line	Description	Tank Waste Transfer Line?	Planned Isolation Technique
A	Cascade line to tank C-105	Yes	No action until closure fill in tank C-104 or C-105 blocks this line
--	04A pit drain	No	To be left open
--	04C pit drain	No	To be left open

Figure 2-9. Tank C-107 Plan View.

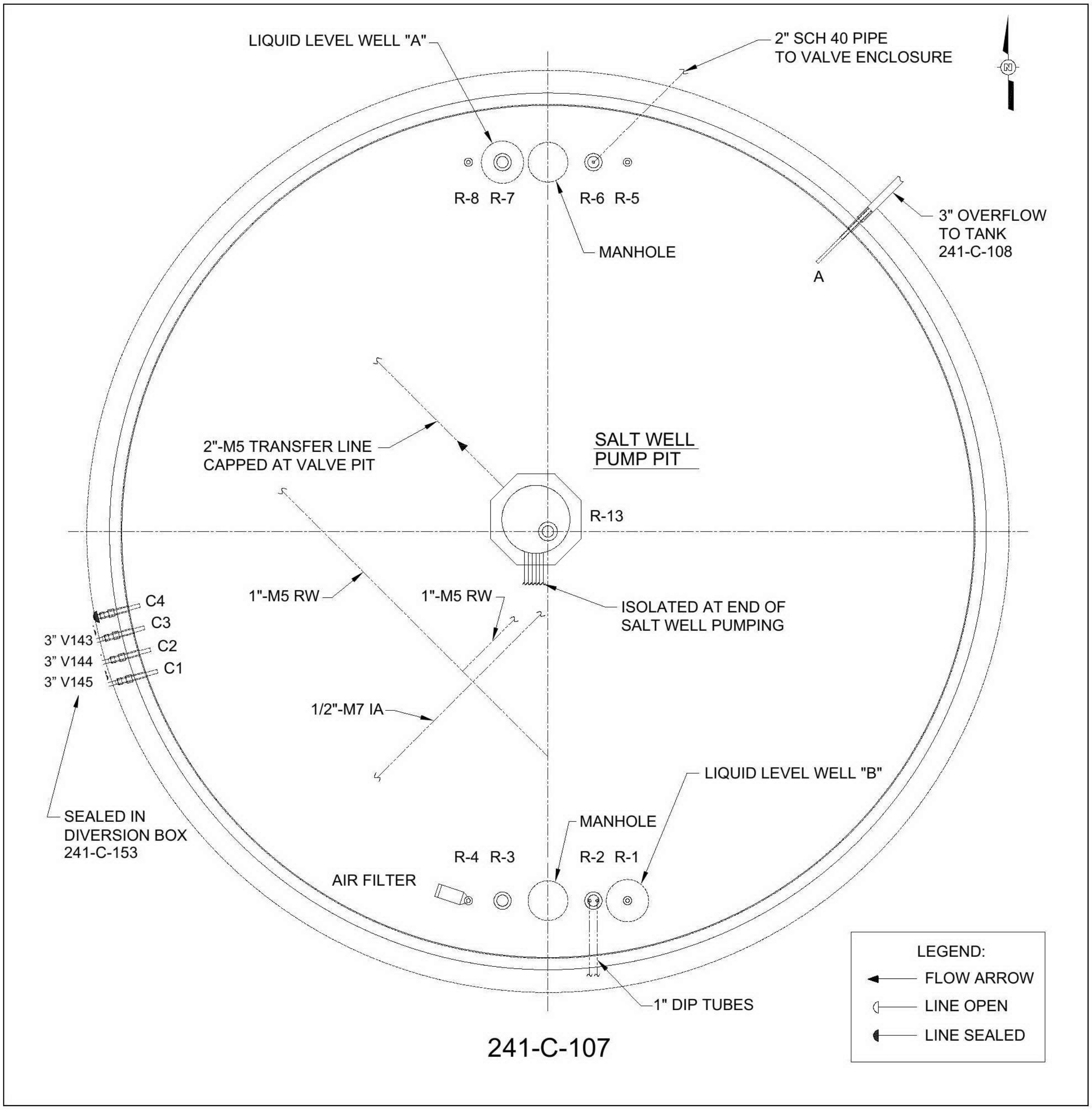


Table 2-10. Single-Shell Tank C-107 Previously Isolated Lines.

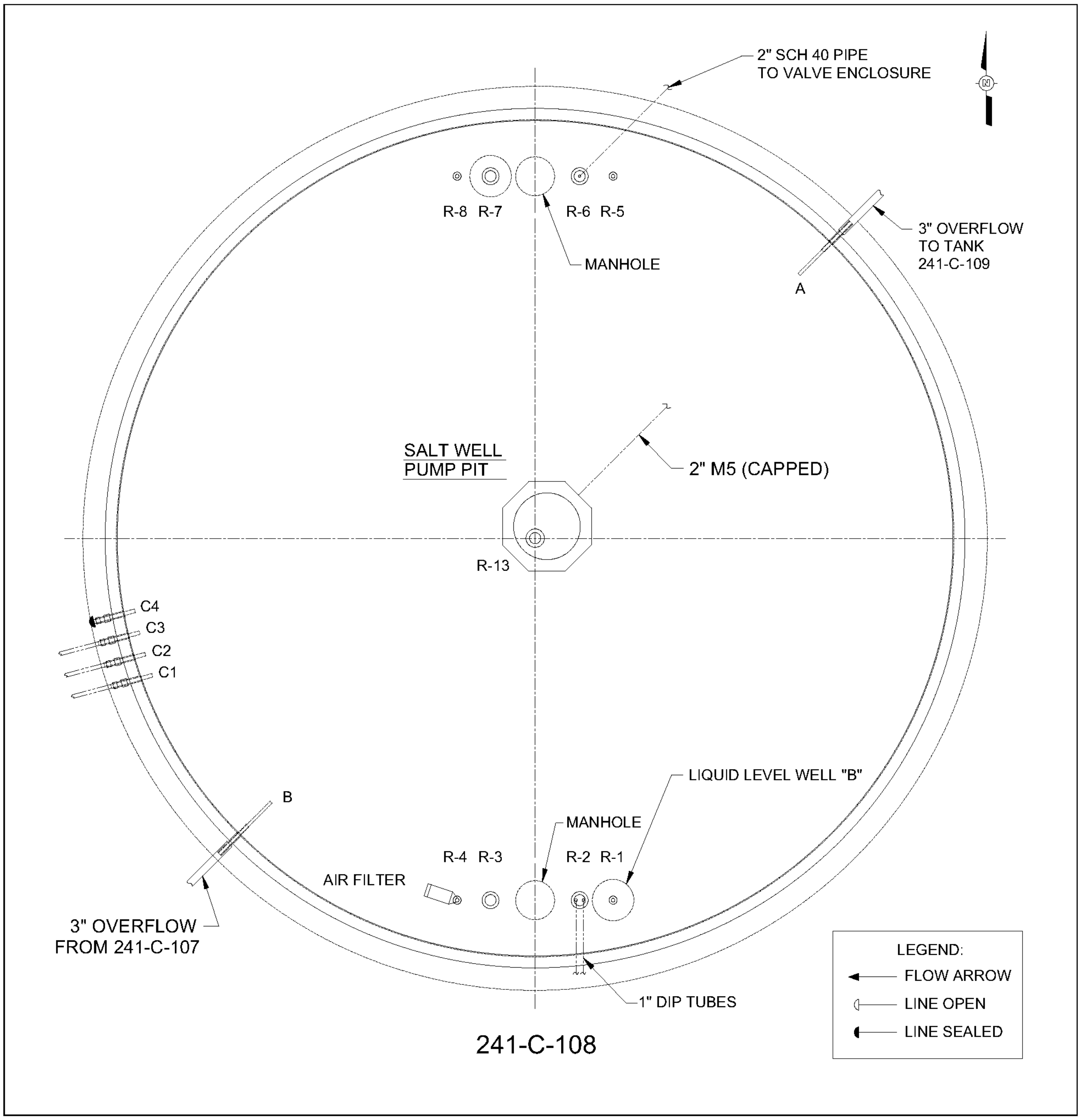
Intrusion Path	Description	Tank Waste Transfer Line?	Isolation Technique and Status	Verification*
C1 (V145)	Transfer line on tank nozzle C1	Yes	Isolated in diversion box 241-C-153, L10	H-2-73347, H-2-73339, and H-14-104175
C2 (V144)	Transfer line on tank nozzle C2	Yes	Isolated in diversion box 241-C-153, L9	H-2-73347, H-2-73339, and H-14-104175
C3 (V143)	Transfer line on tank nozzle C3	Yes	Isolated in diversion box 241-C-153, L8	H-2-73347, H-2-73339, and H-14-104175
C4	Spare tank nozzle on C4	No	Line capped outside tank during construction. Never used.	HW-72743
Undesignated	Transfer line. First cycle waste scavenging. 2-in. line in R-6.	Yes	Valve manifold removed; blind flange on lines	H-2-73450
2" M5	Transfer line – saltwell	Yes	Isolated in valve pit 241-C, L3	H-2-73338 and H-14-104175
--	Saltwell pump pit	No	Saltwell pump pit lines isolated and weather covered	H-2-73634
--	Weight factor enclosure off of saltwell pump pit	No	Lines isolated and weather enclosed	H-2-73347, H-2-73451, and H-2-73634

* Verification documents reference information is provided in Section 9.0 of this document.

Table 2-11. Single-Shell Tank C-107 Currently Open Lines.

Line	Description	Tank waste transfer line?	Planned isolation technique
A	Cascade line to tank C-108	Yes	No action until final closure fill in tank C-108 blocks this line

Figure 2-10. Tank C-108 Plan View.



Nine pathways enter tank C-108 or its associated pit. The pathways include lines, risers, a pit drain, and ventilation ducts. Six pathways into tank C-108 have already been isolated, as shown on Table 2-12. Current plans for isolation of all remaining pathways are shown in Table 2-13. This work will be accomplished in accordance with the tank closure plan.

Table 2-12. Tank C-108 Previously Isolated Lines.

Intrusion Path	Description	Tank Waste Transfer Line?	Isolation Technique and Status	Verification*
C1	Spare tank nozzle	No	Capped during tank construction, never used	H-2-73342
C2	Spare tank nozzle	No	Capped during tank construction, never used	H-2-73342
C3	Spare tank nozzle	No	Capped during tank construction, never used	H-2-73342
C4	Spare tank nozzle	No	Capped during tank construction, never used	H-2-73342
M5	Saltwell transfer line	Yes	Capped outside valve pit	H-2-73348/ H-2-73877
Unknown	Waste scavenging line in R-6	Yes	Capped	H-2-73348

* Verification documents reference information is provided in Section 9.0 of this document.

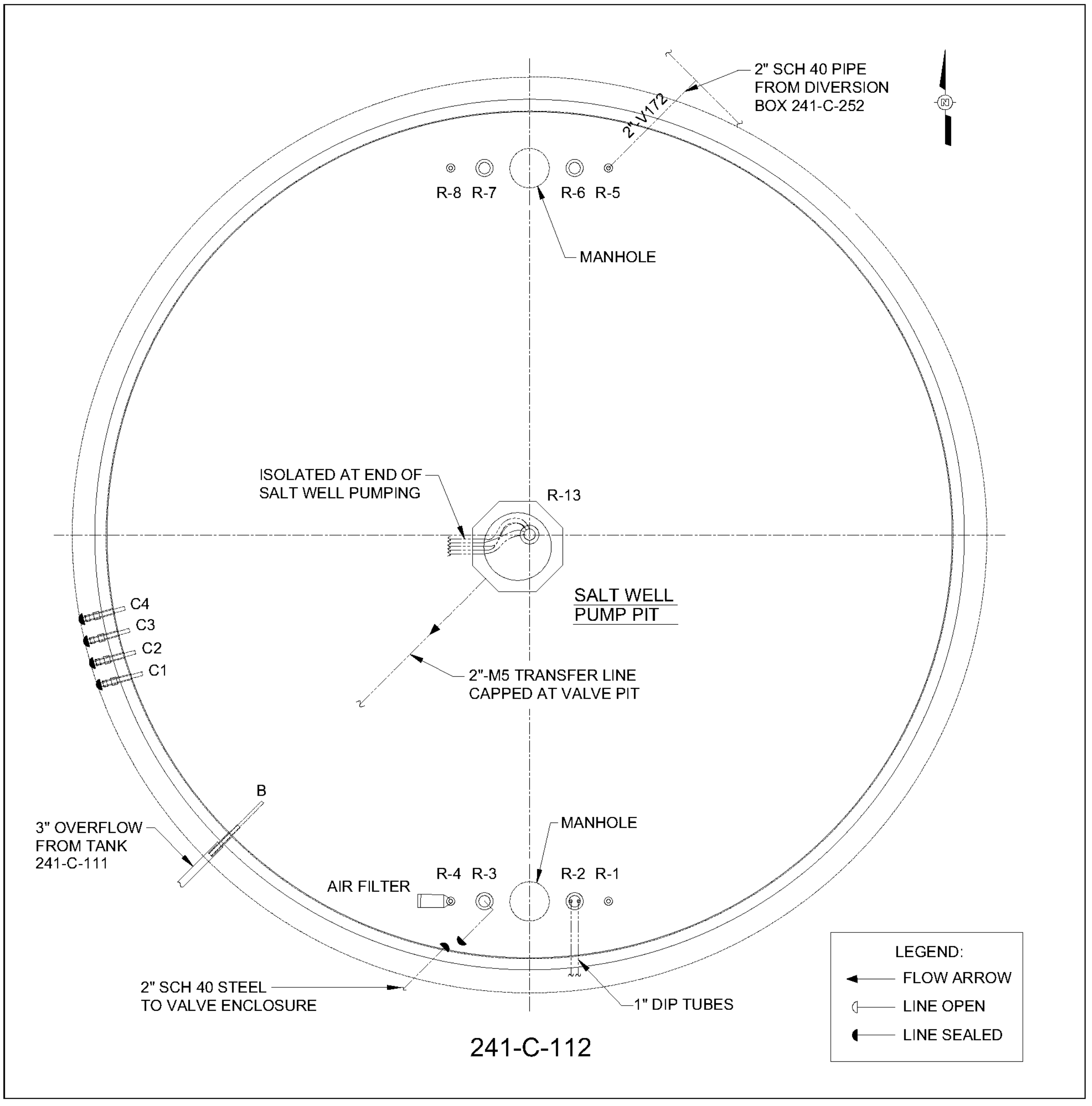
Table 2-13. Tank C-108 Currently Open Lines.

Line	Description	Tank Waste Transfer Line?	Planned Isolation Technique
A	Cascade line to tank C-109	Yes	No action until closure fill in tank C-108 or C-109
B	Cascade line from tank C-107	Yes	No action until closure fill in tank C-107 or C-108 blocks this line
--	02C pit drain	No	To be left open

2.6.5 Tank C-112 Ancillary Equipment

Tank C-112 is connected to tank C-111 by a 3-in.-diameter cascade line. Tank C-112 has nine risers of varying diameters and lengths of protrusion into the tank. The risers provide access to various in-tank equipment. Table 2-3 identifies the purpose of each riser. A cross-section view of tank C-112 is shown in Figure 2-4. Figure 2-11 illustrates the line and riser locations into and around tank C-112 along with their current uses.

Figure 2-11. Tank C-112 Plan View.



Eleven pathways enter tank C-112 or its associated pit. The pathways include lines, risers, a pit drain, and ventilation ducts. Nine pathways into tank C-112 have already been isolated, as shown on Table 2-14. Current plans for isolation of all remaining pathways are shown in Table 2-15. This work will be accomplished in accordance with the tank closure plan.

Table 2-14. Tank C-112 Previously Isolated Lines.

Line	Description	Tank waste transfer line?	Isolation technique and status	Verification*
C1	Spare tank nozzle	No	Capped at tank construction, never used	Capped per HW-72743
C2	Spare tank nozzle	No	Capped at tank construction, never used	Capped per HW-72743
C3	Spare tank nozzle	No	Capped at tank construction, never used	Capped per HW-72743
C4	Spare tank nozzle	No	Capped at tank construction, never used	Capped per HW-72743
V172	Waste transfer line; line is common with tank C-109	Yes	Valves disabled in closed position; isolation blank on nozzle in 241-C-252, U1	H-2-73339, H-2-73351, and H-14-104175
Undesignated	Saltwell transfer line (2 in.–M5)	Yes	Isolated at valve pit 241-C, L5	H-14-104175
Undesignated	Valve manifold (first-cycle waste scavenging) (R-3)	Yes	Valve manifold removed and both ends of line blanked	H-2-73450
Undesignated	Weight factor enclosure lines off of saltwell pump pit	No	Lines isolated and enclosure is weather covered	H-2-73351, H-2-73451, and H-2-73634

* Verification documents reference information is provided in Section 9.0 of this document.

Table 2-15. Tank C-112 Currently Open Lines.

Line	Description	Tank Waste Transfer Line?	Planned Isolation Technique
B	3-in. cascade line from tank C-111	Yes	No action until final closure fill in tank C-112 blocks this line

3.0 PLANNED WASTE RETRIEVAL TECHNOLOGY

This section provides a description of the primary and secondary waste retrieval technologies for retrieving the waste from tanks C-102, C-104, C-107, C-108, and C-112. The rationale for selection of primary and secondary technologies is provided in Section 3.3. However, in accordance with Appendix C, Part 1 of the Decree:

> "If 360 cubic feet is reached with the first retrieval technology, the first retrieval technology shall be used to the "limits of technology" and a second retrieval technology shall not be required."

The primary technology is the first technology deployed for waste retrieval.

The primary technology for C-102, C-104, C-108, and C-112 will be modified sluicing. For C-102 the modified sluicing will be done with an Extended Reach Sluicer (ERSS). If required to meet the tank residual waste conditions in the Decree, the second technology for C-104, C-108 or C-112 will be a chemical retrieval process. The second technology for C-102 will be high pressure water deployed with the ERSS. The primary technology for C-107 will be sluicing with supernate or water. The second technology will be high-pressure water spray. Both of these technologies will be deployed via MARS-S. The MARS-S is designed to implement both the primary and secondary technology when needed. Retrieval activities will switch from one technology to the other as required to reach the Consent Decree residual waste goal.

In accordance with the Decree, Appendix C, Part 1:

> "If the waste residual goal of 360 cubic feet is not achieved using the established two technologies, an additional retrieval technology established in a revised TWRWP shall be deployed to the "limits of technology;" provided that DOE may request that the State agree that DOE may forego implementing a third retrieval technology if DOE believes implementing such technology is not practicable under the criteria set forth above [in Appendix C, Part 1 of the Decree]. If DOE and Ecology are unable to reach agreement, the resolution of the issue of whether a third retrieval technology shall be deployed shall be resolved through the dispute resolution process set forth in Section IX of this Decree."

3.1 SYSTEM DESCRIPTION

This section provides a description of the waste retrieval systems (WRS) and how they will be operated. Continued design development and incorporation of lessons learned may lead to changes in the design and/or operating strategy.

3.1.1 Physical System Description

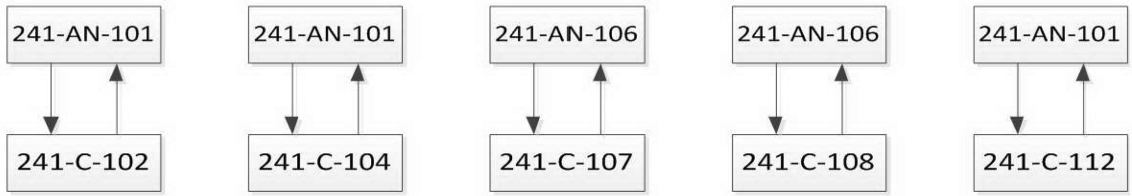
The WRS will consist of a modified sludge sluicing system to mobilize and retrieve waste from tanks C-102, C-104, C-108, and C-112. The sluicing system will consist of two (or more) sluice nozzles and a slurry pump in each tank. The sluice nozzles or hydraulic sluicers will be controlled from a control trailer located near the tanks. The sluice nozzles will be installed in existing tank risers. The sluice nozzles will have the capability to direct liquid at various locations in the tanks. The C-102 WRS will have the capability to use high pressure water to break apart hard agglomerations of waste. The flow rate through the sluice nozzles will be adjusted based on the pump-out rate so that the rate of liquid introduction will approximately equal the rate of solution removal with the objective of minimizing the liquid waste volume in the retrieval tank.

The WRS for tank C-107 will be the Mobile Arm Retrieval System-Sluicing (MARS-S). Standard modified sluicing is maintained as an alternate WRS for C-107 in the event this first deployment of the MARS-S has to be halted. The MARS-S sluicing process consists of an extendable robotic arm suspended from a large central riser added to the tank and serves as the deployment platform for two separate retrieval technologies. The MARS-S is a mobile arm capable of rotating and extending in the tank. The system is equipped with two technologies to mobilize the waste and direct it to a pump for removal. For one technology, the end of the arm is equipped with sluice nozzles that direct supernate and/or water onto the waste surface from a short distance away, and directs the mobilized waste slurry backwards to a slurry pump. A second technology provided by the MARS-S is the addition of high pressure water spray nozzles that serve to break up hard waste agglomerations and direct them to the slurry pump. The slurry pump may use a backstop that can capture the slurry waste and is equipped with more supernate and water nozzles to further break the waste up for removal by the pump.

The waste retrieved from tanks C-102, C-104, C-107, C-108, and C-112 will be transferred to a DST. To minimize the overall volume of waste requiring storage in the DST system, the waste retrieval project plans to use DST supernate as the primary sluice liquid (see Section 3.1.2 for operating description). The WRS will also have the capability to use raw water for sluicing with valving change or minor modifications.

The waste retrieval plan as of October 2010 for using DSTs for waste receipt and as source tanks for supernate recycle is shown in Figure 3-1. The DSTs were selected based on their location, available space, and existing or planned equipment upgrades. Additional detail on the planned use of supernate during waste retrieval is discussed in Section 3.2.

Figure 3-1. Waste Retrieval Liquid Supply and Double-Shell Tank Receiver Tank Designation.



Various monitoring instruments will be used to collect data to support operation of the WRS and perform environmental monitoring. Cameras will be installed in each of the SSTs to provide the capability to visually monitor and aid in control of waste retrieval operations. Instrumentation will also be provided to monitor process control data (e.g., pressures and flow rates). This information will be used to support material balance calculations. The existing ENRAF[1] level gauges will be retracted during waste retrieval operations and will be used periodically to monitor waste levels.

Before initiating waste retrieval, a formal waste compatibility assessment will be performed in accordance with HNF-SD-WM-OCD-015, *Tank Farm Waste Transfer Compatibility Program*. HNF-SD-WM-OCD-015 provides a formal process for determining waste compatibility through the preparation of documented waste compatibility assessments for waste transfers. The primary purpose of the program is to ensure that sufficient controls are in place to prevent the formation of incompatible mixtures during waste transfer operations. Waste compatibility assessments are prepared before all waste transfers into the DST system to ensure that the waste transfer will comply with specific administrative control, safety, regulatory, programmatic, and operational decision rules related to waste chemistry and waste properties. Waste compatibility assessments require the preparation of calculations to determine source tank and/or receiver tank compositions and to assess those compositions against specified decision rules that are provided in HNF-SD-WM-OCD-015.

Formal issuance of the compatibility assessment will not be completed until just before waste retrieval operations begin to ensure that current conditions are captured in the assessment.

During waste retrieval operations, the tank(s) being retrieved will be actively ventilated. The ventilation system will consist of skid-mounted high-efficiency particulate air filtered portable exhauster(s). Condensate drainage from the exhauster(s) will be routed back to an SST being retrieved or an SST undergoing equipment installation in preparation for retrieval. Prior to any change to this drainage routing a change to this TWRWP will be approved by Ecology.

ORP and the tank operations contractor (TOC), pursuant to federal requirements for protection of their workers, will develop and implement a personal exposure sampling and monitoring plan for SST waste retrievals. This plan will be developed and implemented by the operations Industrial Hygiene (IH) departments per the TOC Environmental Health Program with consideration of input from Ecology. Subsequent to issuance of the IH sampling and monitoring plan, changes to that portion of the plan pertaining to sampling exhauster emissions at the stack will be provided to Ecology for Ecology's information in as timely a manner as possible.

New equipment will be installed in the tanks to support waste retrieval. Existing equipment will be removed if and as required to make room for the new equipment.

For modified sluicing tanks, the new slurry pump will be installed in the center riser located in the center pit. Each pump may be mounted on a winch system that will allow the pump to be

[1] ENRAF is a trademark of Enraf, Inc., Enraf B.V., Delft, The Netherlands.

lowered as waste retrieval progresses. The pump suction will be installed just under the waste surface to start, so little or no water should be required for installation due to the sludge nature (i.e., not hard saltcake) of the waste and the small submergence of the pump suction. The system will be designed to allow the pump suction to be lowered as low as possible in each tank to facilitate maximum waste removal. This will allow approximately 10 ft of height adjustment. The pump installation will be performed by lowering the pump into the tank with a crane. A booster pump, if used, will be located within the central riser pit. The WRS for tanks C-108 and C-112 may require modifications to the saltwell pits to accommodate installation of a slurry pump in the center of the tanks.

The modified sluicing pump adjustment features described previously should allow the pump to be installed with little or no water additions. However, if tank conditions require water additions to successfully install the pumps (e.g., debris under the pump installation riser), water additions would be controlled in accordance with OSD-T-151-00013, *Operating Specifications for Single-Shell Waste Storage Tanks*). This water would be added through one or both of the sluicers by lancing or by backflushing through the pump. Lancing refers to lowering a water lance into the waste and adding water to fluidize hard material under the addition point. The initial installation height of the pump will be determined using the in-tank video system.

The sluice nozzles in tanks C-102 and C-104 will be installed within the existing pump and sluice pits. The configuration of tanks C-108 and C-112 is different in that there are no concrete pits and only a single central corrugated metal saltwell pump pit. The WRSs for tanks C-108 and C-112 will require design and construction of riser extensions to support the installation of the two sluice nozzles and slurry pump.

A new central riser will need to be installed in C-107 to provide access for the MARS-S to the tank. The MARS-S design puts the weight of the MARS unit and ancillary equipment on the support pad around the central riser, not on the riser itself. See Section 3.1.1.1 for further information concerning the installation of the new central riser for C-107.

Once the new riser is in place and the MARS-S support pad is installed, the platform is installed that supports the weight of the MARS-S and distributes the load to the support pad. The C-107 MARS-S abovegrade equipment sits on this support platform located around the new riser. The turntable is installed next. The MARS-S mast is installed onto the turntable and extends down into the tank. The mast supports the MARS-S carriage and robotic arm. The arm has an elbow and three telescoping segments and is attached to a carriage that moves up and down on the mast when the arm is being installed or removed. The arm supports a wrist, with pan and tilt capabilities and houses low pressure supernate and high pressure water nozzles attached to the wrist. A strongback is deployed alongside the mast/arm within the riser. It supports the hose management system and may include a video camera for viewing along the axis of the arm. The combined motion of these components allows all waste bearing areas in the tank to be accessed by the nozzles on the sluicing end-effector.

When the in-tank equipment is in place, the abovegrade equipment, including rotary union and the transfer hoses for the MARS-S is installed. The last items installed are the shielding panels. Drawing H-14-107936 shows the MARS-S assembly installation and H-14-107937 shows the MARS general arrangement. The MARS-S is designed to meet the requirements in RPP-SPEC-39989, *Performance Specification for The Mobile Arm Retrieval System for Tank 241-C-107.*

The mast also supports the slurry pump. The combined motion of the turn-table, carriage, arm telescoping segments, and wrist pan and tilt would be used to access all areas of a tank bottom during a sluicing operation. The MARS-S uses several different processes to remove waste from the tank. For the first methodology, several nozzles on the end-effector are used to mobilize (dissolve or suspend waste in the sluicing fluid) waste and sweep it backwards to the intake of the slurry pump. These nozzles normally use supernate for waste mobilization. A second methodology uses additional nozzles on the end-effector to supply high pressure water to break up hardened waste aggregations from a short distance away. The broken pieces are then mobilized and directed back to the slurry pump.

The pump is planned to be equipped with a backstop that includes 'wings' to help capture waste directed towards the pump, and additional nozzles which further direct the material to the slurry pump intake and perform size reduction to enhance retrieval.

The MARS-S is equipped with a sensing system that detects back pressure when the arm bumps into a tank wall or bottom, and halts motion of the arm in that direction before excessive pressure is exerted. This is expected to minimize damage to the arm (or the tank wall/bottom). Visual monitoring of the MARS-S head will also minimize bumping of the MARS-S head into the tank wall or bottom. The sensor will be operable prior to insertion of the MARS-S into the tank, but it is not planned to remove the arm to repair the sensor should it fail after the MARS-S is installed.

The MARS-S is operated from a control trailer outside the tank farm.

The in-tank imaging system will be installed in an available riser in the tank. Table 3-1 provides the planned riser usage for the tanks C-102, C-104, C-107, C-108, and C-112 WRSs. This riser usage may change.

For C-104, a hydraulically operated tool will be inserted in riser 15 near the central pump pit. This tool will extend to the bottom of the tank and be used to attempt to move debris under the pump so the pump can be lowered. The tool is planned to also have water addition capability to aid retrieval if necessary.

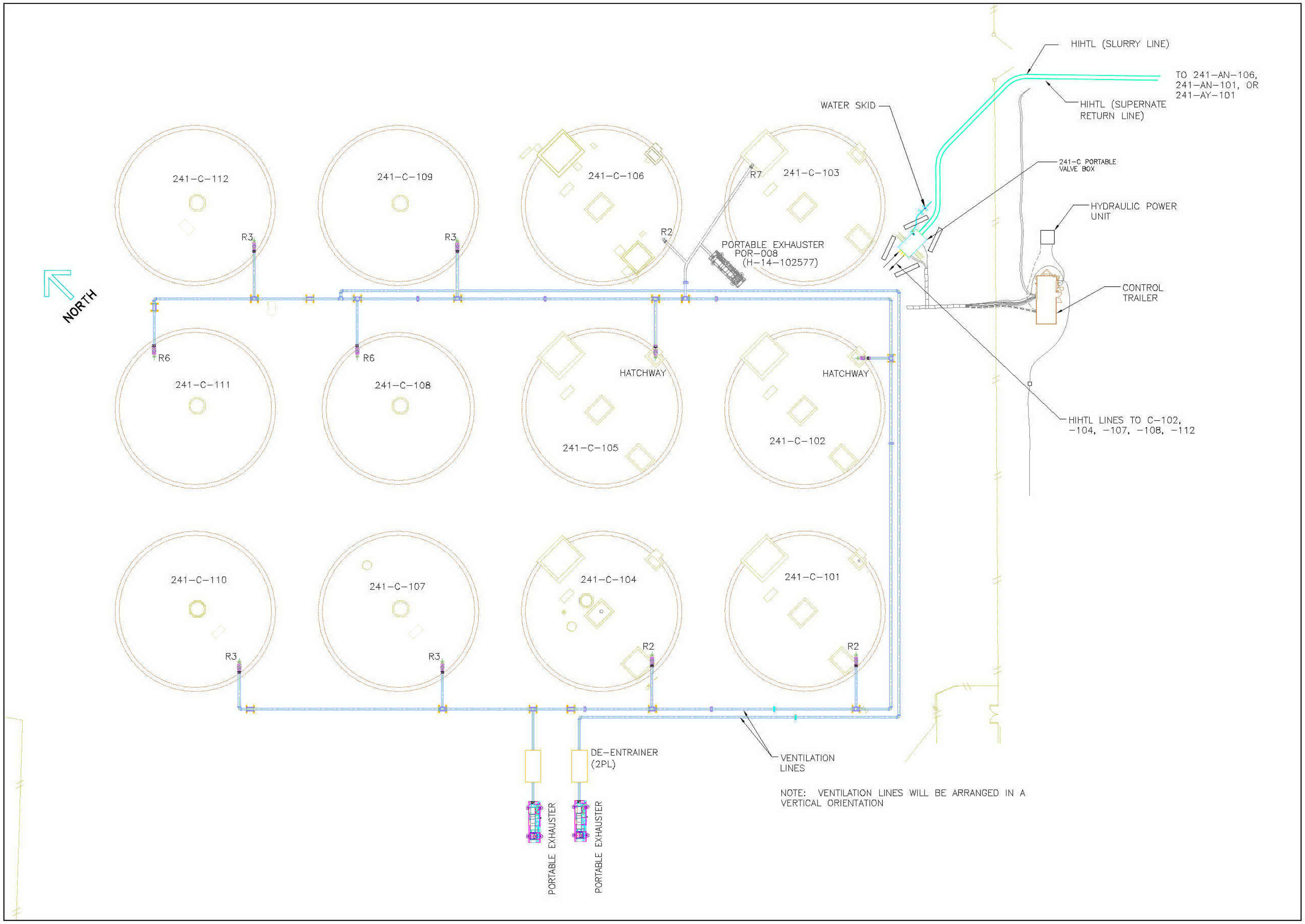
A potential ventilation equipment layout in the tank farm is provided in Figure 3-2. A sketch of the WRS installation planned for tanks C-102 and C-104 is provided in Figure 3-3. A sketch of the WRS installation planned for tanks C-108 and C-112 is provided in Figure 3-4. Figure 3-5 shows the potential MARS-S installation planned for C-107.

The portable valve boxes serve to control the routing and flow of liquid to the sluice nozzles and to control water additions to the waste retrieval process. The valve boxes provide secondary containment and the collection/detection of any leakage in a sump. The portable valve boxes have leak detectors that are connected to the pump shutdown system in the control trailer. In the event that a leak is detected in the portable valve boxes, the transfer pumps in the SST being retrieved and in the receiver DST would be shut down. The portable valve boxes each have a sump and a sump pump that can be configured to transfer any leakage to the SST being retrieved.

Portable diversion boxes will be added to the C-Farm retrieval system and will be used for the tanks in this work plan. The transfer lines to and from up to three tanks will be routed through a valving arrangement in each box to permit switching retrieval operations between the tanks. The diversion boxes provide secondary containment and the collection/detection of any leakage in a sump. The diversion boxes each have a leak detector that is connected to the pump shutdown system in the control trailer. In the event that a leak is detected in a diversion box, the transfer pumps in the SST being retrieved and in the receiver DST would be shut down. The diversion boxes each have a sump and a sump pump that can be configured to transfer leakage to the SST being retrieved.

The transfer lines and DSTs are RCRA compliant.

Figure 3-2. Potential New Ventilation Equipment Layout.



3-8

Table 3-1. Planned Riser Usage for Tanks C-102, C-104, C-107, C-108, and C-112 Waste Retrieval System.

Riser Number	Tank C-102[2]	Tank C-104[2]	Tank C-107[2]	Tank C-108[2]	Tank C-112[2]
2	ENRAF[1] level gauge	Exhauster connection	Multiport adapter	Sluicer	Sluicer
3	Sluicer	Sluicer	Exhauster connection	Vacuum relief/camera port	Exhauster connection
4	--	--	Condensate return	--	--
5	--	--	--	--	ENRAF level gauge
6	Sluicer	Sluicer	--	Exhauster connection	Vacuum relief, camera port
7	Vacuum relief, camera port	Vacuum relief	Multiport adapter with inlet vent and camera ports.	Sluicer	Sluicer
8	--	ENRAF level gauge	ENRAF level gauge	ENRAF level gauge	--
13	Slurry pump	Slurry pump	--	Slurry pump	Slurry pump
New 13	--	--	MARS-S	--	--
14	--	Camera port	--	--	--
Condenser hatchway	Exhauster connection	--	--	--	--

[1]ENRAF is a trademark of Enraf, Inc., Enraf B.V., Delft, The Netherlands.
[2]Riser usage may change following detailed design and/or during operations.

Figure 3-3. Tanks C-102 and C-104 Waste Retrieval System In-Tank Components.

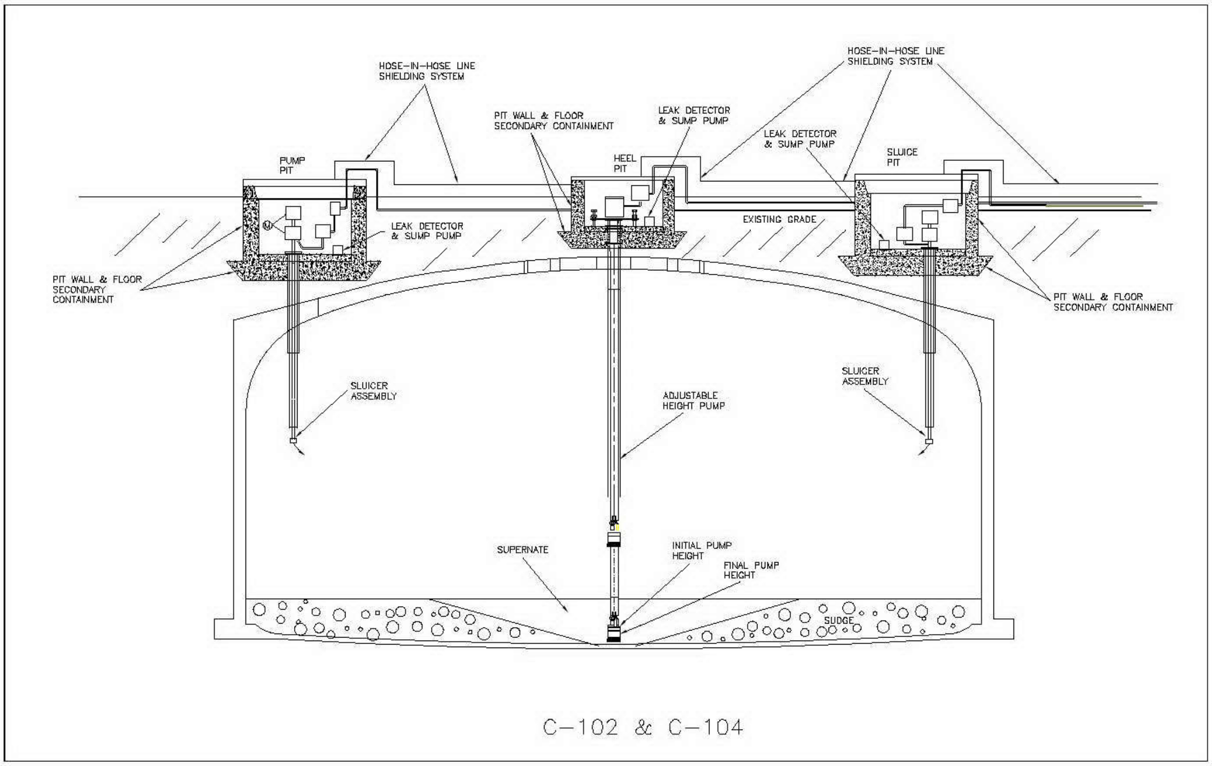


Figure 3-4. Tanks C-108 and C-112 Waste Retrieval System In-Tank Components.

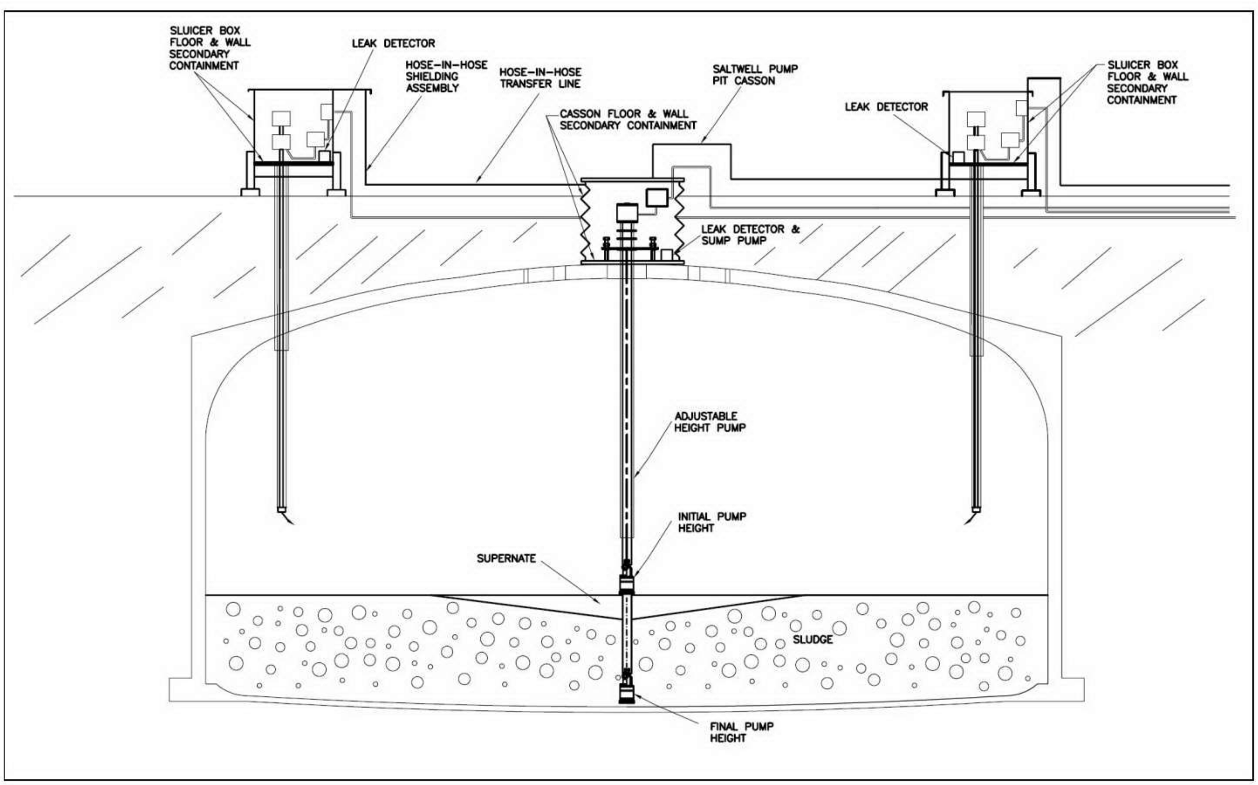
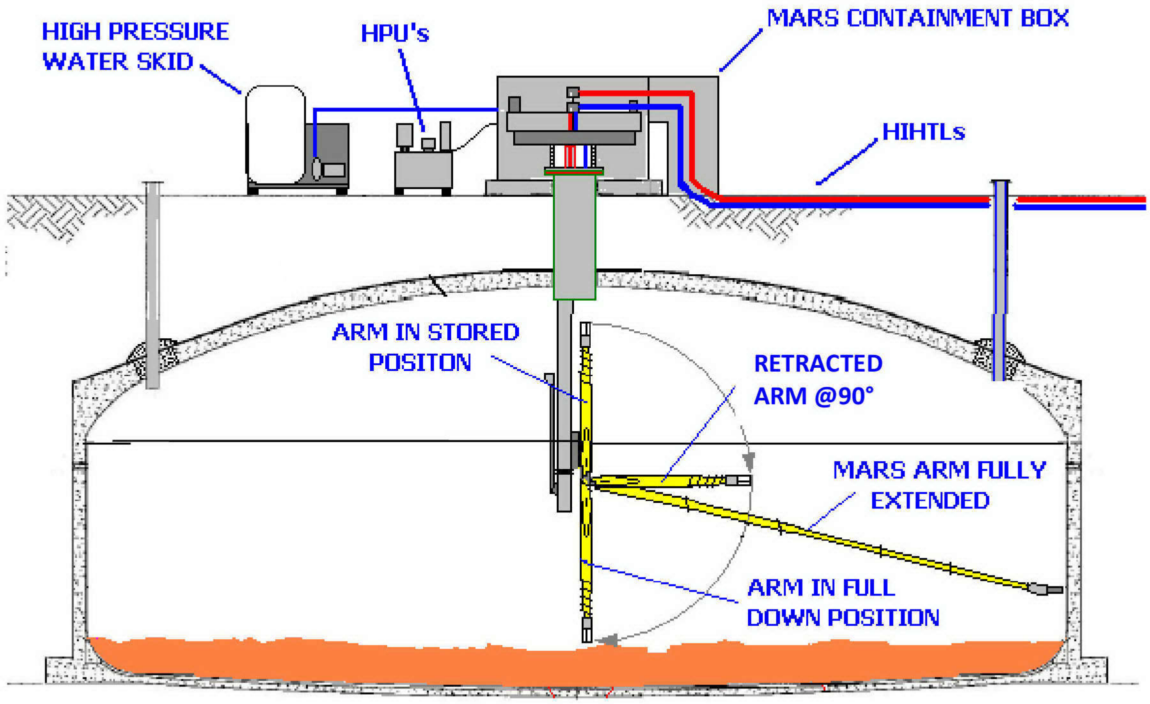


Figure 3-5. Tank C-107 Waste Retrieval System-Bulk Retrieval Operations.



3.1.1.1. Installation of New Large Central Riser for MARS-S in C-107

Below is a description of the planned method for installation of the new large central riser for C-107. The description is provided is a general guide only, and the final method followed may differ somewhat from that described, depending upon final testing and work control developments.

The new central riser for C-107 will require excavation of soil around the existing central caisson down to the concrete dome. Excavation will be performed per the requirements developed to minimize tank structural issues while meeting personnel safety concerns. The existing old saltwell equipment caisson on the tank will be removed and a new nominal 74 inch diameter caisson installed. The area around the new caisson will be backfilled and support pads installed. A nominal 55 inch diameter hole is then cut into the tank dome. It is planned to cut the hole using garnet suspended in a high pressure water slurry. The concrete plug formed when the hole is cut will contain the old 12 in. tank riser, if it hasn't already been removed. The plug will be suspended during the cutting operation using anchor bolts attached via rigging to a crane hook. When the hole cutting is complete the plug will be removed and a new nominal 47 inch central riser with a shielding plug installed to fill the opening. The new riser is then adjusted with leveling jacks to provide correct alignment.

The dome cutting and riser installation method is described on drawing H-14-107697, *Large Riser Installation Sequence*. Related information is shown on drawing H-14-107694, *Site Plan*, H-14-107695, *Large Riser Details*, H-14-107696, *Pad Details, and* H-14-107698, *Riser Plug* *and Anchor Plate Details*. The backfill requirements for the riser installation process are provided in RPP-SPEC-41963, *Construction Specification for Installation of A Large Riser on A Single-Shell Tank.*

The large riser will not transmit a load to the dome by means of direct contact (i.e. MARS-S equipment weight is not put on the large riser), the loads from the retrieval equipment and concrete pad are instead distributed to the soil. See Appendix G for a more thorough explanation of the dome cutting and riser installation and for response to Ecology questions on the installation.

Installation of the large riser will be evaluated for hazards following current TOC hazards review procedures prior to performing the installation.

Prior to cutting the central hole, the anchor bolts used to support the plug during cutting and removal will be installed by qualified personnel following manufacturer's recommendations and checked as described in the controlling work documentation to verify the bolts have acceptable contact with the plug. The method for suspending the plug during and after the cutting step is designed to be quite conservative. The concrete present in the dome is believed to have more than adequate strength to support the plug with the anchor bolts in place. Based upon in-tank video of the tank dome, the tank thermal history, and the construction method for the dome there is no reason to suspect any concrete degradation has occurred.

Structural evaluations have been performed evaluating the tank dome loading conditions resulting from cutting the hole into C-107 and adding the large riser for support of the MARS-S equipment, and monitoring/evaluation will be performed during the riser installation process. The pre-cut evaluations are RPP-CALC-43416, *An Evaluation of Single-Shell Tank 241-C-107 for the Addition of a Large Penetration in the Tank Dome*, and RPP-CALC-47657, *Single-Shell Tanks Large Penetration Addition: Tank 241-C-107 Dome and Haunch Comparative Analysis*. These pre-cut evaluations show the structural integrity of the tank dome will be maintained following the installation of the large riser.

An independent, qualified registered professional engineer (IQRPE) report will be prepared and issued for the large riser installation. This report will be separate from the IQRPE report for the MARS-S retrieval equipment. See Section 3.8 for clarifying words on WAC compliance.

3.1.2 Double-Shell Receiver Tanks

The supernate pump and slurry distributor installed in DST AN-106 may continue to be used to pump supernate back to the C farm and distribute the sludge as received from the SST. The pump in DST AN-101 will also be used to pump supernate in support of C farm retrieval. A new slurry distributor will be installed in DST AN-101 to distribute the sludge received from C farm tanks. A new supernate pump and a new slurry distributor will be provided if needed for DST AZ-101 to support waste retrieval operations.

Because the elevation of the AN farm is approximately 22 ft higher than the C farm and the elevation of the AZ tank farm is approximately 25 ft higher than the C farm, the slurry distributor and the supernate pump incorporate anti-siphon devices to prevent unintentional flow from the

DST to the SST. All waste transfers, including transfer of waste from the C farm tanks to the DSTs and the transfer of supernate from DSTs back to C farm tanks, will be performed using transfer lines that provide secondary containment. The waste retrieval project currently plans to use overground hose-in-hose transfer lines (HIHTLs) and the *Resource Conservation and Recovery Act of 1976* (RCRA)-compliant DST transfer system.

3.1.3 Waste Retrieval System Operating Description

The overall WRS operating strategy will consist of reducing the SST waste inventories. The process will be monitored using closed-circuit television to facilitate waste retrieval and minimize any liquids in the tanks. Supernate will be used as the primary retrieval liquid. Raw water will be used in limited quantities as necessary for waste conveyance and transfer line flushing.

During routine modified sluicing operations, waste retrieval will be initiated by starting the supernate pump in the DST source tank and using the pumped supernate to provide sluicing fluid to the selected sluice nozzle. Initial sluicing will be focused in the center portion of the tank to minimize the time required to get liquid to the slurry pump to allow it to be started. The in-tank camera will be used to provide visual input for directing the sluice nozzle. The slurry pump in tank C-102, C-104, C-108, or C-112 will be started as soon as liquid from the sluicer operation reaches the area of the pump inlet and there is enough liquid present to prime and operate the pump. During waste retrieval, the flow of liquid into the tanks through the sluice nozzles will be controlled to both limit accumulation of liquid in the tank and to maximize waste retrieval efficiency. The slurry removed will consist of both mobilized tank waste and DST supernate used for mobilization. Maintaining a balanced pumping rate into and out of the tanks is integral to minimizing the liquid volume in the tanks and reducing the potential for leakage.

An additional technology provided by the ERSS is the capability to add high pressure water to break up particles that resist breakup or mobilization with the lower pressure supernate (or water) stream. High pressure water could be used at any time during the retrieval process but it is not envisioned that much will be needed until towards the end of retrieval.

During routine MARS-S operations, waste retrieval is similar to that for modified sluicing, with the exception that the supernate nozzles on the MARS-S will be located near the waste surface. The MARS-S arm will be moved radially and axially to reach all areas of the tank. The slurried waste is directed back to the central pump and removed from the tank. Nozzles located at the pump backstop are used to further break up waste particles. An additional technology provided by the MARS-S is the capability to add high pressure water to break up particles that resist breakup or mobilization with the lower pressure supernate (or water) stream. Water could be used at any time during the retrieval process but it is not envisioned that much will be needed until towards the end of retrieval.

If initial sluicing efforts show that tank C-102, C-104, C-107, C-108, or C-112 sludge is not readily mobilized, it may be necessary to add sufficient liquid to the tank(s) to cover the sludge and allow it to sit for a period of time to soften the solid waste before sluicing is resumed. It is not likely that there will be any need to soften the waste. Tank C-108 waste is estimated in the

BBI to be about 40 wt% water; tank C-102 waste is estimated to be 40 to 65 wt% water; and tanks C-104, C-107, and C-112 waste is estimated to be about 50 wt% water. The only reason to soften the waste would be if the surface had become so hard it resisted breakup by solution from the sluicing nozzles. Extensive dryout of the waste (not likely at the estimated water levels and the 70 to 100 °F waste temperatures) could cause some agglomeration of the material. The waste could also be held together with salt crystals from supernate that had evaporated. Should either of these occur and the waste not breakup effectively when hit with solution from the sluicing nozzles, adding liquid to the waste surface may be tried to soften it for retrieval. Liquid breaks down the bonds in dried out waste or dissolves most salt crystals. The supernate used will not be saturated at the start of retrieval in a tank and thus will be expected to dissolve such salts or break the crystal structure down sufficiently to permit retrieval.

The volume of free liquid added to soften any waste would be minimized by keeping the free liquid height above the waste to as small as practical. Any free liquid added beyond this would provide little benefit. The time period needed to soften the waste is unknown; it is expected to be a few days or longer.

Pumping during sluicing will maintain minimum liquid volume in the tanks. This will be performed by initially directing the nozzle flow towards the center of the tanks. As the sluice liquid contacts the tank waste, the sludge will be mobilized and retrieved via the slurry pumps. Typically, one sluicer will be operated at a time operating at a flow rate of approximately 60 to 120 gal/min.

During all field activities, standard operating procedures and safety precautions will be implemented to protect worker health and safety, the public, and the environment. In accordance with standard operating procedures, health physics and industrial health technicians will monitor conditions within the tank farm in accordance with approved monitoring plans.

When the level of residual solids gets low in the tank, the volume of solids removed per unit volume of sluicing fluid removed from the tank will be tracked. The units used will be selected by engineering personnel. Waste retrieval operations will continue in an effort to obtain the goal of 360 ft^3 or less of residual waste remains in the tank, and/or the limits of technology have been reached for this retrieval method. The project will determine when a tank retrieval is complete by following the Consent Decree requirements stating "that the recovery rate of that retrieval technology for that tank is, or has become, limited to such an extent that it extends the retrieval duration to the point at which continued operation of the retrieval technology is not practicable, with the consideration of practicability to include matters such as risk reduction, facilitating tank closures, cost, the potential for exacerbating leaks, worker safety and the overall impact on the tank waste retrieval and treatment mission."

Until a risk evaluation is available, the limit of technology for modified sluicing is defined in RPP-50910, *Single-Shell Tank Waste Retrieval Limit of Technology Definition for Modified Sluicing* as when the concentration of SST waste in the retrieved slurry sent to the DST is within, or bracketing, the range of 0 to 0.6 volume percent.

There is no limit of technology definition for an ERSS or MARS-S waste retrieval process. A limit of technology definition will not be developed until sufficient ERSS and MARS-S retrieval

operations have been performed to enable development of a justifiable definition. Until an ERSS MARS-S limit of technology definition is developed the same value used for modified sluicing in RPP-50910 is applied to MARS-S retrieval operations.

There is no limit of technology definition for a chemical retrieval process. A limit of technology definition will not be developed until sufficient chemical heel retrieval operations have been performed to enable development of a justifiable definition. It is estimated that this will take 3 to 4 heel retrieval operations.

Appendix C, Part 1 of the Decree defines the limit of technology as follows:

> "The "limits of technology" means that the recovery rate of that retrieval technology for that tank is, or has become, limited to such an extent that it extends the retrieval duration to the point at which continued operation of the retrieval technology is not practicable, with consideration of practicability to include matters such as risk reduction, facilitating tank closures, costs, the potential for exacerbating leaks, worker safety, and the overall impact on the tank waste retrieval and treatment missions."

For MARS-S, data for retrieval performance measurement used to show the limits of technology have been met will be used after implementation of one or both low pressure sluicing and high pressure water operations (each technology will not be evaluated separately for its limit of technology).

Experience has shown that unexpected waste forms and tank conditions may be encountered and that equipment performance can degrade with time. The ORP will inform Ecology at least every 2 weeks, through normally scheduled meetings, about unexpected waste forms, behavior and tank conditions along with retrieval equipment performance changes that would impact overall retrieval rates and retrieval volume. If a normally scheduled meeting does not occur Ecology will initiate a meeting for this information exchange.

At these meetings, ORP will provide to Ecology the basis and rationale for continuing retrieval when it is suspected that waste form behavior, tank condition and/or equipment performance has diminished significantly or performance impacted the ability of the deployed equipment to operate in order to meet the waste residual goal of 360 ft^3.

Ecology is notified in the Tri-Party Agreement project manager's monthly meeting when the limits of technology have been reached. Status reports are continued until waste retrieval operations cease. An SST waste retrieval evaluation form and a retrieval report are then prepared and issued and in accordance with the Decree, Part IV, B. 5:

> "When DOE completes retrieval of waste from a tank covered by this Decree, DOE will submit to Ecology a written certification that DOE has completed retrieval of that tank. For purposes of this Consent Decree, "complete retrieval" means the retrieval of tank waste in accordance with Part 1 of Appendix C and with the retrieval technology/systems that were established by Part 1 of the TWRWP either by approval of Ecology or after dispute resolution by the Court under Section IX of the Decree."

Following completion of waste retrieval and final tank flushing, the residual waste volume will be determined using the methodology defined in RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*, and RPP-PLAN-23827, *Sampling and Analysis Plan for Single-Shell Tanks Component Closure.*

3.1.4 Chemical Retrieval Process

Chemical retrieval process details are contained in the process control plan for each tank using a chemical retrieval process. When samples are available the retrieval process is tested on samples of tank waste. If hard heel samples are not obtained the hard heel composition is deduced from tank historical data. The hard heel volume to be treated is normally not known until sluicing retrieval is complete. The hard heel volume can be determined from visual observation, level sensors, or liquid displacement using tank level sensors. The composition and volume of the heel are used to determine the quantity and type of chemicals used for chemical retrieval process.

The chemical retrieval process may be a series of steps or a single action depending on how the waste reacts to the process. If a single step will dissolve sufficient solids to achieve the volume reduction mandated by the Decree, only one chemical retrieval process step will be deployed. The chemical retrieval process may include one or more of the following:

- water to remove compounds insoluble in the caustic liquids found in the tanks,
- high molarity caustic solution to break down aluminum hydroxide compounds, or
- other chemicals to aid the retrieval of sludge.

Ecology will be informed of the pre-retrieval estimated volume of liquid(s) to be added to the tank prior to the initial addition(s). Water additions for dissolution and volume reduction associated with a chemical retrieval process are separate actions from the heel rinse described in section 3.2.

Unlike modified sluicing, there is no operational data available that can be used to estimate the recovery rate for a limit of technology determination for a chemical retrieval process planned for C-104, C-108, or C-112. If the first step of a multiple step dissolution achieves the Decree volume target the limit of technology will be considered to have been met for the chemical retrieval process technology. Using unnecessary chemical retrieval process steps adds risk to worker safety and has retrieval schedule impacts, DST storage volume impacts, and thus possible mission impacts.

If the Decree target volume is not achieved, and all steps of the chemical retrieval process have been deployed as specified in the process control plan, the limit of technology will be considered to have been met for the chemical retrieval process provided the data shows that additional chemical retrieval process steps are not practicable.

Consideration for additional waste retrieval actions will be according to the Decree Appendix C, Part 1 as noted in section 3.0.

3.2 LIQUID ADDITIONS DURING WASTE RETRIEVAL

Supernate from DST AN-101, AN-106, or AZ-101 will be introduced to tanks C-102, C-104, C-107, C-108, and C-112 to mobilize sludge. Supernate will be added at a rate of approximately 60 (or less) to 120 gal/min. The retrieval liquid, along with tank solids, will be removed from these tanks at approximately the same rate. Utilizing recycled supernate to retrieve the waste from the tanks will minimize the overall volume of waste generated during the waste retrieval process. The modified sludge sluicing process will minimize the volume of liquid in the SST during waste retrieval operations.

The use of supernate will be limited by the following:

1. The waste compatibility assessment for supernate recycle will be completed and reported to Ecology. This compatibility assessment shall be made to determine if the solution is acceptable for use in retrieving the SST solids. Ecology will be informed of the results of this assessment, before initiation of retrieval operations and a copy of the assessment report shall be provided to Ecology

2. Submittal of a retrieval data report, as described in M-045-86, 12 months following DOE's certification to Ecology that retrieval is complete. That report shall include a review of the efficiency and performance of the in-tank settling of the retrieved solids in the receiving DST, an estimate of the amount of solids that were recycled during waste retrieval, and the impacts those solids have on removing additional solids from the SSTs.

3. Should the SST be shown to leak during the retrieval process, a liquid sample will be taken if needed to verify the ^{99}Tc concentration in the DST supernate used for sluicing.

4. Should a DST sample be required during the C-102, C-104, C-107 or C-112 retrieval process for corrosion control or other reasons, a ^{99}Tc analysis will be requested on the sample. A DST sample has already been obtained during the C-108 retrieval process.

5. Ecology will be informed by email when the cumulative volume of supernate liquid being recycled exceeds the estimated quantity of 1 million gal., and for each incremental 1 million gal. recycled.

6. Following the use of supernate, a minimum of three tank heel rinses using a minimum volume of raw water that is three times the estimated residual waste volume will be required to ensure that residual waste is removed to the extent practical. If the TOC shows that a comparable reduction in soluble supernate constituents has been accomplished through other retrieval actions, the rinse may be omitted.

When adding liquid to the SST for the sole purpose of obtaining a waste level measurement, the following conditions apply:

1. The HRR leak detection system for the tank described in Section 4.2.1 must be continuously operable for at least 48 hours prior to the liquid addition.
2. The benchmark level described in Section 4.6.1 will not be exceeded during the liquid addition.

3. Excess liquid will be removed from the tank as soon as practical once a usable waste level measurement is obtained.
4. The liquid to be used for volume displacement measurement should only be supernate. Use of raw water for volume displacement instead of or in addition to supernate shall be discussed with Ecology prior to use.

A process flowsheet has been prepared for the C farm 100-series tanks (RPP-21753, *C Farm 100-Series Tanks, Retrieval Process Flowsheet Description*). The calculations performed in support of the flowsheet assume that the retrieved solids are about 3 vol% in the slurry transferred to the receiving DST. The waste retrieval process flowsheet estimate of the total liquid volume transferred during the sluicing of each tank is provided in Table 3-2. In addition, the flowsheet allocates a nominal 105,000 gal. of water for tank and equipment flushing during each tank's waste retrieval operations. Following the initiation of C-104 active retrieval operations, solutions currently contained in the CR vault sumps for Cells 1, 2, 3, and 11, and line flush water may be transferred using a hose-in-sleeve line into C-104 for subsequent transfer out to the receiving DST. See approved TWRWP change modification notice 2009-2 in Appendix G for additional Ecology CR Vault sump solution transfer requirements.

Table 3-2. Tank C-102, C-104, C-107, C-108, and C-112 Waste Retrieval Summary Data. [a]

Tank	Initial Tank Waste Volume prior to Retrieval (kgal)	Retrieval Flush Volume (kgal) [b]	DST Supernate Recycle (kgal)	Estimated Operating Duration (days) [c]
C-102	316	105	10,270	115
C-104	259	105	8,420	100
C-107	247	105	8,070	98
C-108	66	105	2,180	50
C-112	104	105	3,410	60

DST = double-shell tank.

[a] RPP-21753, 2005, *C Farm 100-Series Tanks, Retrieval Process Flowsheet Description*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

[b] Flushing volume allocation from RPP-21753.

[c] Durations estimated based on the general operating assumptions of 3 shifts operating 7 days/week with 60% operating efficiency. Sluicing durations assume 3 vol% solids loading in slurry and an average transfer rate of 75 gal/min.

At the cessation of retrieval operations, the tank walls and heel will be flushed with water. When performing the flushes, the flush water may be used to push some of the residual waste to a convenient sampling location. For each flush, the volume of water added will be metered and recorded. The flush liquid will be pumped to a minimum heel following each flush addition. It is assumed that performing the final tank flushes will remove residual solids to the extent practical on the walls, dilute soluble radionuclides and chemicals in the tank liquid, and may dissolve potentially soluble compounds that are insoluble in the higher molarity caustic solutions normally present in the tank. The ENRAF level gauge readings taken during the flushing will provide backup data for final tank residual waste measurement.

The final flush volume will be dependent upon the final heel composition and volume. As a minimum, there will be three flushes with a minimum flush volume of three times the volume of the estimated waste heel volume.

The timing for transfers out of tanks C-102, C-104, C-107, C-108, and C-112 is dependent upon personnel resource availability, equipment availability, and DST conditions. Once waste retrieval is started, it should follow the general pattern described, but no liquid additions or removals to/from these tanks can be predicted for more than a day or two in advance; therefore, no detailed timeline can be developed showing all liquid additions and removals. The water or supernate addition/removal may be intermittent or continuous. Based upon experience with other modified sluicing and saltcake dissolution retrievals, it will likely last 8 to 16 hours, then be followed by at least a few days wait, then continue. Work continuity will be dependent upon resource availability and external influences. Ideally the retrievals could be completed within a few months, but delays with tank farm work and lack of available resources could stretch retrieval times out to 12 months per tank.

3.2.1 Basis for Using Supernate

If water were to be used for retrieving the waste from tanks C-102, C-104, C-107, C-108, and C-112, the total volume of liquid required would be approximately 32.9 million gal. (32.4 million gal. for retrieval at 3 vol% waste + 5 × 105,000 gal. for flushes). If water were used for retrieving waste from the five C farm tanks addressed in this document, the retrieved waste volume would exceed the capacity of the DST system and would require multiple waste transfers to other DSTs and evaporation of the liquid to reduce the volume. To evaporate all of the water to retain DST operating space, 50 to 100 evaporator campaigns lasting for between 3.5 and 8 years would be required. This number of transfers and evaporator campaigns would induce significant delays to waste retrieval operations.

Because the supernate is recycled, the net liquid addition to DST receipt tanks will be the nominal 90,000 to 105,000 gal. of flush water per tank plus the volume of interstitial liquid in the retrieved tanks. Following completion of C tank farm waste retrievals, the DST receipt tanks will be at or near their storage capacity.

The basis for the number of evaporator campaigns and their durations comes from the following group of assumptions:

- Currently an evaporator campaign may be 400,000 to 800,000 gal. Evaporation is done on a feed tank basis. If a DST were freed to hold only retrieval water-waste slurry, up to 1 million gal. could be evaporated per batch. If it were necessary to mix the dilute slurry with a number of other tanks, a batch size may be reduced to only approximately 300,000 gal.

- The dilute sluicing fluid would require two passes through the evaporator to achieve full concentration.
- The first pass through the evaporator would achieve a 50% waste volume reduction.
- An average of 1 week of transfers is required to fill the feed tank with 1 million gal. of feed.
- A 1-million-gal. campaign could last approximately 12 days or more, and 2 days of campaign shutdown activities would be required before the next campaign could be started.

All of these assumptions are based on prior evaporator operating experience.

The number of campaigns is determined by starting with the initial volume of waste to be processed, 32.9 million gal. To this is added the volume of waste left after the first pass through the evaporator (i.e., 0.5 × 32.9 million gal. = 16.4 million gal.). Summing these volumes gives 49 million gal. Dividing by the 1-million-gal. campaign volume gives about 50 campaigns.

The duration of the campaigns is equal to the sum of duration of its elements (i.e., transfers [7 days] + evaporator campaign [12 days] + shutdown [2 days] = 21 days).

The duration of 50 consecutive campaigns is 1,050 days. Adjusting this value for the operating efficiencies of between 70 and 90%, gives a total duration for 50 consecutive 1-million-gal. campaigns of between 3.5 and 4 years. This is a theoretical time only. To this must be added downtime for maintenance and other issues, and the additional problems associated with transferring 32.9 million gal. of waste within tank farms. The 25 DSTs in the 200 East Area contain approximately 23.3 million gal. as of November 30, 2004. At a nominal 1.1 million gal. per tank, there is no room for the volumes associated with all water sluicing, nor will there be sufficient space cleared up until a number of years following Waste Treatment Plant startup. Therefore, evaporation time for water sluicing only will take longer than 3.5 to 4 years.

This evaluation of the impact of water-only sluicing should be considered as the minimum possible impact. Other factors (e.g., staging transfers to accumulate the required volume of waste feed, problems associated with sampling and analysis) could cause additional delays of the evaporator operations, and further impact waste retrieval operations.

The advantages and disadvantages of using supernate recycle instead of water for retrieval of the waste in tanks C-102, C-104, C-107, C-108, and C-112 are provided in Table 3-3.

Table 3-3. Advantages and Disadvantages of Using DST Supernate for Retrieval of Insoluble Waste Solids. (2 Sheets)

Supernate Recycle Advantage	Approximately 1 million gal less liquid effluent discharged from the Liquid Effluent Treatment Facility in the 200 East Area for every 1 million gal of water saved.
Supernate Recycle	An estimated 13 to 22 fewer drums of waste sent to disposal from the

The advantages and disadvantages of using supernate recycle instead of water for retrieval of the waste in tanks C-102, C-104, C-107, C-108, and C-112 are provided in Table 3-3.

Table 3-3. Advantages and Disadvantages of Using DST Supernate for Retrieval of Insoluble Waste Solids. (2 Sheets)

Advantage	Liquid Effluent Treatment Facility for every 1 million gal of water not added to the tank.
Supernate Recycle Advantage	Supernate recycle provides a huge increase in DST room available for waste retrieved from SSTs. If this volume is not available due to sluicing with water, some SST waste retrievals in addition to that discussed in this document will be delayed, resulting in wastes remaining stored in noncompliant tanks for a longer period.
Supernate Recycle Advantage	There will be a nominal two to three fewer evaporator campaigns for each 1 million gal of water saved.
Supernate Recycle Advantage	Supernate recycle will require less fresh NaOH and $NaNO_2$ to be added to bring the resulting DST solutions into the concentration limits specified for corrosion control. Depending on other constituent concentrations in the DST solutions following mixing with the insoluble solids slurry and flush water, between 0 and 44,000 kg of 100 % NaOH will need to be added to the DST system to bring each 1 million gal of insoluble solids slurry and flush water into specification. Some additional $NaNO_2$ may also be required depending on other constituent concentrations in the DST solutions following mixing with the insoluble solids slurry and flush water.
Supernate Recycle Advantage	Elimination of the need to process the additional NaOH and $NaNO_2$ chemicals through the WTP. A 44,000-kg addition of sodium to the DST system would require about 15 days of WTP operating time.
Supernate Recycle Disadvantage	The design and equipment costs to recycle supernate are more than the design and equipment costs associated with water addition.
Supernate Recycle Disadvantage	The supernate recycle process is not as flexible due to the added difficulties of maintaining equipment that is contaminated vs. that which has only contacted water.
Supernate Recycle Disadvantage	The supernate recycle process is more complex due to the need for encased lines and leak detection equipment not needed for water only lines.
Supernate Recycle Disadvantage	A DST pump with an adjustable suction or a suction fixed in the supernate well above the sludge level is required for supernate recycle.

3.3 TECHNOLOGIES CONSIDERED AND RATIONALE FOR SELECTION

Primary candidate waste retrieval technologies currently available for deployment at tanks C-102, C-104, C-107, C-108, and C-112 are (1) modified sluicing, (2) the mobile retrieval system, and (3) sluicing with MARS-S. Modified sluicing uses water or DST supernate to mobilize waste to a pump where it can be removed from a tank. The mobile retrieval system consists of an articulated mast system, which is a vacuum-based system deployed in the center of the tank with a crawler deployed to move sludge from the perimeter of the tank to the center of the tank where it can be removed with the vacuum system. MARS-S is believed to offer an improvement over modified sluicing because the mobilizing fluid is added closer to the waste surface and can direct the slurry better to the slurry removal pump.

Although modified sluicing and MARS-S could introduce more liquids to the tank than the mobile retrieval system, the modified sluicing and the MARS-S sluicing systems provide a higher waste retrieval rate and are much better for retrieval from sound tanks. Addition of liquid to sound tanks as identified in HNF-EP-0182 using the modified sluicing or MARS-S systems is acceptable. The mobile retrieval system uses vacuum to remove waste to the tank farm surface where liquid is added to enable the waste to be transferred as a slurry. Because of this difference, the mobile retrieval system or the MARS vacuum system (not described in this document) are currently the preferred waste retrieval technologies for known or suspected leaking tanks.

When modified sluicing or MARS-S sluicing are performed using DST supernate, the overall volume of waste requiring management (storage and/or volume reduction) in the DST system is reduced.

Modified sluicing is a proven technology that has been successfully demonstrated. The only volume added to the DST system is the volume of sludge removed from the SST, plus the water used for line flushes or other uses. There is no deployed process that is more effective.

The MARS-S sluicing system is expected to be an improvement over modified sluicing because it is believed capable of reducing the residual waste volume in a tank to below the Consent Decree limit without requiring an additional technology. The MARS-S enables close access to almost all of the waste in a tank to improve waste mobilization over that of modified sluicing. The first deployment of the MARS-S sluicing system will demonstrate the system capabilities, as well as provide time for making improvements if necessary prior to further deployment. After considering both candidate waste retrieval technologies and designation of the tanks as being sound, modified sluicing using recycled DST supernate was selected as the primary technology for deployment in tanks C-102, C-104, C-108, and C-112. The MARS-S sluicing system is selected for deployment on C-107. This will be the initial deployment for the MARS-S system. The operating experience will provide information for future deployment of the system.

The second technology alternatives, if necessary, should one be required for residual waste removal following modified sluicing, are an in-tank vehicle, high pressure water, and a chemical retrieval process.

Generally, an in-tank vehicle is desirable for large or monolithic particles since it can break these up for sluicing, while a chemical retrieval of larger aggregates may be slow or ineffective due to the small surface area for dissolution. High pressure water or an in-tank vehicle is preferred as the heel volume increases because a chemical retrieval process may take up too much DST space and, for caustic or acid dissolutions, will have proportionally more impact to the DST space. A chemical retrieval process is preferable for heels where the volume is relatively low so the impact on DST space and the WTP throughput volume is less. A chemical retrieval process may also be preferable if the particles are small because the surface area for dissolution is greater and an in-tank vehicle may just push the fine particles around the tank.

A chemical retrieval process was selected as the second technology for C-104 and C-108 as it can be deployed in less time than an in-tank vehicle and because it is believed the estimated residual heel volume could be chemically reduced to below 360 ft^3 without causing a significant impact to the available DST space or the WTP throughput volume.

A chemical retrieval process was selected as the second technology for C-112 as it can be deployed in less time than an in-tank vehicle when the primary technology is no longer effective and the tank residual waste volume in the Decree is exceeded.

High pressure water was selected as the second technology for C-102 as it can be deployed in less time than an in-tank vehicle when the primary technology is no longer effective and the tank residual waste volume in the Decree is exceeded.

Second technology selection inherently relies on past experience and assumptions on the tank waste characteristics that will be present after the first technology is deployed to its limits. If new data is obtained that shows chemical retrieval is not the preferred second technology for tanks C-104, C-108, C-102, and C-112 a TWRWP modification will be made to seek approval for the preferred technology.

The primary and second technologies selected are anticipated to provide the best methods to achieve the 360 cubic feet target volume goal specified in the Decree, when deployed to their "limits of technology." The "limits of technology" as defined in the Decree is noted in section 3.1.3.

3.4 ANTICIPATED PERFORMANCE GOALS

The retrieval technology equipment selected for tanks C-102, C-104, C-107, C-108, and C-112 will be designed, operated, and deployed to each of their limits of technology, as defined in this document, in an effort to obtain a waste residue goal of 360 cubic feet of waste or less for each tank in accordance with the Decree (see Table 3-2).

3.5 WASTE RETRIEVAL SYSTEM DIAGRAM

A preliminary diagram of the modified sluicing WRS in-tank components is provided in Figures 3-3 and 3-4. A preliminary diagram of the MARS-S sluicing WRS is provided in Figure 3-5. As noted in Section 3.1.1, the elevation in the AN tank farm is approximately 22 ft higher than the elevation in the C tank farm and the elevation in the AZ tank farm is approximately 25 ft higher than the elevation in the C tank farm.

3.6 WASTE RETRIEVAL SYSTEM FUNCTIONS AND REQUIREMENTS

This section defines the upper-level functions and corresponding requirements to which the tanks C-102, C-104, C-107, C-108, and C-112 WRSs must be designed and operated. This work plan is not a system specification that defines design criteria for the WRSs. However, the system specification for the tanks WRSs will be consistent with this work plan. The functions and requirements are provided in Table 3-3 and are focused on defining the upper-level requirements for the tanks.

Table 3-4. Tanks C-102, C-104, C-107, C-108, and C-112 Waste Retrieval System Functions and Requirements. (2 Sheets)

Function	Requirement	Basis*	Key Elements
Control gaseous and particulate discharges	The ventilation system exhaust shall be filtered to restrict emissions to the environment.	WAC 173-303 WAC 173-400 WAC 173-460 WAC 246-247 TFC-ESHQ-ENV-STD-03 TFC-ESHQ-ENV-STD-04	Mitigate potential release to the public and the environment.
Mitigate potential for leaks to occur during waste retrieval	Prevent inadvertent release from tank C-102, C-104, C-107, C-108, or tank C-112 to the environment.	RPP-13033, Section 3.3.2.3.4	Do not raise waste level above benchmark level. Benchmark level to be provided in process control plan.
Control waste level in tanks C-102, C-104, C-107, C-108, and C-112	The WRS shall be operated to prevent waste level from exceeding 185 in.	OSD-T-151-00013	Minimize liquid level to the extent practical.
Control waste level in DST receiver tank	The WRS shall be operated to maintain waste level within specified allowable maximum and minimum values.	OSD-T-151-00007	Provide for safe waste storage in DSTs.
Remove waste from tanks C-102, C-104, C-107, C-108, and C-112	The retrieval technologies will be designed, deployed, and operated to each of their "limits of technology" in an effort to achieve the waste residue goal of 360 ft^3 of waste or less for each tank. The limit of technology is defined in the Decree.	WAC 173-303 Decree	The retrieval technologies shall have the potential to achieve a waste residue of 360 ft^3 or less.
Control and monitor the waste removal process in tanks C-102, C-104, C-107, C-108, and C-112	The WRS shall provide the monitor and control capability to control the waste retrieval and transfer process. This includes controlling and monitoring the following WRS process parameters: • Pressures • Flow rates • Differential pressures across exhaust ventilation filters • Leak detection systems.	RPP-13033 HNF-SD-WM-TSR-006 WAC 173-303 WAC 246-247 TFC-ENG-STD-26	Provide for safe and effective operation of the WRS.
Minimize waste generation	The WRS shall minimize waste generation to the greatest extent practical.	WAC 173-303 40 CFR 264.73(b)(9)	No numerical requirement.

Table 3-4. Tanks C-102, C-104, C-107, C-108, and C-112 Waste Retrieval System Functions and Requirements. (2 Sheets)

Function	Requirement	Basis*	Key Elements
Nuclear safety	The WRS shall be designed and operated to protect workers, the public, the environment, and equipment from exposure to radioactive tank waste and emissions during the retrieval campaign.	WAC 246-247 10 CFR 830 RPP-13033 HNF-SD-WM-TSR-006 HNF-IP-1266	Ensure protection of workers and the public from routine operations and potential accident conditions.
Occupational safety and health	The WRS shall be designed for safe installation, operation and maintenance.	WAC 173-303-283(3)(i) 29 CFR 1910 10 CFR 835 29 CFR 1926	OSHA standards. Occupational Radiation Protection.
WRS secondary containment and leak detection	For ex-tank equipment and piping, the WRS shall incorporate secondary containment and leak-detection design features.	40 CFR 265 WAC 173-303 DOE O 435.1 RPP-13033 HNF-SD-WM-TSR-006	Provide for safe and compliant transfer of waste to the receiver DST.

DST = double-shell tank.
Ecology = Washington State Department of Ecology.

OSHA = Occupational Safety and Health Administration.
WRS = waste retrieval system.
* Basis documents reference information is provided in Section 9.0 of this document.

3.7 ANTICIPATED IMPACTS OF TANK WASTE RETRIEVAL ON FUTURE PIPELINE/ANCILLARY EQUIPMENT RETRIEVAL

The existing buried waste transfer lines routed to tanks C-102, C-104, C-107, C-108, and C-112 have been isolated to prevent the inadvertent transfer of waste or intrusion of water into the tanks. Following waste retrieval activities for these tanks, the new transfer lines and auxiliary equipment will be flushed as needed and the equipment reused or disposed of as discussed in Section 3.9.

Any line flushes for the new transfer lines should direct the flush solution to the receiver DSTs. However, because of the physical location of C tank farm at a lower elevation than the DSTs, there will be some line drainback. The holdup for each transfer line is in the 150- to 200-gal. range. This solution would go to the tank just retrieved, unless a valve change could be made to direct the solution to another SST covered by this tank waste retrieval work plan which had not yet completed retrieval.

Flushing of any valve or diversion boxes should not be necessary following retrieval since any such flushing, which is expected to be transferred back to the SST being retrieved, would be expected to be performed before completion of retrieval. Should the situation arise where a valve or diversion box needs to be flushed following retrieval, it is estimated that the flush volume would be in the 100- to 200-gal. range. This solution would go to the tank just retrieved, unless a valve change could be made to direct the solution to another SST covered by this tank waste retrieval work plan which had not yet completed retrieval.

When retrieval activities are completed, the exhauster(s) used will be disconnected for use elsewhere. This will require draining the exhauster seal pot back to the receiver tank for the drain line. Such drainage will be in the 0- to 20-gal. range.

It is currently planned to leave all modified sluicing in-tank equipment (e.g., the transfer pump) in the tank following retrieval. However, in the unlikely event it is necessary to remove such equipment, it may have to be washed down upon removal to remove excess contamination or to reduce exposure for personnel protection. The volume of water expected for such purposes would likely be in the 50- to 200-gal. range.

It is undetermined at this time whether the MARS-S in-tank equipment will remain in the tank or not following retrieval. Reuse of the C-107 MARS-S equipment will be determined following completion of C-107 retrieval. If it is necessary to remove the MARS-S arm from C-107, it may have to be washed down upon removal to remove excess contamination or to reduce exposure for personnel protection. The volume of water expected for such purposes cannot be estimated without operating experience.

Existing risers, pits, and/or caissons associated with the tanks will be isolated following the retrieval activities. These isolation methods are designed to minimize water intrusion to the tank.

In accordance with RPP-13774, disposition of the ex-tank ancillary equipment, including pipelines, will be performed in accordance with a separate component closure activity plan. Flushing of old lines or pits would not be done unless required or permitted by the component closure activity plan. Should such flushing be required or necessary, it would not take place until closure activities were underway, so the impact of any line flush volumes would be accounted for in the closure plan approved tank fill process. See Section 7.1.3.2 for assumptions regarding characterization of residual waste in piping system components.

Following retrieval, it may be necessary to add small (0- to 50-gal.) volumes of water periodically to flush the ENRAF plummet before tank closure. No other activities are envisioned that will purposely add liquids back to a tank once waste retrieval is complete. Should it become necessary to add liquid to a retrieved tank for any reason other than those stated above, Ecology will be notified per existing notification channels.

3.8 INFORMATION FOR NEW ABOVEGROUND TANK SYSTEMS

Transfer system equipment provided for transferring CR Vault sump solutions to C-104 will meet the requirements of WAC 173-303-640 (3). While there are no new aboveground waste tanks or waste treatment systems, the ancillary and containment equipment are considered part of

a tank system in accordance with WAC-173-303-040, "Definitions." The waste tank system equipment is described in Section 3.1.1.

A written integrity assessment, reviewed and certified by an IQRPE, attesting that the transfer-related equipment and associated transfer lines are suitable for use during waste retrieval operations will be prepared in accordance with WAC 173-303-640(3), "Design and Installation of New Tank Systems or Components," and submitted to Ecology following completion of the design and field installation of the WRS. This includes verification that the subject equipment meets the requirements set forth in WAC 173-303-640(3) and WAC 173-303-640(4), "Containment and Detection of Releases." If additional systems or additional transfer line systems are used, each system will be evaluated by an IQRPE. The design provided to the IQRPE for review will include all new or existing transfer systems, structures or components, including secondary containment (e.g., central caisson if used) and leak detection equipment used for waste transfer lines.

The requirements for an IQRPE assessment and the permitting decision logic for new equipment or repairs/upgrades to equipment will be performed in compliance with TFC-ESHQ-ENV_PP-C-11, *Independent Qualified Registered Professional Engineer Assessment Process*.

Risers were reviewed as part of the original SST System Integrity Assessment (RPP-10435). SST system components (e.g., risers, pits, etc.) that were identified as part of the SST system for the original Integrity Assessment are not part of the retrieval system (unless specifically identified as such) and do not require a separate or additional integrity assessment if the function of the equipment doesn't change from its original purpose (e.g., the original purpose of risers is to provide tank access) and changes to the component are not outside the original component design basis and specifications.

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3.9 DISPOSITION OF WASTE RETRIEVAL SYSTEM FOLLOWING WASTE RETRIEVAL

3.9.1 Disposition of New Waste Retrieval System Components

Following completion of waste retrieval, the modified sluicing in-tank equipment will be left in place for disposition during component closure actions. The abovegrade modified sluicing equipment (e.g., transfer lines, portable valve and diversion boxes) will be reused to the extent possible for future waste retrieval activities in the C tank farm. Disposition of the C-107 MARS-S in-tank and abovegrade equipment will be determined following retrieval. Transfer lines and the portable valve and diversion boxes will be flushed to reach acceptable exposure rates for disconnecting and relocating the equipment. Any abovegrade modified sluicing or MARS-S equipment that needs to be removed and is not suitable for reuse will be packaged and disposed of onsite in accordance with the approved waste acceptance criteria for the Hanford Site burial grounds and TFC-OPS-WM-C-10, *Contaminated Equipment Management Practices*. The HIHTLs will be managed in accordance with RPP-12711, *Temporary Waste Transfer Line Management Program Plan*.

3.9.2 Disposition of Existing Ancillary Equipment

Ancillary equipment associated with tanks C-102, C-104, C-107, C-108, and C-112 is limited to waste transfer lines and equipment installed in pits and abovegrade risers. The current status of the ancillary equipment associated with tanks C-102, C-104, C-107, C-108, and C-112 is described in Section 2.6. Any contaminated equipment located within risers that needs to be removed following waste retrieval will be packaged and disposed of onsite in accordance with the approved waste acceptance criteria for the Hanford Site burial grounds and TFC-OPS-WM-C-10.

In accordance with the SST system closure plan (RPP-13774), disposition of the ex-tank ancillary equipment, including pipelines, will be performed in accordance with a separate component closure activity plan. Closure plans will be incorporated into the SST permit.

3.10 AIR MONITORING PLAN

ORP and the TOC, pursuant to federal requirements for protection of their workers, will develop and implement IH monitoring plans for exhauster stack emissions for the retrieval of tanks C-102, C-104, C-107, C-108, and C-112. The plans will be developed and implemented pursuant to the requirements of TFC-PLN-34, *Industrial Hygiene Exposure Assessment Strategy*. The constituents of potential concern (COPCs) for which exhauster stack sampling and analysis will be conducted will be identified in the IH monitoring plans for each tank retrieval. The COPCs identified in the IH monitoring plans will be all or a subset, as determined to be appropriate by the TOC IH, of those constituents listed in RPP-20949, *Data Quality Objectives For The*

Evaluation Of Tank Chemical Emissions For Industrial Hygiene Technical Basis, Table 4-1, developed with input from Ecology and RPP-22491, *Industrial Hygiene Vapor Technical Basis*. No COPC shall be dropped from the Tank Vapor Information Sheet (TVIS) list developed for C-Farm without 90 days prior notification to and approval from Ecology. If ORP notifies Ecology of its desire to cease exhauster stack sampling for a COPC initially identified and listed in an IH monitoring plan and no response is received from Ecology within 90 days, the COPC will be deleted from the IH monitoring plan and sample and analysis activities for that COPC will cease. New COPCs may be added to an IH monitoring plan without notification to or approval from Ecology and without modifying or revising this tank waste retrieval work plan.

The sampling and analysis methods shall be EPA, National Institute for Occupational Safety and Health-approved, or Occupational Safety and Health Administration (OSHA)-approved methods or an equivalent TOC-approved method, as identified in RPP-20949. The exhauster stack samples will be analyzed at the 222-S Laboratory, the Waste Sampling and Characterization Facility, or an equivalent laboratory consistent with the quality assurance/quality control procedures for that laboratory. Further, laboratory analysis data will be kept on file at the laboratory consistent with the laboratory record keeping procedures for that laboratory for a period of not less than 5 years and will be available to Ecology, within 24 hours, upon request.

Ecology and ORP understand and agree that the activities discussed above do not restrict ORP and the TOC from taking any and/or all steps necessary as ORP and the TOC deem appropriate to protect its workforce in response to data and information generated by an IH monitoring plan or incidents as they might arise during waste retrieval. Ecology and ORP also understand and agree that the preceding sampling and analysis discussion is presented to ensure ORP is achieving the agreed to sampling and analysis for the protection of the public and its workers and does not modify the exemption from the requirements of 40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities," and 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities," Subpart CC, granted to ORP under 40 CFR 265.1080(b)(6). Therefore, this discussion does not imply any change to the respective authority of either Ecology or ORP regarding the sampling, analysis, monitoring, and control of airborne emissions from Hanford Site tanks.

4.0 DESCRIPTION OF PLANNED LEAK DETECTION AND MONITORING TECHNOLOGIES

NOTE: Section 4 on leak detection is revised in RPP-22393 Rev 4 to make it consistent with the Section 4 wording in RPP-33116, *241-C-110 Tank Waste Retrieval Work Plan*, Rev 2, which was approved by Ecology on July 3, 2008. The italicized wording at the start of most subsections is provided for consistency with the subsection contents in RPP-33116; however, the Decree establishes the requirements for TWRWP content. Retrieval of C-108 was begun and the majority of the waste in the tank removed under RPP-22393 Revs 3A through 3D. RPP-22393 Rev 4 (and any additional revisions to this work plan) is applicable to the remaining C-108 waste retrieval operations, and to retrieval operations for C-102, C-104, C-107 and C-112.

4.1 EXISTING TANK LEAK MONITORING

This section describes tank leak monitoring activities that have been historically performed or are currently being performed.

Prior to beginning retrieval operations, single-shell tanks are in waste storage mode. The requirements for leak detection while in waste storage mode are provided in OSD-T-151-00031, *Operating Specifications for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection.* After retrieval operations commenced for C-108 the tank entered retrieval mode as described in 4.2. When retrieval operations are ready to commence for C-102, C-104, C-107 or C-112 the tank enters retrieval mode as described in 4.2.

4.1.1 Drywell Monitoring

Identify the number and location of drywells near the subject tank. Identify ongoing routine drywell monitoring activities. (configuration, depth, frequency of and methodology for sampling)

There are five drywells near tank C-102 even though the five drywells are associated with other tanks surrounding tank C-102 (Figure 4-1). The five drywells are 30-03-07, 30-00-03, 30-01-01, 30-05-05, and 30-05-04, with the closest drywell located about 12 ft from tank C-102. Three of the drywells are 100 ft deep and two are 120 ft deep (GJ-HAN-86).

There are eight drywells spaced around tank C-104 that are between 2 and 10 ft from the edge of the tank (Figure 4-1). The eight drywells include 30-04-01, 30-04-02, 30-04-03, 30-05-06, 30-04-04, 30-04-05, 30-04-08, and 30-04-12 (GJ-HAN-87, *Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-104*). Three of the drywells are 50 to 60 ft deep, two drywells are 100 ft deep, and three are 135 to 145 ft deep (GJ-HAN-87).

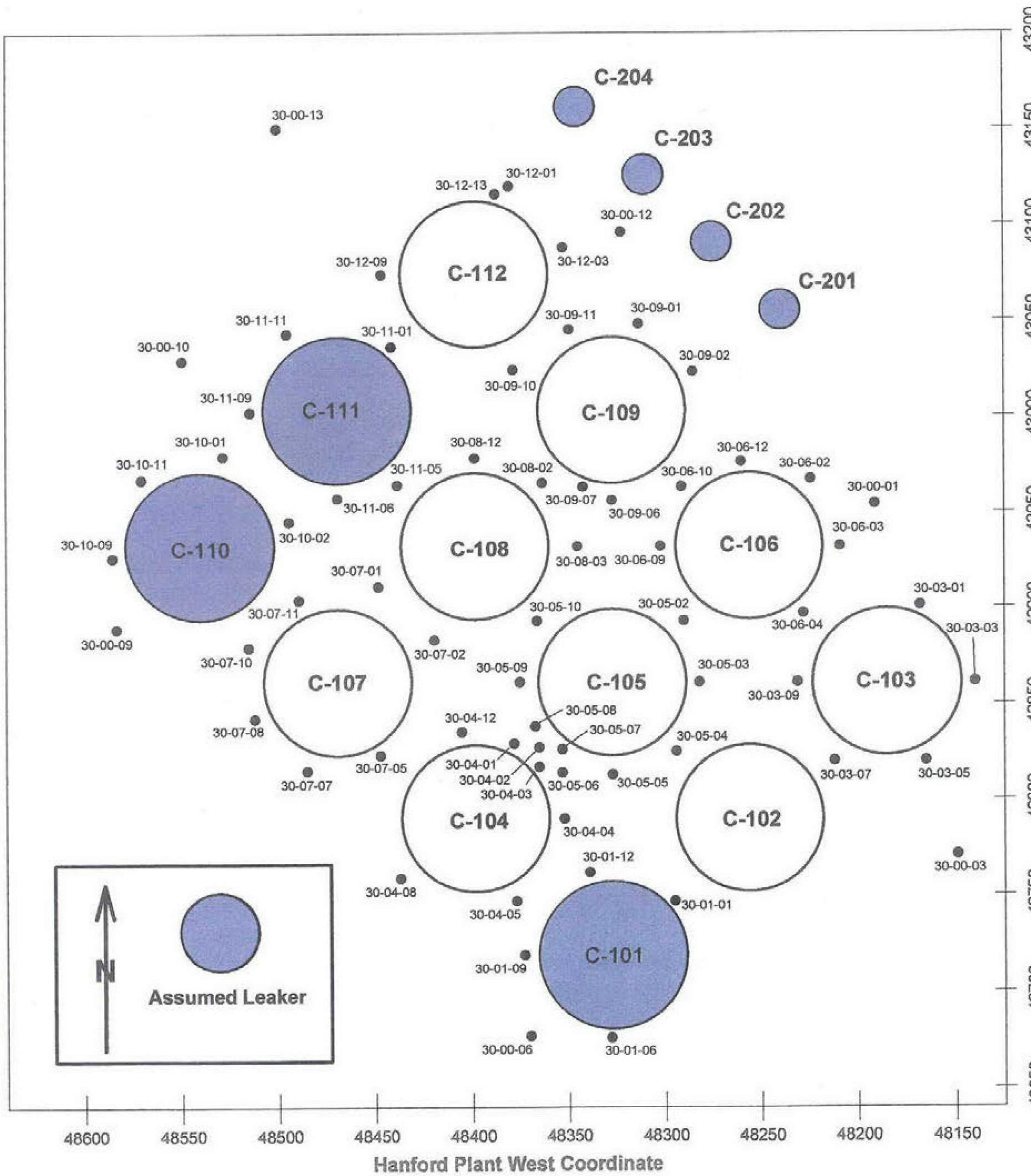
There are seven drywells spaced around tank C-107 that are between 3 and 12 ft from the edge of the tank (Figure 4-1). The seven drywells include 30-07-01, 30-07-02, 30-07-05, 30-07-07, 30-07-08, 30-07-10, and 30-07-11. All seven drywells were drilled to a depth of 100 ft (GJ-HAN-88, *Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-107*).

There are seven drywells spaced around tank C-108 that are between 5 and 13 ft from the edge of the tank. The seven drywells include 30-08-02, 30-08-03, 30-05-10, 30-07-02, 30-07-01, 30-11-05, and 30-08-12. Five of the drywells are 100 ft deep. One drywell is 50 ft deep (30-08-03), although it was drilled to 150 ft, and one drywell (30-05-10) is 135 ft deep (GJ-HAN-90, *Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-108*).

There are seven drywells spaced around tank C-112 that are between 5 and 17 ft from the edge of the tank. The seven drywells include 30-12-13, 30-12-01, 30-12-03, 30-09-11, 30-09-10, 30-11-01, and 30-12-09. Six of the drywells are 100 ft deep and one (30-12-13) is 120 ft deep (GJ-HAN-94, *Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-112*).

For tanks in waste storage mode there is no routine drywell logging performed.

Figure 4-1. Plan View of the C Tank Farm Showing Drywells.



4.1.2 Groundwater Monitoring

Identify the number and location of groundwater monitoring wells associated with the Waste Management Areas (WMA). Summarize current groundwater monitoring activities.

Groundwater monitoring at WMA C was begun in 1990 using four RCRA groundwater monitoring wells constructed in 1989 (299-E27-12, 299-27-13, 299-E27-14, and 299-E27-15). Additional monitoring wells have been added since 1989. A current list of the WMA C groundwater wells can be found in DOE/RL-2009-77. The wells are sampled quarterly to meet prior agreements made with Ecology. Quarterly samples are analyzed at a minimum for anions, cyanide, inductively coupled plasma metals, gross beta, ^{99}Tc, and total uranium, and a low-level gamma scan is performed. Sampling is conducted in accordance with DOE/RL-2009-77 and DOE/RL-2001-49.

The quarterly groundwater monitoring that is currently performed is adequate for the purpose of supplementary data collection during waste retrieval. Ecology is provided quarterly groundwater monitoring sample results in the quarterly and annual groundwater monitoring reports. These reports were previously issued by Pacific Northwest National Laboratory (e.g., results from the groundwater monitoring at the C tank farm for the third quarter of 2006 are reported in PNNL-16349, *Quarterly RCRA Groundwater Monitoring Data for Period July through September 2006*), in 2007 they started being issued by Fluor Hanford.

If a leak is detected during retrieval, groundwater monitoring frequency will be reevaluated in accordance with the regulatory requirements in WAC 173-303, "Dangerous Waste Regulations."

4.1.2.1 Use of Groundwater Monitoring for Retrieval Process Control.

(1) Evaluate the use of appropriately located existing groundwater monitoring wells for retrieval process control.

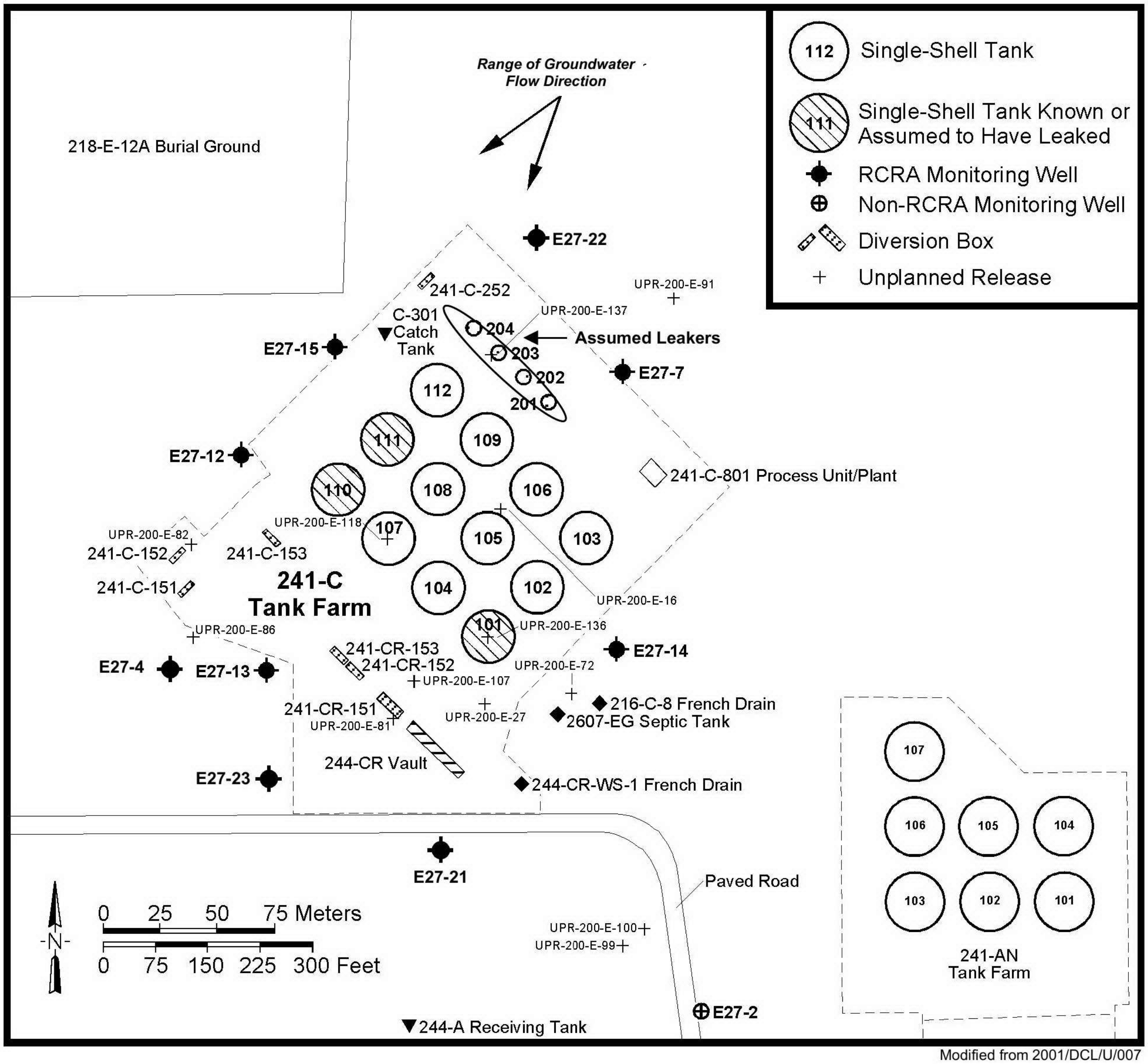
Based on the limitations of flow transport calculations and the time required for a retrieval leak to show up in groundwater samples, groundwater monitoring data will not be used for retrieval process control, but is available, for background reference information only, through the site groundwater monitoring program.

4.1.2.2 Groundwater Sampling Prior to and Following Retrieval.

(2) Ensure that appropriately located existing groundwater monitoring wells will be sampled within a two month period prior to and following the retrieval (quarterly sampling satisfies this requirement).

Quarterly groundwater sampling is performed for the C-farm groundwater monitoring wells. In accordance with 04-TPD-083, "*Agreement on Content of Tank Waste Retrieval Work Plans*" (04-TPD-083 – letter), it was agreed to in writing by ORP, Ecology, and the tank farm contractor that quarterly groundwater sampling satisfies the TWRWP outline requirement C.1.b.(2) (this wording is in italics at the start of Section 4.1.2.2) to take groundwater samples within a 2-month period prior to and following retrieval.

Figure 4-2. Waste Management Area C and Regulated Structures.*^



* Adapted from Figure B.18 in PNNL-14548, 2004, *Hanford Site Groundwater Monitoring for Fiscal Year 2003*, Pacific Northwest National Laboratory, Richland, Washington.

^The most current list of groundwater monitoring wells can be found in DOE/RL-2009-77

4.1.3 Existing Tank Level Monitoring Equipment and Activities

Identify existing level measurement instrumentation in the subject tank and receiver tank. Identify ongoing tank level monitoring activities.

Tanks C-102, C-104, C-107, C-108 and C-112 currently have operable Enraf level gauges installed. The DST receiver tanks also have the same type of level gauge installed. Each DST receiver tank annulus has leak detection devices installed such as conductivity gauges, Enraf level gauges or similar instruments for detection of leaks from the primary tank liner.

The waste levels in tanks C-102, C-104, C-107, and C-112 while in storage mode (and C-108 when it was in storage mode) are monitored for intrusion on a quarterly basis using an ENRAF level gauge (OSD-T-151-00031, *Operating Specifications for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection*). The basis for in-tank leak detection and intrusion monitoring is provided in RPP-9937, *Single-Shell Tank System Leak Detection and Monitoring Functions and Requirements Document*.

The primary level monitoring in the receiver DST is performed as described in OSD-T-151-00031. The annulus leak detector instruments provide indication of tank leaks as described in OSD-T-151-00031.

Level monitoring for the tank receiving the exhauster condensate, if not the SST being retrieved, will be performed as specified in the applicable Ecology approved TWRWP for that tank.

4.2 PROPOSED LEAK DETECTION MONITORING SYSTEM DESCRIPTION

This section provides a description of the leak detection and monitoring (LDM) system that will be deployed at tank s C-102, C-104, C-107, C-112, and the remaining C-108 waste retrieval operations, along with a description of how the system will be operated.

The definition of when a tank is changed from storage mode to retrieval mode is provided in OSD-T-151-00031. A tank is considered to be officially in retrieval status if one of two conditions is met: either waste has been physically removed from the tank by retrieval operations or, preparations for retrieval operations are directly responsible for rendering a primary leak detection or intrusion monitoring device out of service.

When all waste removal operations have been completed, a final waste volume measurement obtained, and all post-retrieval monitoring required by this document completed, the tank retrieval status is maintained but retrieval leak detection is complete and the tank is monitored for intrusion as specified in Section 6.0.

4.2.1 Description of Proposed LDM System Configuration Used During Waste Retrieval

(Physical and Operating)

a. Describe the proposed LDM system configuration to be used during waste retrieval.

The leak detection and monitoring (LDM) method for C-102, C-104, C-107, C-108 and C-112 during retrieval uses deployment of a high-resolution resistivity (HRR) LDM system with drywells and the tank thermocouple as electrodes. The HRR system will be fully implemented administratively as well as physically implemented in the field when used.

Established drywell logging methods were used to survey the drywells surrounding C-108 prior to the start of retrieval, and will be used to survey the drywells surrounding C-102, C-104, C-107 and C-112 before the start of retrieval in these tanks. Drywell monitoring will be used as a backup means of leak detection if the HRR system becomes inoperable. The use of drywell logging as a backup is specified in 4.2.1.1.

Under limited conditions, as specified in 4.2.1.2, SST liquid level measurement may also be used for leak detection and monitoring.

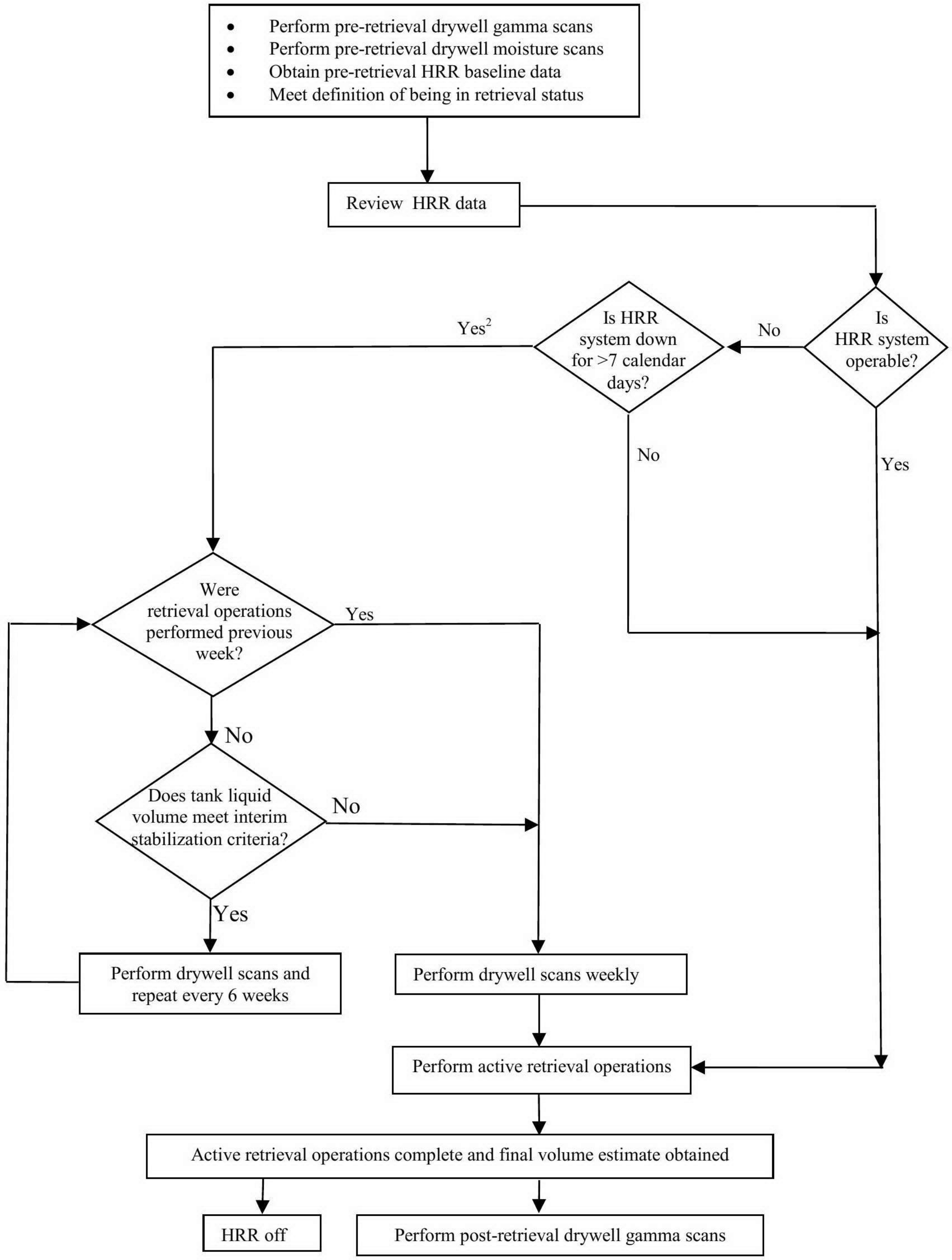
Figure 4-3 is a logic chart showing what leak detection method(s) are used, and when with one exception for C-102. In lieu of weekly moisture logging that is required because the C-102 interstitial liquid volume exceeds the interim stabilization criteria (HNF-EP-0182), HRR may be used for 30 days once a quarter prior to the start of retrieval. Any other changes to leak detection will be approved on a tank-by-tank basis. Details of the methods shown in Figure 4-3 are provided in 4.2.1.1 through 4.2.1.3.

LDM systems consisting of standard leak detection arrangements are used for transfer lines and pits.

The LDM system used for the receiver DST is the same one described in Section 4.1.3.

Any resulting changes to LDM activities described in this TWRWP will be approved by Ecology within 24 hours through the Change Notice form.

Figure 4-3. Leak Detection Methodology for SST Retrieval.[1]



[1]Leak detection using SST level measurement may supersede HRR and drywell monitoring when criteria in 4.2.1.2 are met
[2]Only until HRR back in service

4.2.1.1. Drywell Monitoring. Drywell logging refers to use of moisture gauges and/or gross gamma detectors to monitor soil conditions surrounding the tank for increases in moisture content and/or gamma activity that may be evidence of tank leakage. Drywell logging will be performed as follows:

- Gamma scans will be obtained for each listed drywell prior to initiation of retrieval operations in the tank (already obtained for C-108)
- Moisture scans will be obtained for each listed drywell prior to initiation of retrieval operations in the tank (already obtained for C-108)
- After retrieval operations have been initiated for C-102, C-104, C-107 and C-112, and during the remaining C-108 retrieval operations, drywell logging will only be performed if needed as a backup leak detection method.
- Gamma scans will be obtained for each listed drywell following completion of active retrieval operations in the tank

None of the pre-retrieval C-108 gamma scans showed an unexpected presence of radioactivity in the soil adjacent to the drywell. Should a pre-retrieval gamma scan for C-102, C-104, C-107 or C-112 show an unexpected presence of radioactivity in the soil adjacent to any of the listed drywells, and the unexpected reading is confirmed, the tank leak assessment process in procedure TFC-ENG-CHEM-D-42, *Tank Leak Assessment Process,* would be implemented. Retrieval activities as described in this work plan would not commence until the unexpected reading has been evaluated and shown to not alter the leak status stated in 2.1.3 for the tank whose waste was to be retrieved.

From the start of C-108 waste retrieval activities in December 2006 through the approval date of Revision 4 of this work plan the C-108 drywells listed below were moisture logged on a weekly basis. Current plans for C-102, C-104, C-107 and C-112 include monitoring of the drywells listed below prior to retrieval operations:

- **Tank C-102** – 30-03-07, 30-00-03, 30-01-01, 30-05-05, and 30-05-04
- **Tank C-104** – 30-04-01, 30-04-02, 30-04-03, 30-05-06, 30-04-04, 30-04-05, 30-04-08, and 30-04-12
- **Tank C-107** – 30-07-01, 30-07-02, 30-07-05, 30-07-07, 30-07-08, 30-07-10, and 30-07-11
- **Tank C-108** – 30-08-02, 30-08-03, 30-05-10, 30-07-02, 30-07-01, 30-11-05, and 30-08-12
- **Tank C-112** – 30-12-13, 30-12-01, 30-12-03, 30-09-10, 30-09-11, 30-11-01, and 30-12-09.

There is a potential that access to some drywells may be precluded by the placement of equipment or shielding, restricted due to ALARA (as low as reasonably achievable) concerns, or alterations to the tank farm surface as a part of ongoing waste retrieval activities.

The pre-retrieval and post-retrieval gamma scans will be obtained from near the ground surface to near the bottom of each drywell.

The pre-retrieval moisture scans were obtained from near the ground surface to near the bottom of each drywell for C-108. Pre-retrieval moisture logging for C-108 was performed to provide a baseline for comparison for moisture logging performed during waste retrieval. The pre-retrieval moisture scans will be obtained from near the ground surface to near the bottom of each drywell for C-102, C-104, C-107 and C-112. Pre-retrieval moisture logging will be performed to provide a baseline for comparison should moisture logging be performed for backup leak detection during waste retrieval.

Should moisture logging be necessary during waste retrieval activities, significant increases in soil moisture levels would be followed up by performing a gamma scan to determine if the moisture increase was due to a waste leak. If there is an unexplained increase in soil moisture content observed during moisture logging and access is not practical for any gamma monitoring system, Ecology will be informed and an alternate means of investigation proposed.

Since post-retrieval gamma scans are to be performed following retrieval, there is no need to perform a post-retrieval moisture scan.

Drywell logging, when performed as a backup leak detection method, will monitor specific region(s) of interest for increases in soil moisture (or gamma) content. These may include the interval from above the existing waste surface to below the base of the tank. The depth interval to log when drywell logging is performed as a backup leak detection method will be specified in the process control plan.

Due to operational constraints, required drywell logging may be missed occasionally if it is used as backup to HRR. Ecology will be informed of missed required drywell monitoring.

Pre- and post-retrieval drywell gamma logging and any gamma logging done during retrieval operations may be performed with the radionuclide assessment system (RAS truck), the radionuclide monitoring system (RMS), or the spectral gamma system (SGLS). Moisture logging will be performed with hand-held moisture probes or any of the vehicle mounted systems setup for moisture logging. The following background information describes the drywell logging tools, what they measure, and general measurement capabilities.

The handheld moisture gauge is a commercially available system (model 503DR HYDROPROBE®)[2] designed for manual measurement of in situ moisture content. This unit employs an ^{241}Am/Be neutron source and a neutron detector to measure the neutron flux rate at a given depth in the drywell. A formula is then used to relate the neutron flux rate to volume

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[2] 503DR HYDROPROBE® is a registered trademark of CPN International, Inc., Concord, California.

percent moisture in the soil. Use of the handheld moisture gauge does not require truck access into the tank farm and is more practical for frequent use.

The RAS truck was specifically designed for routine gamma monitoring against the baseline established from the spectral gamma logging system data. The RAS uses a series of three interchangeable NaI(Tl)-based scintillation detectors for measurement over the range from background levels to about 10^5 pCi/g ^{137}Cs. The RAS records counts in specific energy ranges as well as total gamma activity. Although it does not have the energy resolution capability of the spectral gamma logging system, it is mounted on a smaller truck and collects data at a faster rate.

The RMS is a modular, portable logging unit capable of concurrent measurement of gross gamma activity and neutron moisture content. The RMS will have calibrated neutron moisture and gross (total) gamma detectors on a combined probe. It will provide dual data logs over preselected depth intervals in the drywells. The overall size and portability of the RMS will minimize interference with surface equipment, and the capability of collecting both moisture and gamma data in a single log run can result in a significant reduction in the cost of monitoring activities when compared to obtaining separate neutron and gamma logs. The RMS also provides for electronic data recording. When implemented, the RMS may be substituted for the handheld moisture gauge and may also be used in place of truck-mounted logging systems. Drywells with very high gamma activity (none of the seven around tank C-110 are in this category) may still require the use of the high rate logging system that is part of the SGLS, but it is possible that a high rate detector can be developed for the RMS. Development of the RMS is complete but as of mid 2008 it is not yet available for deployment. It is anticipated that the RMS will have a measurement range from background up to 100,000 pCi/g ^{137}Cs and 0 to 25 vol% moisture content.

The SGLS logging system was used to establish baseline conditions in 1995-2000. This logging system is based on a liquid nitrogen cooled high purity germanium detector, which provides excellent gamma energy resolution for identification and quantification of individual radionuclides from background levels (method detection limit about 0.1 pCi/g ^{137}Cs under typical conditions) up to about 10,000 pCi/g ^{137}Cs. A high rate detector with internal and external shields is available to extend the measurement range to about 10^9 pCi/g ^{137}Cs.

The SGLS truck can also be used to operate a neutron moisture logging system, which measures in situ vadose zone moisture over the range of 0 to about 25 vol% moisture content. The neutron moisture logging system uses a similar source-detector relationship as the handheld moisture gauge.

It takes about one shift of operation to obtain moisture logging data from all the drywells around a tank with the hand-held moisture probe. It takes about one shift of operation to obtain RAS data from one drywell.

The handheld moisture gauge will be deployed by qualified personnel in accordance with TO-320-022, *Operate Model 503DR M1 HP-2 or M1 HP-3 Hydroprobe Neutron Moisture Gauge* or TO-320-060, *Operate Model 503DR M1 HP-4 Hydroprobe Neutron Moisture Gauge.*

The logging systems will be deployed by qualified personnel in accordance with the applicable procedures for that equipment.

The results from drywell monitoring, as well as a summary and analysis of this monitoring, including tools used, calibration, boreholes logged, depth of logging, frequency, logging rate, and data analysis will be submitted to Ecology within the retrieval data report in accordance with Appendix I of the HFFACO.

4.2.1.2. Leak Detection Using SST Liquid Level Measurement. SST level measurement data are normally limited during periods when active retrieval operations are not being performed due to the strategy of minimizing liquid in the tank. In addition, because of the dished bottoms of the tanks and the location of the level instrumentation near the side in the C-100 series SSTs, waste levels cannot be measured below approximately 12,000 gal. However, should conditions exist where a continuous liquid surface measurement is available (e.g., a pump fail prior to removing as much liquid as practical from the tank and replacement of the pump cannot occur immediately) this measurement could provide an additional means of leak detection superior to either drywell monitoring or HRR. SST Liquid level measurement can be used for leak detection during waste retrieval under the following conditions:

1. The tank level gauge must be an Enraf level gauge of the type normally used in tank farms

2. There must be a liquid surface under the Enraf plummet, with no part of the plummet touching any waste solids or the tank bottom

3. There are no active retrieval operations being performed

4. The tank is not being actively exhausted except as required to meet air permit requirements*

5. The measured waste level is not increasing, such as can occur if liquid is slowly draining from waste solids above the liquid surface

6. During periods when the Enraf is used for leak detection the Enraf level will be recorded at least once every calendar day.

* If the exhaust is applied to the tank for > 7 days and causes a significant level decrease rate, moisture logging will be evaluated as an alternative leak detection method.

Material balance will not be credited for SST leak detection during waste retrieval activities.

4.2.1.3. High-Resolution Resistivity. HRR will be used for leak detection during the retrieval of the remaining waste in C-108, and the retrieval of waste in C-102, C-104, C-107 and C-112. The equipment operates continuously except when down for repairs, calibrations, electrical outages, or similar reasons. Should a problem occur which renders the HRR leak detection system inoperable, drywell monitoring would be used as a backup means of leak detection, within the conditions specified in Figure 4-3 and 4.2.1.1.

The HRR method uses geophysical resistivity measurements as a means to detect changes in baseline soil moisture levels. The electrical resistivity of the soil around and beneath a waste tank depends on a number of parameters, one of which is moisture content. The leakage of water or tank waste into these sediments changes the soil resistivity. The HRR method detects a potential leak by comparing a present resistivity measurement against a previously obtained baseline measurement. Comparison to a baseline allows the HRR method to discount existing resistivity differences in the soil caused by factors that include conductive structures or prior leaks. Changes in soil moisture from precipitation need to be taken into consideration during monitoring to reduce the potential for making an incorrect leak determination.

HRR data processing, data review, leak evaluation methodology and definitions of anomalies and unexplained anomalies are described in RPP-32477, *High Resolution Resistivity Leak Detection Data Processing and Evaluation Methods and Requirements.* The HRR leak detection requirements in RPP-32477 and in this TWRWP will be implemented in approved procedures by trained and designated personnel prior to the start of waste retrieval operations.

The basic resistivity measurement concept utilizes the existing drywells and/or a tank electrode (normally the tank thermocouple) as measurement electrodes. There are reference transmitter and receiver electrodes located a nominal 1,500 ft or more from the tank farm. Power is applied to a drywell-reference transmitter electrode pair and an amperage measurement obtained. Concurrently, a voltage measurement is obtained at another electrode-reference receiver electrode pair. Soil resistivity is calculated by dividing the voltage measured across the receiver electrode pair by the current measured across the transmitter pair. These measurements are repeated continuously and the subsequent resistivity data analyzed for changes with time.

The HRR data may be reviewed any time. When the system is operating the raw data is normally less than an hour old.

Ecology will be informed via e-mail or phone if an unexplained HRR anomaly exists. The response to an unexplained HRR anomaly is described in 4.6. It is anticipated that three months or more may be needed to analyze all the available data and obtain any needed supporting information to enable resolution of the unexplained HRR anomaly. If, after three months, the unexplained HRR anomaly has not been resolved, Ecology will be consulted as to possible changes in groundwater and analyte monitoring frequency.

A limitation to the HRR system is that it provides data primarily as a two-dimensional diagram from the viewpoint of looking down on the tank. Thus a leak may be detected by HRR, and the general location of the leak around the tank noted, but the actual depth may or may not be able to be discerned from the data.

4.2.1.4. Leak Detection in Transfer Lines and Pits During Waste Retrieval. Supernate will be transferred from the receiver DST and liquid waste and slurry will be transferred from the SST back to the receiver DST using temporary hose-in-hose overground transfer lines and pits. Leak detectors located in pits will be monitored during waste transfers. Leaks may also be detected by monitoring flows and by radiation monitoring of the HIHTL in accordance with the requirements of RPP-13033 and RPP-12711, *Temporary Waste Transfer Line Management Program Plan*. Pits associated with the receiver tank will also be monitored.

Leakage from the primary overground transfer hose (inner hose) will be contained by the secondary confinement system (outer hose). The secondary confinement system is designed to drain any fluid released from the primary hose to a common point for collection, detection, and removal. Leak detection elements are installed in pits at the ends of the transfer lines. If a leak occurs the liquid will contact the detector, which will actuate an alarm and the transfer pumps shut down either automatically or manually.

4.2.1.5 Leak Detection in DST Receiver Tank During Waste Retrieval. The existing leak detection systems in the receiver DST will be utilized as required in OSD-T-151-00031. A leak from the primary vessel of the receiver DST will be detected by leak detection instruments installed in the annulus.

4.2.2 Use of Drywells and Groundwater Wells During and After Waste Retrieval

b. *Describe the proposed use of existing drywells and groundwater monitoring wells during and after waste retrieval operations.*

During remaining waste retrieval operations on C-108, and during waste retrieval on C-102, C-104, C-107 and C-112 existing drywells will be monitored if needed as a backup means of leak detection as described in Section 4.2.1.1.

The post-retrieval gamma scans may be done by any of the gamma logging methods discussed in Section 4.2.1.1 within 6 months following the completion of waste retrieval on the tank.

Groundwater monitoring wells will be sampled and the samples analyzed both during and after waste retrieval operations as described in Section 4.1.2

4.3 RATIONALE FOR SELECTION OF LEAK DETECTION MONITORING TECHNOLOGY

Rationale for selection of LDM technology.

The LDM technology selected for deployment represents the best available technology. The HRR system, as described in Section 4.2.1.3 is believed to provide improved leak detection monitoring over that provided by drywell monitoring.

Pre-retrieval drywell gamma scans are performed to provide an updated baseline for that drywell prior to initiation of waste retrieval activities.

Pre-retrieval drywell moisture logging for C-108 was performed to provide a baseline for that drywell prior to initiation of waste retrieval activities for moisture logging leak detection during waste retrieval activities. Pre-retrieval drywell moisture logging is performed for C-102, C-104, C-107 and C-112 to provide a baseline for that drywell prior to initiation of waste retrieval activities in case moisture logging is required as a backup means of leak detection during waste retrieval activities.

A pre-retrieval HRR baseline is performed since HRR leak detection is based upon observation of resistivity change from an established baseline.

Post-retrieval gamma scans will be obtained for conservatism, to verify there has been no significant change from the pre-retrieval gamma scans.

Use of SST liquid level data for leak detection, when such data are available and obtained under the conditions listed, would provide a leak detection capability exceeding that provided by drywell logging or HRR.

4.4 LEAK DETECTION FUNCTIONS AND REQUIREMENTS

Functions and attendant requirements necessary to support design of proposed LDM system(s). Functions and requirements to be provided at a level-of-detail consistent with a Level 1 specification (see RPP-7825 [S-112 F&R], Section 4 and/or RPP-18811 [C-103/105 F&R]).

This section defines the upper-level functions and corresponding requirements to which the leak detection systems must be designed and operated. The system specification for the C tank farm 100 series tanks will be consistent with this TWRWP. The functions and requirements for LDM are given in Table 4-1.

Table 4-1. Tank C-102, C-104, C-107, C-108 and C-112 Leak Detection and Monitoring Functions and Requirements.

Function	Requirement	Basis	Key Elements
Detect leaks during waste removal from SST	The LDM system shall be capable of detecting liquid waste releases during all waste removal operations.	WAC 173-303	Utilize LDM technologies to detect loss of liquid from a tank; see Section 4.2.1.
Monitor leaks from SST during waste removal	The WRS shall be capable of providing data to support quantifying leak volumes from the tanks in the event a release is detected during waste retrieval operations.	WAC 173-303	Utilize both ex-tank LDM technologies and process data that will allow estimate of leak volume and migration rate to be developed to the extent practical in the event of a leak.
Mitigate leaks during SST waste retrieval	The integrated retrieval and LDM system shall be designed and operated to mitigate leaks as the primary means of minimizing environmental impacts from leaks during waste retrieval if they occur.	WAC 173-303	Leak mitigation strategy described in Section 4.6.
WRS secondary containment and leak detection	For ex-tank equipment and piping, the WRS shall incorporate secondary containment and leak-detection design features in accordance with 40 CFR 265.193 and DOE O 435.1.	40 CFR 265 WAC 173-303 DOE O 435.1 RPP-13033 HNF-SD-WM-TSR-006	Provide for safe and compliant transfer of waste to the receiver DST.

DST = double-shell tank.
LDM = leak detection and monitoring.
WRS = waste retrieval system.

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities."

DOE O 435.1, 2001, *Radioactive Waste Management*.

HNF-SD-WM-TSR-006, 2005, *Tank Farms Technical Safety Requirements*.

RPP-13033, 2005, *Tank Farms Documented Safety Analysis*.

WAC 173-303, "Dangerous Waste Regulations."

4.5 ANTICIPATED TECHNOLOGY PERFORMANCE

Anticipated technology performance capability (discuss deployment, data collected, timeliness of data analysis for process control).

4.5.1 Drywell Monitoring

There is no single value that can be stated as the maximum leak that could go undetected by drywell monitoring for C-102, C-104, C-107, C-108 and C-112.

There are a wide range of variables that influence the effectiveness of drywell monitoring. A Monte Carlo-type analysis of drywell monitoring performance for SST leak detection was prepared that considered the impact of all significant variables (RPP-10413, *Tank S-112 Saltcake Waste Retrieval Demonstration Project Leak Detection, Monitoring, and Mitigation Strategy*, Appendix B). This document provided the results of an in-depth computer analysis that evaluated the variables affecting drywell monitoring performance, varied them over selected ranges and calculated the leak volume which might occur by the time of leak detection. Over 100,000 combinations were analyzed. The following wording on drywell monitoring performance in italics is extracted from RPP-10413.

From Section 5.3 of RPP-10413:

....For slow leak rates ranging from 0.03 gal/hr to 1.44 gal/hr, the travel time and associated leak volumes for a leak originating near a drywell are small. The theoretical leak volume and associated time required to reach a drywell from the center of the tank floor to a drywell (modeled as a 45-foot distance) are larger. Detection of a slow leak from the center of the tank floor with a drywell is unrealistic as the time required for sufficient liquid to leak from the tank and migrate to the drywell is significantly longer than the planned waste retrieval duration. Summary statistics for travel time and total volume leaked under slow leak conditions are shown in Table 5.2 [this is Table 5.2 in RPP-10413, not a table in this work plan]. *The mean values for travel times are 12 days for the 10-foot distance and 2.0 years for the 45-foot distance. The corresponding mean values for volume leaked are 100 gallons and 6,200 gallons. The 5th and 95th percentile values are also listed in Table 5.2. Approximately 90% of the results fall between these two extremes.*

Table 5.2. Summary Statistical Results for Ex-Tank leak Detection Response Time (for leaks less than 1.5 gal/hr)

Parameter	*10-foot Distance (f = 0.75)*	*45-foot Distance (f = 0.50)*
Mean travel time	*12 d*	*710 d (2.0 y)*
Median travel time	*4.8 d*	*290 d (0.80 y)*
5th percentile time	*1.0 d*	*59 d*
95th percentile time	*43 d*	*2,600 d (7.1 y)*
Mean volume leaked	*100 gal*	*6,200 gal*
Median volume leaked	*73 gal*	*4,400 gal*
5th percentile volume	*20 gal*	*1,200 gal*
95th percentile volume	*300 gal*	*18,000 gal*

Notes: The mean value is the sum of the times or volumes divided by the number of trials. The median value is the time or volume is [sic] *the 50th percentile in the cumulative distribution (i.e., half the results lie below the median value). The 5th and 95th percentiles show the range of times or volumes that encompass 90% of the calculated results.*

Additional uncertainty analyses were performed to evaluate a larger range in potential leak rates. Historical leak rates were reviewed and a range in-tank leak rates from 0.03 to 102 gal/hr. To account for the higher probability of a slow leak compared to a fast leak a lognormal distribution was assigned to the leak rate parameter (referred to as the lognormal leak rate model). For this leak range the 95th percentile volume at both the 10-foot and 45-ft distance increased over those shown in Table 5.2. The summary statistics for the larger leak rate range are provided in Table 5.3 [this is Table 5.3 in RPP-10413, not a table in this work plan]*………*

Table 5.3. Summary Statistical Results for Ex-Tank leak Detection Response Time (for large leaks)

Parameter	*10-foot Distance ($f = 0.75$)*	*45-foot Distance ($f = 0.50$)*
Mean travel time	*20 d*	*1,200 d (3.3 y)*
Median travel time	*2.2 d*	*130 d*
5th percentile time	*0.07 d*	*4.1 d*
95th percentile time	*72 d*	*4,400 d (12 y)*
Mean volume leaked	*100 gal*	*6,200 gal*
Median volume leaked	*73 gal*	*4,400 gal*
5th percentile volume	*20 gal*	*1,200 gal*
95th percentile volume	*300 gal*	*18,000 gal*

Notes: The mean value is the sum of the times or volumes divided by the number of trials. The median value is the time or volume is [sic] *the 50th percentile in the cumulative distribution (i.e., half the results lie below the median value). The 5th and 95th percentiles show the range of times or volumes that encompass 90% of the calculated results.*

From Attachment B3 of RPP-10413:

The main text shows stochastic results for two leak-to-drywell distances, 10 ft. and 45 ft. In this appendix, the leak-to-drywell distance (B) is allowed to vary over the bottom and side surfaces of the tank. It will be assumed that a leak could occur anywhere on the sides or bottom of the underground tank. It is further assumed that the sides are more likely locations for the leak. A probability distribution is constructed for B and the distribution of travel times is calculated. Three cases are considered. The first has only one drywell for the tank. The second has two drywells on opposite sides of the tank. The third case has three drywells evenly spread around the tank. As might be expected, as the number of drywells, increases, the mean travel time decreases…..

…The stochastic results for these three cases are summarized in Table B3.1 [this is Table B3.1 in RPP-10413, not a table in this work plan]. *As the number of drywells increases, the moisture travel time and volume leaked decrease….*

Table B3.1 Summary of Stochastic Results

Parameter	***One***	***Two***	***Three***
Mean travel time	*2,670 d*	*650 d*	*234 d*
Median travel time	*716 d*	*144 d*	*54 d*
5th percentile time	*6.6 d*	*3.4 d*	*2.5 d*
95th percentile time	*10,500 d*	*2,5900 d*	*924 d*
Mean volume leaked	*23,100 gal*	*5,620 gal*	*2,030 gal*
Median volume leaked	*11,200gal*	*2,1600 gal*	*795 gal*
5th percentile volume	*105 gal*	*59 gal*	*46 gal*
95th percentile volume	*87,700 gal*	*22,400 gal*	*7,980 gal*

Notes: The mean value is the sum of the times or volumes divided by the number of trials. The median value is the time or volume is [sic] *the 50th percentile in the cumulative distribution (i.e., half the results lie below the median value). The 5th and 95th percentiles show the range of times or volumes that encompass 90% of the calculated results.*

Tank C-102 has five drywells around the tank with the closest one about 12 ft away. From Figure 4-1, it can be seen that there are no drywells located around about half the tank perimeter on the east-southeast side. A re-evaluation of the 95th percentile maximum leak volume that could be spotted for the tank C-102 drywell arrangement is not warranted because a re-evaluation of RPP-10413 will only provide a number, it will not provide additional information on how to minimize a potential leak. The keys to leak mitigation strategy are detailed in Section 4.6.

Drywell logging is a currently deployed technology and has been used for a number of years within the tank farms. Some of the equipment such as the RMS is newly developed, but the basic principles of operation remain the same. It normally requires about a shift to perform handheld moisture logging on all the drywells around a tank, assuming a 15- to 30-ft logging range with data taken every foot. Approximately one shift is required to do a gamma scan with the RAS truck on one drywell, based on a full 75-100-ft scan. If the RAS was used only over the same range as the hand-held moisture logging, more than one drywell could possibly be logged in a shift. Logging a well with the RMS vehicle, when approved for use, should take less time than for the RAS. A full SGLS scan of a single drywell will take a shift. If the SGLS scan was limited to the same depth range as the hand-held moisture monitoring, more than one drywell might be logged in a shift.

The data collected during moisture logging consists of neutron counts at different depths below grade in a drywell. These neutron counts are converted to a soil volume percent water using a formula developed for each source/detector combination. Data may be taken manually or electronically.

The data collected during gamma logging consists of count rates at different depths below grade in a drywell. These counts can be reviewed as a total count rate at that specific depth or for the SGLS converted to a soil radionuclide concentration with a formula developed for each detector. Electronic data are recorded on a storage medium.

Moisture logging data sheets are normally given to data analysis personnel the same or following day from when the logging was performed. In instances such as when logging is done on a day when personnel are normally off, it may be several days before the sheets are reviewed. Following review, operations personnel are notified by data analysis personnel of out of the ordinary readings. This notification will thus usually be 1 to 2 days after the data are taken, but in limited instances may be up to 4 days.

The keys to leak mitigation strategy are detailed in Section 4.6.1.

Data collected with the handheld moisture gauge will be analyzed within a few days. Data collected with the truck-mounted logging system will be analyzed within a few weeks under normal operations.

Due to the uncertainty and variance in the performance of the technology, there is no instantaneous method to measure leak migration rates.

4.5.2 SST Liquid Level Monitoring

Should the conditions listed in 4.2.1.2 be met, SST level monitoring can provide a leak detection capability that exceeds that for either drywell monitoring or HRR. The accepted accuracy of an Enraf gauge is ±0.1 in., or ±275 gal when the reading is taken within the 75 ft. diameter section of the tank. The precision of the gauge is ±0.01 in., or ±28 gal. An Enraf gauge operating on a liquid surface could easily note a decrease in liquid level of less than 275 gal. Such a decrease would not automatically indicate a tank leak. The decrease would need to be evaluated to determine if there were other causes besides a leak.

4.5.3 HRR Leak Detection

During the leak injection test performed in 2006 adjacent to tank S-102 a non-radioactive salt solution was injected into the ground at depth of approximately the base of the tank. The solution for the first test was injected into the soil, and the solution for the nine additional tests injected into the soil wetted by the first test. RPP-30121, *Tank 241-S-102 High-Resolution Resistivity Leak Detection and Monitoring Test Report*, indicates that these 'leaks' were detected 8 of the 10 times, and for those 8 detections the leak volumes at the time of detection were in the nominal range of 100 to 600 gal. RPP-30121 further states that the leak detection capability of the HRR injection test system, based upon all 10 tests, is a volume of 2,100 gal at a 95% confidence interval. This statement is only applicable to the HRR injection test system in the geometry and under the conditions and leak rates tested ('tank' simulated as a 6 inch diameter steel pipe extending downward approximately 100 ft with the leak occurring at a depth of approximately 45 ft., 5 to 20 gal/h leak rates).

It is reasonable to assume that the response for an HRR system deployed around an SST in C-Farm may be somewhat less than that reported in RPP-30121 for the leak injection test setup due to the differences in geometry between the test setup and a 100 Series SST in C-Farm, including the presence of concrete around the steel SST body which may diffuse or hold up leakage. There may also be a slightly lower conductivity for the liquids stored in the C-Farm tanks when compared to the injection test salt solution. Based on past tank leak experience, the rate of an actual tank leak would also likely be less than the range of leak rates tested in the leak injection test. Due to these differences and other limitations preventing direct extrapolation of test results to field deployment for an SST, a quantitative value cannot be stated for the leak detection capability of an HRR system deployed in C-Farm. However, it can be qualitatively stated that based upon experience at the Mock Test Site, the S-102 leak injection test, observation of the response of surface electrodes tested both at S-102 and C-103, and general HRR system operation both in S-Farm and C-Farm it is believed an HRR system deployed in C-Farm should provide leak detection capability better than the calculated drywell monitoring leak detection capability in Section 4.5.1. HRR interrogates the soil around and under a tank. The system sensitivity may decrease somewhat with the distance of an electrode (drywell) from the tank, but resistivity changes were still seen with drywells 100 ft. away from the injection point during the injection testing. With drywell logging, waste liquid likely needs to be less than a foot from the drywell to be detected by moisture monitoring. Gamma monitoring could probably detect a leak when the liquid was 2 to 3 ft. from the drywell, depending upon conditions. With the much larger area interrogated by HRR, HRR is expected to have a much better sensitivity for leak detection when using the drywell-to-tank electrode data upon which the leak injection test conclusions were based. Sensitivity for HRR leak detection using drywell-to-drywell data is less under most conditions than that for drywell-to-tank data, but is still expected to be better than drywell monitoring due to the larger soil volume interrogated by HRR.

The leak detection capability for HRR is also enhanced in comparison to drywell monitoring since it operates on a near continuous basis, except when out of service.

Due to the uncertainty and variance in the performance of the technology, there is no instantaneous method to measure leak migration rates.

The data collected during HRR consist of voltage and amperage readings taken at periodic intervals for all electrode combinations. These are converted into a soil resistivity reading by dividing the voltage by the amperage. The raw data are then processed through software and analyzed for trends that may be indicative of a tank leak. The raw calculated resistivity values can also be reviewed directly without processing.

The HRR data may be reviewed any time by qualified personnel. The raw data available may be an hour or less old. Processed data lags 4 to 6 hr behind the raw data due to the need to wait for a number of data sets to pass to perform spike rejection and filter the data. If the data are reviewed once a day the data used may thus be from less than 1 to 54 hrs old when first reviewed.

4.6 MITIGATION STRATEGY

Mitigation strategy including a response plan to a detected leak (identify responses to various leak rates) including notifications and provisions for obtaining approval of any remedial actions.

4.6.1 Leak Mitigation for Waste Retrieval Tank Leak

The leak mitigation strategy (i.e., reduction of leak loss potential) is to minimize the liquid volume within the tank during waste retrieval operations. Leak minimization for a waste retrieval tank leak will be provided by actions taken during waste retrieval. These include the following:

- The in-tank liquid inventory during waste retrieval will be less than liquid level present in the tank before interim stabilization activities were undertaken.
- Addition of liquid to the retrieval tank is minimized and liquid pools that form are removed as practical.
- Liquid inventories during sluicing retrieval operations will be removed between waste retrieval campaigns. Liquid inventories during heel removal operations will be maintained to the limits specified in the process control plan.
- Waste is retrieved to the extent practical by working from the center of the tank outwards.
- Evaluating HRR system data as specified in Section 4.2.1.3.
- Equipment handling controls are used to minimize the potential for dropping equipment into the tank, which could penetrate the tank bottom during installation.
- Maintaining a benchmark level in the tank. The waste level shall not exceed this benchmark. The benchmark level is defined in the process control plan.

If there is a need to operate the system longer than currently planned to demonstrate the limit of the technology to recover waste that is difficult to retrieve, the basic leak minimization step is still to limit the volume of any free liquid in the tank.

The 'timeliness' of any leak response action is dictated in part by how often the HRR data (or drywell monitoring data when used as a backup means of leak detection), are reviewed. Until a potential leak is noted there is no leak response, only the steps enumerated above to minimize the leak potential and leak volume. Anomalies noted during HRR data review are evaluated for leak potential. When this data review indicates an unexplained anomaly exists that may be caused by a potential tank leak, all liquid additions to the tank are stopped and the leak assessment process is begun.

The leak assessment process steps are:

- Implement TFC-ENG-CHEM-D-42, *Tank Leak Assessment Process*, leak assessment procedure. No specific completion times are stated for the referenced steps in the leak assessment process. Leak assessment steps in TFC-ENG-CHEM-D-42 include:

- **Review available information and identify additional information needs.** Available information includes in-tank and ex-tank measured data (e.g., surface level, flow rate, barometric pressure); tank process history; historical drywell logs; photographs; etc.

- **Develop specific leak and non-leak hypotheses.** Analysts and subject matter experts develop leak and non-leak hypotheses through a concurrence approach.

- **Assess leak probability.** The probability for each leak and non-leak hypothesis is calculated. The probability assessment is reviewed and concurred with by the analysts.

- **Prepare leak assessment report.** The leak assessment report includes the information reviewed, discussion of hypotheses considered, summary of analysts' assessments, summary of mathematical probabilities, and final determination.

- Ecology will be informed within 72 hours that the evaluation process in TFC-ENG-CHEM-D-42 was initiated and that retrieval operations have been suspended to validate if a leak has occurred.

- During the leak assessment process, continue to retrieve liquid from the tank as practical. There is also no timeline for this step; this operation would continue if it was already being performed. If waste retrieval operations were not being performed and there was free liquid in the tank that could be removed, this removal would commence as soon as resources could be assembled to begin pumping, and the route to the receiver DST, and the DST itself, were available and able to accept the transfer.

There is no specific timeline for stopping liquid addition to the tank, it would occur as soon as direction was sent to field personnel to halt liquid addition. This direction would be sent as soon as operations management was notified following receipt of information that showed an unexplained anomaly existed.

The response to a potential leak will be the same regardless of the leak rate.

If the leak assessment concludes that no leak is indicated, waste retrieval operations will resume under normal operating procedures. Should a leak be validated, the operating contractor will notify the appropriate regulatory agencies in accordance with TFC-ESHQ-ENV_FS-C-01, *Environmental Notification*. This includes notification to Ecology pursuant to the requirements of WAC 173-303.

If the event or condition meets one of the occurrence reporting criteria, TFC-OPS-OPER-C-24, *Occurrence Reporting and Processing of Operations Information*, provides a number of steps to follow leading up to the point where the environmental notification procedure TFC-ESHQ-ENV_FS-C-01 is applied. Procedures are in place that direct immediate actions necessary to stabilize the facility/operation to a safe condition and preserve conditions for subsequent investigation (TFC-OPS-OPER-C-24). The applicable steps related to Ecology notification excerpted from TFC-ESHQ-ENV_FS-C-01 include:

- Notify Tank Farm Contractor Environmental personnel of the leak.
- Determine if the spill or release exceeds 40 CFR 302, "Designation, Reportable Quantities, and Notification," reportable quantity for the material.
- Determine if a RCRA contingency plan needs to be implemented.
- Notify Ecology and the Washington State Department of Health if the reportable quantity has been exceeded and/or the RCRA contingency plan has been implemented. (Note: These notifications are performed per specific requirements on a checklist.)

4.6.2 Leak Mitigation for Receiving Tank Leak

The only receiver tank for SST waste is a DST. The primary mitigation strategy for a DST leak is to maintain operable leak detection systems and respond as specified in procedures to potential or confirmed leaks.

The following is a summary of leak mitigation actions for a DST. A more detailed discussion can be found in HNF-3484, *Double-Shell Tank Emergency Pumping Guide*, and RPP-5842, *Time Deployment Study for Annulus Pumping*.

Actions taken in the event of a leak of waste from primary tank piping into the secondary containment system of the DST system or other receiver tank during a waste transfer from an SST to a DST include (1) stopping the flow of waste into the tank system (stopping the transfer), (2) pumping waste in the primary tank to another DST until the liquid level in the secondary containment is no longer increasing, and (3) removing the waste from the secondary containment system as soon as practicable. Tanks that develop leaks at or near the tank bottom may also require salt well jet pumping to remove trapped liquids from between solid layers in the tank.

The response to a DST leak would be the same regardless of whether the leak was due to a transfer leak into the annulus or a leak of the DST primary tank. Notifications are performed per specific checklist requirements and transmitted to the listed parties no later than noon of the next business day.

The following specific conditions associated with DST leak detection that require Ecology notification are excerpted from TFC-ESHQ-ENV_FS-C-01:

- Leak detection equipment preventive maintenance or functional testing that will exceed 24 hours downtime.
- Leak detection equipment repair that will require more than 90 days to complete.
- Annulus leak detector alarms that are not due to operational activities; intrusion caused alarms that do not clear within four hours of annunciation must be reported.
- Operating annulus continuous air monitor readings that equal or exceed the continuous air monitor alarm setpoint, and are not due to atmospheric radon or its decay products, or not due to operational activities (e.g., annulus contamination due to vacuum imbalance between annulus and primary tank ventilation system or other operational activity).

The above leak detection and mitigation systems are approved and implemented through the DST RCRA permitting process.

4.6.3 Leak Mitigation for Transfer Line Leak

Transfer line leakage occurring near the DST would likely drain to the DST receiver tank. All other transfer line leakage will drain back to either the SST being retrieved or a containment structure on the transfer line. Leakage to the containment structure is transferred to the SST being retrieved. Response to transfer leak detection alarms is performed per procedure (procedures for waste transfer will be developed before waste retrieval operations).
Leak detection is performed in a similar manner to, and response is similar to that for, existing tank farm transfers. There is nothing unique to the tank waste retrieval leak detection system logic when compared to existing tank farms transfer leak detection. Leak mitigation is provided by the design of equipment that channels all leakage into an outer encasement that drains to an alarmed location and a collection tank. The transfer is shut down when the alarm occurs.

Should a leak be detected in the aboveground diversion boxes or pits, the waste transfer pumps would be shut down and the leakage would be transferred to the SST being retrieved using the sump pump. Leaks within one of the sluicer boxes will result in pump shutdown with leakage draining to the SST. Leaked waste will be returned to the SST being retrieved instead of the DST receiver tank because the elevation of the receiver DST farms is higher than that at the C tank farm and wastes leaked to the secondary containment of the transfer lines would drain to the containments at the C tank farm, and leaked wastes would not be transferred to the DST through a transfer system with unknown or questionable integrity. The leaks would be repaired or the leak location bypassed before resuming waste retrieval operations.

Should a visible (aboveground) leak or release be detected during waste retrieval operations, any transfers in progress would be stopped immediately and response actions defined in RPP-27869, *Building Emergency Plan for Tank Farms*, would be implemented. A visible leak or spill would only occur as a result of an accident or equipment failure. RPP-27869 identifies the facility hazards, including hazardous materials, and defines the facility-specific emergency planning and response. The emergency plan also describes incident response actions including the initial response actions to immediately protect the health and safety of persons in the affected area, determining if emergency notification is necessary, and taking steps necessary to ensure that a secondary release, fire, or explosion does not occur. The response actions also include steps taken to collect and contain released waste per the regulatory requirements of WAC 173-303.

5.0 REGULATORY REQUIREMENTS IN SUPPORT OF RETRIEVAL OPERATIONS

Retrieval of waste from the C-Farm SSTs will be performed under the requirements of the Decree, *Atomic Energy Act of 1954*, RCRA, Chapter 70.105 RCW and its implementing regulations, and WAC-173-303. The SSTs do not provide secondary containment and are not compliant with RCRA and Chapter 70.105 RCW interim facility standards of Subpart J of 40 CFR 265. The SSTs are currently authorized to continue operations under Chapter 70.105 RCW pending closure in accordance with WAC 173-303-610, "Closure and Post-Closure," under the authority of the HFFACO Milestone M-45-00, "Complete Closure of all Single Shell Tanks Farms." Except as otherwise modified by HFFACO Milestone M-45-00, DOE conducts day-to-day operations of the SSTs in accordance with the interim facility standards established in WAC-173-303-400(3), "Interim Status Facility Standards." WAC 173-303-400(3) incorporates by reference the interim status performance standards set forth by the EPA in 40 CFR 265. Additionally, the SSTs are governed by federal regulations promulgated under the authority of the *Atomic Energy Act of 1954* and various DOE directives incorporated into the contract between ORP and the TOC (DE-AC27-08RV14800 for current TOC). These requirements are implemented through operating plans and procedures by the TOC.

Interim status facility standards in WAC 173-303-400(3)(a) incorporate, by reference, the interim status standards set forth by EPA in 40 CFR 265 Subpart J for tank systems. Elements of the interim status standards relevant to the WRS along with the WRS features and/or operating plans and procedures are summarized in Table 5-1.

If necessary, DOE will seek approval to retrieve waste that could contain polychlorinated biphenyls from tanks C-102, C-104, C-107, C-108, and C-112 using supernate from the receiver DST and transfer the resulting slurry to the respective receiver DST from EPA before initiating waste retrieval operations. DST supernate is classified as polychlorinated biphenyl remediation waste in accordance with Ecology et al. (2000), *Framework Agreement for Management of Polychlorinated Biphenyls (PCBs) in Hanford Tank Waste*. Because the DST supernate is polychlorinated biphenyl remediation waste, the retrieval of waste from SSTs, when using DST supernate, requires a Risk-Based Disposal Approval, approved by EPA, pursuant to the *Toxic Substances Control Act of 1976.*

The ventilation system(s) used during waste retrieval operations are designed to pass air through the tank, thereby reducing condensation and fog within the tank. The ventilation systems required by Washington State Department of Health include a heater, prefilter, demister, two high-efficiency particulate air filters and test sections, exhaust fan, and stack. Details of the ventilation systems are provided in *00-05-006, Hanford Site Air Operating Permit,* as amended and succeeded.

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval. (9 Sheets)

Regulation	Requirement	Compliance Method
265.15 [WAC 173-303-320], General Inspection Requirements	(a) The owner or operator must inspect his facility for malfunctions and deterioration, operator errors, and discharges (b) The owner or operator must develop and follow a written schedule for inspecting all monitoring equipment, safety and emergency equipment, security devices, and operating and structural equipment that are important to preventing, detecting, or responding to environmental or human health hazards. (c) The owner or operator must remedy any deterioration or malfunction of equipment or structures which the inspection reveals on a schedule which ensures that the problem does not lead to an environmental health hazard. (d) The owner or operator must record inspections in an inspection log or summary.	RPP-16922, Section 10, contains the Interim Status inspection schedule for both the SST and DST systems. The inspection requirements are implemented through Operator Rounds and Shift Office tickle files. Deficiencies discovered by operators are entered into the Problem Evaluation Request system and resolved through the Tank Farm Contractor work control process contained in TFC-OPS-MAINT-C-01.
265.16 [WAC 173-303-330], Personnel Training	(a) Facility personnel must successfully complete a program of classroom instruction or on-the-job training that teaches them to perform their duties in a way that ensures the facility's compliance with the requirements of this part. (b) Facility personnel must successfully complete the program required in paragraph (a) of this section within six months after the date of their employment or assignment to a facility, or to a new position at a facility, whichever is later. Employees hired after the effective date of these regulations must not work in unsupervised positions until they have completed the training requirements of paragraph (a) of this section. (c) Facility personnel must take part in an annual review of the initial training required in paragraph (a) of this section (d) The owner or operator must maintain records at the facility (e) Training records must be kept until closure of the facility	TFC-PLN-07 contains the training requirements for tank farm workers. Completion of the requirements is recorded in the ITEM. ITEM records are also used to support regulatory agency inquiry during compliance inspections. Tank farm employees who enter the TSD portion of the facility also complete, at a minimum, 24-hour hazardous waste worker training. Employees who may come in contact with tank waste complete the 40-hour hazardous waste worker training. Both groups complete annual 8-hour hazardous waste worker refresher training.
Subpart D [WAC 173-303-350] [WAC 173-303-360], Contingency Plan and Emergency Procedures	265.51 [WAC 173-303-350 (1)]: Each owner or operator must have a contingency plan. 265.52 [WAC 173-303-350 (2) and (3)]: (a) The contingency plan must describe the actions facility personnel must take in response to fires, explosions, or any unplanned sudden or non-sudden release of hazardous waste or hazardous waste constituents to air, soil, or surface water	The Tank Farm Contingency Plan, which supports both the SST and DST systems, is contained inRPP-27869. Supporting the contingency plan are the abnormal operating procedures and the emergency response procedures. Required notifications are contained in TFC-ESHQ-ENV_FS-C-01.

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval. (9 Sheets)

Regulation	Requirement	Compliance Method
	(b) If the owner or operator has already prepared a Spill Prevention, Control, and Countermeasures (SPCC) Plan or some other emergency or contingency plan, he need only amend that plan to incorporate hazardous waste management provisions. (c) The plan must describe arrangements agreed to by local police departments, fire departments, hospitals, contractors, and State and local emergency response teams. (d) The plan must list names, addresses, and phone numbers of all persons qualified to act as emergency coordinator (e) The plan must include a list of all emergency equipment at the facility (f) The plan must include an evacuation plan for facility personnel 265.53 [WAC 173-303-350 (4)]: A copy of the contingency plan must be maintained at the facility. 265.54 [WAC 173-303-350 (5)]: A contingency plan must be reviewed, and immediately amended, if necessary, whenever: (a) Applicable regulations are revised (b) The plan fails in an emergency (c) The facility changes (d) The list of emergency coordinators changes (e) The list of emergency equipment changes 265.55 [WAC 173-303-360 (1)]: At all times, there must be at least one employee either on the facility premises or on call with the responsibility for coordinating all emergency response measures. 265.56 [WAC 173-303-360 (2)]: (a) Whenever there is an imminent or actual emergency situation, the emergency coordinator must immediately: (1) Activate internal facility alarms or communication systems (2) Notify appropriate State or local agencies (b) Whenever there is a release, fire or explosion, the emergency coordinator must immediately identify the character, exact source, amount, and real extent of any released hazard. (c) The emergency coordinator must assess possible hazards to human health or	The contingency plans are maintained in the Waste Feed Operations and the Closure Project shift office. The on-duty Shift Manager serves as the Building Emergency Director. Emergency pumping of the DST is guided by emergency pumping guide HNF-3484. The Building Emergency Plan is maintained and updated as required by the Waste Feed Operations Support group.

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval. (9 Sheets)

Regulation	Requirement	Compliance Method
	the environment (d) If the emergency coordinator determines that the facility has had a release, fire, or explosion which could threaten human health, or the environment, outside the facility, he must report his findings. (e) The emergency coordinator must take all reasonable measures necessary to ensure that fire, explosions, and releases do not occur, recur, or spread to other hazardous waste at the facility (f) If the facility stops operations in response to a fire, explosion or release, the emergency coordinator must monitor for leaks, pressure buildup, gas generation, or ruptures in valves, pipes, or other equipment, wherever this is appropriate (g) Immediately after an emergency, the emergency coordinator must provide for treating, storing, or disposing of recovered waste, contaminated soil or surface water, or any other material that results from a release, fire, or explosion (h) The emergency coordinator must ensure that no waste that may be incompatible with the released material is treated, stored, or disposed of until cleanup procedures are completed and all emergency equipment listed in the contingency plan is cleaned and fit for its intended use before operation is resumed (i) The owner or operator must notify the Regional Administrator, and appropriate State and local authorities, that the facility is in compliance with paragraph (h) before operations are resumed (j) The owner or operator must note in the operating record the time, date, and details of any incident that requires implementing the contingency plan. Within 15 days after the incident, submit a written report on the incident to the Regional Administrator.	

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval. (9 Sheets)

Regulation	Requirement	Compliance Method
265.73 [WAC 173-303-380], Facility Recordkeeping	(a) The owner or operator must keep a written operating record	The written operating record for tank farms consists of the following: • Completed operator rounds • Shift Manager log books • Completed corrective maintenance and preventative maintenance procedures and packages
265.191, Assessment of existing tank systems integrity	(a) For each existing tank system that does not have secondary containment meeting the requirements of 265.193, the owner or operator must determine that the tank system is not leaking or is unfit for use. (b) This assessment must determine that the tank system is adequately designed and has sufficient structural strength and compatibility with the waste(s) to be stored or treated to ensure that it will not collapse, rupture, or fail. (d) If, as a result of the assessment conducted a tank system is found to be leaking or unfit for use, the owner or operator must comply with the requirement of 265.196.	(a) and (b): RPP-10435 prepared and submitted under HFFACO Milestone M-23-24. (d) HFFACO M-45 series milestones
265-192, Design and Installation of New Tank Systems or Components	(a) Owners or operators of new tank systems or components must ensure that the foundation, structural support, seams, connections, and pressure control (if applicable) are adequately designed and that the tank system has sufficient structural strength, compatibility with the waste to be stored or treated, and corrosion protection so that it will not collapse, rupture, or fail. The owner or operator must obtain a written assessment, reviewed and certified by an independent, qualified, registered professional engineer attesting that the system has sufficient structural integrity and is acceptable for the storing and treating of hazardous waste. (b) The owner or operator of a new tank systems must ensure that proper handling procedures are adhered to in order to prevent damage to the system during installation. Prior to covering, enclosing, or placing a new tank system or component in use, an independent, qualified installation inspector or an independent, qualified, registered professional engineer, either of whom is trained and experienced in the proper installation of tank systems, must inspect the system or component. (c) New tank systems or components and piping that are placed underground	The HIHTL design and installation is verified and certified by an IQRPE. Aboveground retrieval systems are verified and certified by an IQRPE (e.g., RPP-16666). System design and IQRPE certification ensure that parts (a), (b), (c), (d), and (e) are met. Cathodic protection is not installed on the HIHTL. **Note:** The 241-C-102 and 241-C-104 concrete pits are not fully compliant with 40 CFR 265.193 and WAC 173-303-640 secondary containment standards and cannot be certified by an IQRPE pursuant to 40 CFR 265.192 or WAC 173-303-640. The alternative design and operating practices, together with location characteristics are as effective as secondary containment because the concrete pits have installed leak detection

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval. (9 Sheets)

Regulation	Requirement	Compliance Method
	and that are backfilled must be provided with a backfill material that is a noncorrosive, porous, homogeneous substance that is carefully installed so that the backfill is placed completely around the tank and compacted to ensure that the tank and piping are fully and uniformly supported. (d) All new tanks and ancillary equipment must be tested for tightness prior to being covered, enclosed, or placed in use. (e) Ancillary equipment must be supported and protected against physical damage and excessive stress due to settlement, vibration, expansion or contraction (f) The owner or operator must provide the type and degree of corrosion protection necessary to ensure the integrity of the tank system during use of the tank system. The installation of a corrosion protection system that is field fabricated must be supervised by an independent corrosion expert to ensure proper installation (g) The owner or operator must obtain and keep on file at the facility a written statement by those persons required to certify the design of the tank system and supervise the installation of the tank system in accordance with the requirements of this section to attest that the tank system was properly designed and installed and that repairs were performed. These written statements must also include the certification statement.	systems that will terminate a waste transfer upon detection of a leak, have a method for removal of any waste or liquid that enters the pit, and have sufficient volume such that they will contain, without overflowing the pit, any leaked waste resulting from transfer line hold-up drainage and pump operation from the time of detection to time of automatic or operator induced shutdown. The pits will not be upgraded to meet the secondary containment standards and will not be inspected by, or certified by, an IQRPE. An IQRPE will certify the leak detection operability criteria have been met before retrieval begins.
265.193, Containment and Detection of Releases	(a) In order to prevent the release of hazardous waste or hazardous constituents to the environment, secondary containment must be provided (b) Secondary containment must be: (1) Designed, installed, and operated to prevent any migration of waste or accumulated liquid out of the system to the soil, ground water, or surface water at any time during the use of the tank system (2) Capable of detecting and colleting releases and accumulated liquids until the collected liquid can be removed. (c) To meet the requirements of paragraph (b) of this section, secondary containment must be at a minimum: (1) Constructed of or lined with materials that are compatible with the waste(s) to be placed in the tank system and must have sufficient strength and thickness to prevent failure due to pressure gradients,	The retrieval system equipment is designed with compliant secondary containment. Design documentation is available for inspection.

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval. (9 Sheets)

Regulation	Requirement	Compliance Method
	physical contact with the waste to which it is exposed, climatic conditions, the stress of installation, and the stress of daily operation. (2) Placed on a foundation or base capable of providing support to the secondary containment system and resistance to pressure gradients above and below the system and capable of preventing failure due to settlement, compression, or uplift. (3) Provided with a leak-detection system that is designed and operated so that it will detect the failure of either the primary and secondary containment structure or any release if hazardous waste or accumulated liquid in the secondary containment system within 24 hours, or at the earliest practicable time if the existing detection technology or site conditions will not allow detection of a release within 24 hours. (4) Sloped or otherwise designed or operated to drain and remove liquids resulting from leaks, spills, or precipitation. Spilled or leaked waste and accumulated precipitation must be removed from the secondary containment system with 24 hours, or in as timely a manner as is possible to prevent harm to human health or the environment, if removal of the released waste or accumulated precipitation cannot be accomplished within 24 hours. (d) Secondary containment for tanks must include one or more of the following devices; (1) A line (external to the tank) (2) A vault (3) A double-walled tank (4) An equivalent device as approved by the Regional Administrator. (e) [Applies to the design of external liners, vaults, and double-walled tanks.] (f) Ancillary equipment must be provided with full secondary containment except for: (1) Aboveground piping (exclusive of flanges, joints, valves, and connections) that are visually inspected for leaks on a daily basis (2) Welded flanges, welded joints, and welded connections that are visually inspected for leaks on a daily basis (3) Sealless or magnetic coupling pumps and sealless valves that are	

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval. (9 Sheets)

Regulation	Requirement	Compliance Method
	visually inspected for leaks on a daily basis (4) Pressurized aboveground piping systems with automatic shutoff devices that are visually inspected for leaks on a daily basis.	
265.194, General Operating Requirements	(a) Hazardous wastes or treatment reagents must not be placed in a tank system if they could cause the tank, its ancillary equipment, or the containment system to rupture, leak, corrode, or otherwise fail. (b) The owner or operator must use appropriate controls and practices to prevent spills and overflows from tank or containment systems. They include at a minimum: (1) Spill prevention controls (2) Overfill prevention controls (3) Maintenance of sufficient freeboard in uncovered tanks to prevent overtopping by wave or wind action or by precipitation	Control of the waste retrieval process is defined in the process control plan for each retrieval: (1) System design. (2) The receiving DST has primary tank level instrumentation which is monitored during transfers. (3) Not applicable.
265.195, Inspections	(a) The owner or operator must inspect, where present, at least once each operating day: (1) Overfill/spill control equipment (2) The aboveground portions of the tank system, if any, to detect corrosion or release of waste (3) Data gathered from monitoring equipment and leak-detection equipment (e.g., pressure and temperature gauges, monitoring wells) to ensure that the tank system is being operated according to its design (4) The construction materials and the area immediately surrounding the externally accessible portion of the tank system including secondary containment structures to detect erosion or signs of release of hazardous waste (b) The owner or operator must inspect cathodic protection systems, if present, according to, at a minimum, the following schedule to ensure that they are functioning properly (1) the proper operation of the cathodic protection system must be confirmed within six months after initial installation and annually thereafter (2) All sources of impressed current must be inspected and/or tested, as	RPP-16922, Section 10, contains the interim status inspection requirements for the tank farms. The inspection requirements are implemented through Operator Round Sheets. Visual inspection of piping components is not practical due to the presence of shielding; potential leaks are indicated by instrumentation. Visual inspections of shielded secondary containment systems for aboveground piping components are performed during operator rounds. Inspection and verification of operation of the cathodic protection systems is accomplished through Tank Farm Contractor approved procedures. The completed cathodic protection procedures and operator round sheets are part of the written operating record.

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval. (9 Sheets)

Regulation	Requirement	Compliance Method
	appropriate, at least bimonthly (c) The owner or operator must document in the operating record of the facility an inspection of those items *(above)*	
265.196 [WAC 173-303-400 (3)(c)(vii)], Response to leaks or spills and disposition of leaking or unfit-for-use tank systems	A tank system or secondary containment system from which there has been a leak or spill, or which is unfit for use, must be removed from service immediately, and the owner or operator must satisfy the following requirements; (a) Cessation of use; prevent flow or addition of wastes (b) Removal of waste from tank system or secondary containment system (c) Containment of visible releases to the environment (d) Notifications, reports	Response to leak or spills is defined in Section 4.0
WAC 173-303-283 (3), Performance standards	The owner/operator must design, construct, operate, or maintain a dangerous waste facility that to the maximum extent practical given the limits of technology prevents: (a) Degradation of ground water quality; (b) Degradation of air quality by open burning or other activities; (c) Degradation of surface water quality; (d) Destruction or impairment of flora and fauna outside the active portion of the facility; (e) Excessive noise (f) Conditions that constitute a negative aesthetic impact for the public using rights of ways, or public lands, or for landowners of adjacent properties; (g) Unstable hillsides or soils as a result of trenches, impoundments, excavations, etc.; (h) The use of processes that do not treat, detoxify, recycle, reclaim, and recover waste material to the extent economically feasible; and (i) Endangerment of the health of employees, or the public near the facility.	The following plans and procedures and their implementation provide the preventative measures required: (a) Groundwater monitoring plan (PNNL-13024). (b) No open burning is allowed. (c) Berms and gutters are in place to prevent surface runoff and surface run-on. (d) No destruction or impairment of flora and fauna occur outside of the tank farms. (e) Noise is monitored per TOC procedures. (f) The tank farms are within the dangerous waste facility (i.e., Hanford site). (g) Appropriate permits are obtained before excavation work is started. No excavation work is associated with tank waste retrieval. (h) The waste retrieval process is designed, constructed and will be operated to treat and recover waste to the limits of

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval. (9 Sheets)

Regulation	Requirement	Compliance Method
		technology in accordance with HFFACO milestone M-45-00 (see Section 3.4). (i) The public is protected by the NOC per WAC 173-303-400 & 460. Workers are protected per TFC-PLN-43.
WAC 173-303-400, Interim Status Facility Standards	Incorporates by reference 40 CFR 265 with the exception of 265.1 (c)(4), 265.149-150 and 265.430. Replaces federal terms in 40 CFR 265 (i.e., regional administrator, hazardous) with state terms (i.e., department, dangerous)	

Note: Documents references information is provided in Section 9.0 of this document.

DST = double-shell tank.
HFFACO = *Hanford Federal Facility Agreement and Consent Order*.
HIHTL = hose-in-hose transfer line.
IQRPE = independent, qualified, registered professional engineer.
ITEM = Integrated Training Electronic Matrix.
NOC = notice of construction.
SST = single-shell tank.
TOC = tank operations contractor
TSD = treatment, storage, and/or disposal.

6.0 PRELIMINARY ISOLATION EVALUATION

This section provides a preliminary isolation evaluation for tanks C-102, C-104, C-107, C-108, and C-112. Intrusion prevention measures were completed in the 1980s for these tanks. The identification of tank penetrations and methods used to isolate intrusion pathways is described in Section 2.0. Isolation details for intrusion measures that have been completed for the tanks are provided on the following drawings:

- H-2-73338, *Piping Waste Tank Isolation C-Tank Farm Plot Plan*, Sheet 1
- H-2-73342, *Piping Waste Tank Isolation TK 241-C-102*, Sheet 1
- H-2-73344, *Piping Waste Tank Isolation TK 241-C-104*, Sheet 1
- H-2-73347, *Piping Waste Tank Isolation TK 241-C-107*, Sheet 1
- H-2-73348, *Piping Waste Tank Isolation TK 241-C-108*, Sheet 1
- H-2-73351, *Piping Waste Tank Isolation TK 241-C-112*, Sheet 1.

Installation of waste retrieval equipment in tanks C-102, C-104, C-107, C-108, and C-112 will involve placement of equipment through new or existing tank risers. Following completion of waste retrieval, the in-tank equipment may be removed or may be left in place for disposition during tank closure activity actions. New isolation drawings or modifications to existing drawings will be prepared to define methods for isolating potential intrusion pathways following completion of waste retrieval. Intrusion monitoring will be conducted per OSD-T-151-00031 until specific post-retrieval monitoring requirements are defined. Pre-retrieval isolation is discussed in Section 2.6.

7.0 PRE-RETRIEVAL RISK ASSESSMENT

This section provides long-term human health risk information to support operational decisions in the event a leak is detected during waste retrieval operations for tanks C-102, C-104, C-107, C-108, and C-112. The need to consider long-term human health impacts in developing tank waste retrieval work plans was established in the HFFACO M-45 milestone series through Change Request M-45-04-01.

According to Appendix I of the HFFACO and the Decree, the information provided in the work plans will include the following:

> *A pre-retrieval risk assessment of potential residuals, consideration of past leaks, and potential leaks during retrieval, based on available data and the most sophisticated analysis available at the time. The purpose of this risk assessment is to aid operational decisions during retrieval activities. This risk assessment will not be used to make final retrieval or closure decisions. The risk assessment will contain the following, as appropriate:*

- *Long-term human health risk associated with potential leaks during retrieval and potential residual waste after completion of retrieval:.*
  - *Potential impacts to groundwater, including a waste management area (WMA)-level risk assessment.*
  - *Potential impacts based on an intruder scenario.*
- *Process management responses to a leak during retrieval and estimated potential leak volume.*
- *The pre-retrieval risk analysis will be based on the following criteria:*
  - *Using the WMA fenceline for point of compliance.*
  - *Identify the primary indicator contaminants (accounting for at least 95% of impact to groundwater risk) and provide the incremental lifetime cancer risk (ILCR) and hazard index (HI).*
  - *Using ILCR and HI for the industrial and residential human scenarios as the risk metric.*
  - *Calculated concentration(s) of primary indicator contaminant(s) in groundwater (mg/L and pCi/L).*

The risk information provided in this section was developed to meet the requirements identified in HFFACO Appendix I. Information is provided for two main categories of impacts: (1) long-term human health risk associated with use of groundwater, and (2) long-term human health risk associated with inadvertent post-closure human intrusion. Uncertainty or sensitivity evaluations of the impact of constituent concentration variability will be provided in the closure plan risk assessment and the retrieval data report.

Groundwater pathway impacts are discussed in Section 7.1. Inadvertent intruder impacts are discussed in Section 7.2. Calculation detail is provided in RPP-22392, *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan.*

7.1 GROUNDWATER PATHWAY IMPACTS

The groundwater pathway impacts evaluation emphasized the development of a set of graphical tools to provide a basis for making informed decisions in the event a leak is detected or unexpected retrieval conditions arise during waste retrieval operations. The format used for the retrieval leak impact graphs was developed with Ecology during a joint workshop on March 31, 2004. The graphs are tank-specific and are intended to provide a means to rapidly convert retrieval leak monitoring data into a rough approximation of potential groundwater pathway impacts for a particular retrieval leak.

The methodology used to develop the retrieval leak impact graphs is described in Section 7.1.1. Tank-specific retrieval leak impact results are discussed in Section 7.1.2. Retrieval leak impact graphs for the individual tanks are provided in Appendix A through Appendix E. A WMA-level perspective on groundwater pathway impacts is provided in Section 7.1.3 to help place the potential retrieval leak impacts from the individual tanks into the context of the potential impacts for the C tank farm as a whole.

7.1.1 Retrieval Leak Evaluation Methodology

The retrieval leak graphs were developed using the following methodology:

- Focus on potential long-term groundwater pathway human health risk at the downgradient tank farm fenceline
- Use radiological incremental lifetime cancer risk (ILCR) and noncarcinogenic chemical hazard index (HI) as the primary human health impact metrics
- Use industrial and residential exposure scenarios
- Identify the significant contributors (95% of total) for each health impact metric and generate a separate graph for each significant contributor
- Derive effects of contaminant release and transport from previous studies
- Use the best available published data and information to the maximum extent possible.

The human health impact values used to generate the retrieval leak impact graphs are estimates based on Equation 7-1.

$$R_i = I_i \times C_i \times H_i \tag{7-1}$$

Where:

- i = indicator contaminant
- R_i = risk metric (radiological ILCR or chemical HI)
- I_i = inventory (Ci or kg released into the environment [e.g., retrieval leakage])
- C_i = unit groundwater concentration factor (pCi/L per Ci, or mg/L per kg)
- H_i = health effects conversion factor (ILCR per pCi/L, or HI per mg/L).

Sections 7.1.1.1 through 7.1.1.4 discuss the individual terms in Equation 7-1, including identification of indicator contaminants, development of contaminant inventories, simulation of contaminant transport, and identification of exposure scenarios and health effects conversions factors.

7.1.1.1. Indicator Contaminants. Retrieval leak impact graphs were generated for a subset of significant contaminants rather than for all contaminants. Significant contaminants were the contaminants estimated to dominate or drive the total impact for a particular human health impact metric. Significant contaminants serve as indicators of the magnitude of total impacts from all contaminants.

An indicator contaminant approach was used to ensure that the resulting graphical tools would provide a reasonable estimate of total impacts but at the same time be sufficiently simple to facilitate rapid decision making without requiring a lot of additional calculation in the event a leak is detected during waste retrieval. The primary human health impact metrics used were radiological ILCR and noncarcinogenic chemical HI. Nonradiological ILCR was also included for information purposes.

Indicator contaminants for each human health impact metric were identified based on the results of the WMA C risk assessment presented in RPP-13774. The *WMA C Closure Action Plan* provided as Appendix C to RPP-13774 includes the results of a comprehensive WMA C long-term groundwater pathway human health risk assessment that was supported by a site-specific numerical vadose zone and groundwater modeling effort. The *Risk Assessment for WMA C Closure Plan* provided as Addendum C1 to RPP-13774 shows contaminant-specific impact contributions at the WMA C downgradient fenceline by source term for technetium-99, iodine-129, nitrate, nitrite, total uranium, and hexavalent chromium. Also shown are the total impacts by source term based on the contributions from all contaminants given in DOE/ORP-2003-02, *Inventory and Source Term Data Package*, for which a toxicity factor was available. Exposure scenarios and risk factors used for the RPP-13774 analysis were obtained from HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessment.*

The HNF-SD-WM-TI-707 evaluation provides unit dose factors, unit risk factors, and unit HI factors for a comprehensive set of contaminants of potential concern for Hanford Site risk assessment. A total of 93 radionuclides and 161 chemicals are evaluated. The unit factors were derived from standard formulas using data considered to be the most current or technically sound. For radionuclides, the cancer morbidity risk coefficients in EPA-402-R-99-001, *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, were used. For chemicals, the non-cancer toxicity reference doses and cancer induction slope factors adopted by EPA and listed in the Integrated Risk Information System (IRIS) (http://www.epa.gov/iris) were used. Where toxicity parameters were not available in IRIS, values from EPA-540/R-97/036, *Health Effects Assessment Summary Tables (HEAST) FY 1997 Update*, and the Risk Assessment Information System (RAIS) (http://risk.lsd.ornl.gov) maintained by the Oak Ridge National Laboratory were used. To provide an indication of the importance of missing toxicity parameters, the evaluation also includes estimates of the missing parameters for chemicals that have a reference dose or slope factor for ingestion, but none for inhalation, or vice versa.

Table 7-1 is a summary from the RPP-13774 base case analysis results showing the contaminant contributions by source term for each of the human health impact metrics. Table 7-1 shows the peak impacts from WMA C potential residual tank waste past leaks (including one tank leak and three ancillary pipeline leaks), and potential retrieval leaks (assuming an 8,000-gal. leak from each of the C-100-series tanks).

The RPP-13774 analysis results indicate the only contributors to total WMA C radiological ILCR at the fenceline at the time of peak would be the highly mobile (distribution coefficient [K_d = 0 mL/g]) radionuclides: technetium-99, iodine-129, carbon-14, and tritium, with technetium-99 being the major driver. Technetium-99 was predicted to contribute approximately 85% to 98% of the total radiological ILCR depending on the source term and receptor scenario. Technetium-99 was therefore selected as the radiological ILCR indicator contaminant for this evaluation. It is recognized that technetium-99 contributes slightly less than 95% of the total radiological ILCR for the industrial scenario; however, technetium-99 clearly predominates the radiological impacts in all cases and is therefore considered an appropriate choice of indicators for radiological ILCR.

The RPP-13774 analysis results indicate the only contributors to the total WMA C noncarcinogenic chemical HI at the fenceline at the time of peak would be the highly mobile (K_d = 0 mL/g) chemicals: hexavalent chromium, nitrite, fluoride, and nitrate, with hexavalent chromium and nitrite being the major drivers. The RPP-13774 analysis conservatively assumed that all chromium inventory was hexavalent chromium. Hexavalent chromium and nitrite combined were predicted to contribute approximately 76 to 95% of the total HI depending on source term and receptor scenario. Hexavalent chromium and nitrite were therefore selected as the noncarcinogenic chemical HI indicator contaminants for this evaluation. It is recognized that hexavalent chromium and nitrite combined contribute slightly less than 95% of the total HI for certain source terms and receptor scenarios; however, these two chemicals combined clearly predominate the noncarcinogenic chemical impacts in all cases and are therefore considered an appropriate choice of indicators for noncarcinogenic chemical HI.

Table 7-1. Contaminant Contributions to Peak Groundwater Pathway Human Health Impacts at Waste Management Area C Fenceline. (2 Sheets)

Source Term	Time of Peak (Yr AD)	Radiological Incremental Lifetime Cancer Risk		Nonradiological Incremental Lifetime Cancer Risk		Noncarcinogenic Chemical Hazard Index	
		Industrial	**Residential**	**Industrial**	**Residential**	**Industrial**	**Residential**
Past leaks [a]	2117	Tc-99 6.9E-06 (85%) I-129 7.1E-07 (9%) C-14 5.4E-07 (6%) H-3 8.8E-10 (<1%) Total 8.1E-06 (100%)	Tc-99 1.7E-04 (95%) I-129 3.7E-06 (2%) C-14 3.9E-06 (3%) H-3 3.7E-09 (<1%) Total 1.8E-04 (100%)	Cr(VI) 1.1E-07 (100%) Total 1.1E-07 (100%)	Cr(VI) 2.4E-07 (100%) Total 2.4E-07 (100%)	Cr(VI) 1.7E-02 (52%) NO_2 1.4E-02 (43%) NO_3 1.7E-03 (5%) F 1.4E-05 (<1%) Total 3.3E-02 (100%)	Cr(VI) 9.7E-02 (49%) NO_2 9.1E-02 (46%) NO_3 1.1E-02 (5%) F 9.7E-05 (<1%) Total 2.0E-01 (100%)
Retrieval leaks [b]	2082	Tc-99 5.7E-06 (89%) I-129 6.1E-07 (9%) C-14 1.3E-07 (2%) H-3 2.9E-10 (<1%) Total 6.5E-06 (100%)	Tc-99 1.4E-04 (98%) I-129 3.2E-06 (2%) C-14 9.0E-07 (<1%) H-3 1.2E-09 (<1%) Total 1.4E-04 (100%)	Cr(VI) 1.7E-07 (100%) Total 1.7E-07 (100%)	Cr(VI) 3.8E-07 (100%) Total 3.8E-07 (100%)	Cr(VI) 2.8E-02 (41%) NO_2 2.6E-02 (39%) NO_3 4.1E-03 (5%) F 1.0E-02 (15%) Total 6.7E-02 (100%)	Cr(VI) 1.5E-01 (36%) NO_2 1.7E-01 (40%) NO_3 2.6E-02 (6%) F 7.3E-02 (18%) Total 4.2E-01 (100%)

Table 7-1. Contaminant Contributions to Peak Groundwater Pathway Human Health Impacts at Waste Management Area C Fenceline. (2 Sheets)

Source Term	Time of Peak (Yr AD)	Radiological Incremental Lifetime Cancer Risk		Nonradiological Incremental Lifetime Cancer Risk		Noncarcinogenic Chemical Hazard Index	
		Industrial	**Residential**	**Industrial**	**Residential**	**Industrial**	**Residential**
Residual tank waste [c]	5614	Tc-99 9.0E-07 (89%) I-129 1.0E-07 (10%) C-14 1.2E-08 (1%) H-3 0.0 (0%) Total 1.0E-06 (100%)	Tc-99 2.2E-05 (97%) I-129 5.2E-07 (2%) C-14 8.8E-08 (<1%) H-3 0.0 (0%) Total 2.3E-05 (100%)	Cr(VI) 2.8E-08 (100%) Total 2.8E-08 (100%)	Cr(VI) 6.3E-08 (100%) Total 6.3E-08 (100%)	Cr(VI) 4.5E-03 (48%) NO_2 3.4E-03 (36%) NO_3 4.5E-04 (5%) F 1.1E-03 (11%) Total 9.4E-03 (100%)	Cr(VI) 2.5E-02 (44%) NO_2 2.2E-02 (38%) NO_3 2.9E-03 (5%) F 7.8E-03 (13%) Total 5.7E-02 (100%)

HFFACO = *Hanford Federal Facility Agreement and Consent Order*.

[a] Source: RPP-13774, Addendum C1, Tables 33 and 34 and additional model output data (includes contributions from one tank leak [C-105] and three unplanned releases [UPR-200-E-81, UPR-200-E-82, UPR-200-E-86]).

[b] Source: RPP-13774, Addendum C1, Tables 36 and 37 and additional model output data (includes contributions from hypothetical 8,000-gal. retrieval leak from each C-100-series tank assuming raw water as the sluicing fluid).

[c] Source: RPP-13774, Addendum C1, Tables 30 and 31 and additional model output data (includes contributions from HFFACO specified post-retrieval residual waste volume in C-100 and C-200-series tanks).

RPP-13774, 2004, *Single-Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

Total uranium was simulated in the RPP-13774 analysis as a moderately mobile (K_d = 0.6 mL/g) contaminant and was not projected to arrive at the fenceline until approximately 5,000 years after closure. At the time of first arrival, the uranium concentration was due primarily to contributions from past leaks and hypothetical retrieval leaks. Uranium from residual waste was not projected to arrive at the fenceline until late in the 10,000-year simulation period. Peak human health impacts were projected to occur within 100 years after closure for past leaks and retrieval leaks and within 3,500 years after closure for residual waste. The peak values in all cases were driven by contributions from the highly mobile (K_d = 0 mL/g) contaminants. Uranium had not yet broken through to the water table at the time of peak for any source term and therefore made no contribution to the peaks. Uranium exhibited increasing concentrations at the end of the 10,000-year simulation and was a primary contributor to the impacts calculated at the end of the simulation. The impacts at the end of the simulation were lower than the peak impacts by an order of magnitude or more.

The RPP-13774 analysis also included an assessment of nonradiological cancer risk. Cancer risks from radionuclides and carcinogenic chemicals are typically reported as separate metrics rather than being summed because of differences in how risk is estimated for these two categories of substances. A total of 24 nonradiological chemical contaminants are included in the BBI. Of these, only one, hexavalent chromium, has a published cancer slope factor.

Nonradiological ILCR was assessed in the RPP-13774 analysis based solely on hexavalent chromium exposure. The nonradiological ILCR results from RPP-13774 are shown in Table 7-1 for information purposes to provide an indication of the potential magnitude of nonradiological ILCR. The results indicate that nonradiological ILCR peaks would be on the order of 10^{-7} for the past leak and retrieval leak source terms and 10^{-8} for the residual waste source term. However, because it is based on only one contaminant, nonradiological ILCR was not carried forward as a separate evaluation metric (i.e., was not used to generate a separate set of retrieval leak impact graphs). The degree to which hexavalent chromium ILCR provides an indication of total ILCR is uncertain because of the limited number of chemical analytes reported in the BBI. There is additional uncertainty regarding chromium speciation and the degree of conservatism introduced by assuming that all chromium is hexavalent chromium.

Note that hexavalent chromium is classified as both a chemical toxicant (evaluated using HI) and a carcinogen (evaluated using ILCR). It is classified as toxic via both ingestion and inhalation but carcinogenic only via inhalation. The inhalation intake for the groundwater pathway exposures is based on re-suspended soil and volatilized water. The soil is assumed to be contaminated by irrigation with contaminated groundwater for both the industrial and residential scenarios. Water volatilization is assumed to occur during showering with contaminated groundwater. Further discussion of exposure parameters and scenarios is provided in HNF-SD-WM-TI-707.

7.1.1.2. Potential Retrieval Leak Inventories. This document presents much of the risk data assuming an 8,000-gal. retrieval leak volume. This quantity is used only as a point of reference, and for consistency and comparison with the volume assumed in the WMA C Closure Plan (RPP-13774, Appendix C) risk assessment. The choice of the reference volume is arbitrary and does not affect how the risk values would be used in the event of a retrieval leak. The 8,000 gal.

is a hypothetical volume that represents neither an anticipated leak volume nor a leak detection limit. Tanks C-102, C-104, C-107, C-108, and C-112 are classified sound and are not anticipated to leak during waste retrieval. If a leak is detected, however, the risk graphs provided in Appendices A through E will allow the leak impacts to be estimated regardless of leak volume.

The retrieval leak impact graphs provided in the appendices were generated by applying Equation 7-1 over a range of hypothetical retrieval leak inventories for each indicator contaminant (RPP-22392 and RPP-22521). Because potential retrieval leak volumes are uncertain, the inventory range was selected to encompass a small leak on the low end and a large leak on the high end. Points of reference were added to the graphs to show the estimated current tank inventory and the estimated inventory associated with a hypothetical 8,000-gal. retrieval leak assuming sluicing with DST supernate as identified in Appendix A, B, C, D, and E of this document for the planned retrieval sequence (Figure 2-1) and receiver DST (Figure 3-1). The 8,000-gal. volume was used only for information purposes to provide a point of reference on the graphs.

Development of the tank-specific inventories shown as points of reference on the graphs for the individual tanks is discussed in the appendices. Current inventory values were taken from the BBI by downloading from the Tank Waste Information Network System (TWINS) database. Hypothetical retrieval leak inventory values were calculated from the best available published data source.

7.1.1.3. Contaminant Transport Simulations. The RPP-13774 analysis provides the most sophisticated currently available predictions of potential long-term groundwater impacts associated with tank waste retrieval and closure activities for WMA C. The groundwater contaminant concentrations used for the retrieval leak impact graphs were derived directly from the modeling output data from the RPP-13774 analysis.

Flow and transport were simulated in the RPP-13774 analysis using two-dimensional cross-sectional models. The cross-sections extended laterally to the tank farm fenceline and vertically downward through the vadose zone into the upper portion of the underlying aquifer. The simulations all assumed a final closure barrier was in place by 2050. The barrier was assumed to function at its design estimate recharge rate (0.5 mm/yr) for 500 years, after which recharge was assumed to increase to 3.5 mm/yr. The simulated cross-sectional groundwater concentrations were distributed uniformly along the length of the downgradient WMA C boundary. The simulations were carried out for a 10,000-year assessment period (i.e., from the year 2000 to the year 12000). The base case simulation results indicated the peak groundwater concentrations from retrieval leaks would arrive at the WMA C downgradient fenceline in the year 2082.

The RPP-13774 transport simulations were performed for the following four types of contaminant sources within WMA C:

- Past leaks from tanks
- Past leaks from ancillary equipment (i.e., past pipe leaks)
- Potential leaks during waste retrieval

- Residual waste remaining in tanks and ancillary equipment.

A total of 14 individual simulation cases were included in the analysis. Each case described the behavior of seven surrogate contaminants of varying distribution coefficients under variable waste release modes for the selected sources. The simulations were all performed using a unit source inventory (i.e., 1 Ci or kg). The contaminants simulated represented seven different measures of contaminant mobility through the use of distribution coefficients (K_d = 0, 0.01, 0.03, 0.1, 0.3, 0.6, and 1.0 mL/g). By using a range of distribution coefficients, the analysis examined a wide variety of contaminants by applying the appropriate inventory and decay rate to the unit results for the contaminant of interest. The indicator contaminants for the current evaluation (technetium-99, hexavalent chromium, nitrite) were all assigned to the highly mobile (K_d = 0 mL/g) surrogate contaminant group.

Table 7-2 shows the RPP-13774 unit-source simulation results for the highly mobile (K_d = 0 mL/g) contaminant group in the retrieval leak source term. The values shown are the predicted peak contaminant concentrations in groundwater at the downgradient WMA C fenceline from release of 1 Ci of radionuclide or 1 kg of chemical. The retrieval leak impact graphs were generated by multiplying the simulated unit-source results by the retrieval leak inventory to obtain an estimate of peak groundwater concentration (Equation 7-1).

Table 7-2. Mobile Contaminant (K_d = 0 mL/g) Unit Inventory Simulation Results for Waste Management Area C Retrieval Leak Source Term.

Contaminant	Peak Groundwater Concentration at WMA C Fenceline*	Units	Time of Peak (Yr AD)
Radionuclide	8.4E+01	pCi/L	2082
Chemical	8.4E-05	mg/L	2082

WMA = waste management area.

* Addendum C1, Figure 9, from RPP-13774, 2004, *Single-Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

7.1.1.4. Exposure Scenarios. Human health impacts were generated and displayed on the retrieval leak impact graphs for an industrial and a residential exposure scenario, consistent with the requirements in HFFACO Appendix I. Both scenarios are based on scenarios described in DOE/RL-91-45, *Hanford Site Risk Assessment Methodology*. The health effects conversion factors for both scenarios are shown in Table 7-3 for the three indicator contaminants.

Table 7-3. Groundwater Unit Health Effects Factors for Industrial and Residential Exposure Scenarios.

Contaminant	Units	Industrial [a]	Residential [b]
Technetium-99	ILCR per pCi/L	1.38E-08	3.36E-07
Hexavalent chromium	HI per mg/L	3.88E+00	2.34E+01
Nitrite	HI per mg/L	9.89E-02	6.36E-01

HI = hazard index.
ILCR = incremental lifetime cancer risk.
[a] Source: HNF-SD-WM-TI-707, Tables 22 and 23.
[b] Source: HNF-SD-WM-TI-707, Tables 26 and 27.
HNF-SD-WM-TI-707, 2004, *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessment*, Rev. 4, CH2M HILL Hanford Group, Inc., Richland, Washington.

The conversion factors shown in Table 7-3 were taken from tables provided in HNF-SD-WM-TI-707. For technetium-99, the conversion factors provide the lifetime cancer morbidity risk per unit concentration in the groundwater. For hexavalent chromium and nitrite, the conversion factors provide the noncarcinogenic chemical HI per unit concentration in the groundwater. The factors were applied to the retrieval leak impact calculations as shown in Equation 7-1.

The industrial scenario represents 20 years of occupational exposure in an industrial setting. The receptor is an individual whose work activity is primarily indoors but also includes outdoor activities such as building and grounds maintenance. Contaminants enter the worker primarily through use of groundwater for drinking water and showering. External exposure to irrigated soil and soil inhalation are also included.

The residential scenario represents 30 years of exposure in a residential setting. The receptor is an individual who resides on the land, grows fruits and vegetables, and raises livestock and poultry for personal consumption. Contaminants enter the receptor through use of groundwater for domestic needs (drinking, cooking, and showering); for irrigation (ingestion of produce, soil, and water; inhalation of soil and water; and external exposure); and for watering livestock (ingestion of meat, poultry, and dairy products).

Uncertainty in the exposure scenarios contributes to the overall uncertainty in long-term risk predictions. To address uncertainty, exposure scenario parameters are generally biased to yield higher exposure and risk values. Inputs to the scenario unit risk factors that could contribute to exposure scenario uncertainty include the various models used (e.g., food chain model, toxicokinetic model) and model parameters (e.g., food chain transfer factors, exposure factors, dose factors, risk factors). Complete descriptions of the exposure scenario parameters, assumptions, and unit risk factor calculations can be found in HNF-SD-WM-TI-707.

7.1.2 Retrieval Leak Impact Analysis Results

Tank-specific retrieval leak impact graphs generated using the methodology described above are provided in Appendices A through E for tanks C-102, C-104, C-107, C-108, and C-112, respectively. Three graphs, one for each indicator contaminant, are provided for each tank. An example calculation is also provided to illustrate how the formula given in Equation 7-1 was applied in generating the graphs.

7.1.3 Waste Management Area C Risk Assessment

This section provides information to allow the potential retrieval leak impacts from the individual tanks to be placed in the context of the potential impacts from the C tank farm as a whole. The information presented was summarized from the WMA C risk assessment results presented in RPP-13774.

Sections 7.1.3.1 through 7.1.3.3 summarize the RPP-13774 analysis results by source term in terms of the projected peak impacts at the WMA C downgradient fenceline from potential retrieval leaks, residual waste, and past leaks.

The RPP-13774 risk assessment was a first-iteration risk assessment developed to show the current understanding of the risks associated with waste retrieval and closure activities for WMA C. The RPP-13774 analysis contained significant limitations and uncertainties. To address these uncertainties, the parameters used for the analysis were in general biased to yield higher risk values. The RPP-13774 analysis provides a list of the uncertainties associated with the risk assessment and how each uncertainty could impact the assessment results. It is expected that as waste retrieval from the C farm 100-series tanks progresses, new information will become available that could reduce the uncertainties presented in RPP-13774.

7.1.3.1. Potential Retrieval Leaks. Potential WMA C retrieval leak impacts are summarized in Table 7-4 from the results of the base case analysis presented in RPP-13774. The table shows the predicted peak groundwater concentration, radiological ILCR, nonradiological ILCR, and noncarcinogenic chemical HI for the indicator contaminants at the downgradient fenceline from the WMA C retrieval leak source term.

The retrieval leak source term was simulated in the RPP-13774 analysis based on a hypothetical 8,000-gal. retrieval leak from each of the twelve C farm 100-series tanks. The four C farm 200-series tanks were assumed not to leak during waste retrieval. A sensitivity case with a larger retrieval leak volume was also included.

Table 7-4. Peak Impacts at the Waste Management Area C Fenceline from Potential Retrieval Leaks. [a]

Contaminant	Time of Peak (Yr AD) [b]	Incremental Lifetime Cancer Risk [c]		Hazard Index [d]		Groundwater Concentration [e]	Drinking Water Standard (MCL)
		Industrial	Residential	Industrial	Residential		
Technetium-99	2082	5.7E-06	1.4E-04	NA	NA	420 pCi/L	900 pCi/L
Hexavalent chromium	2082	1.7E-07	3.8E-07	2.8E-02	1.5E-01	0.0064 mg/L	0.1 mg/L [f]
Nitrite	2082	NA	NA	2.6E-02	1.7E-01	0.26 mg/L	3.3 mg/L [g]
Total radiological	2082	6.5E-06	1.4E-04	NA	NA	NA	NA
Total nonradiological	2082	1.7E-07	3.8E-07	6.7E-02	4.2E-01	NA	NA

EPA = U.S. Environmental Protection Agency.
MCL = maximum contaminant level.
NA = not applicable.

[a] Potential retrieval leaks evaluated in RPP-13774 are based on sluicing with raw water.

[b] Source: RPP-13774, Addendum C1, Tables 36 and 37.

[c] Source: RPP-13774, Addendum C1, Table 36.

[d] Source: RPP-13774, Addendum C1, Table 37.

[e] Source: RPP-13774, Addendum C1, Table 38.

[f] The MCL for chromium is for total chromium. No MCL for hexavalent chromium has been published by EPA.

[g] Concentration for nitrite reported as the ion. The MCL for nitrite reported as nitrogen is 1 mg/L.

RPP-13774, 2004, *Single-Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

The retrieval leak inventories used for the RPP-13774 analysis were generated with the Hanford Tank Waste Operations Simulator (HTWOS) model assuming a raw water sluicing scenario. Retrieval leak inventories for a DST supernate sluicing scenario were not assessed in the RPP-13774 analysis. For this retrieval work plan, retrieval leak inventories for a DST supernate sluicing scenario were estimated using retrieval leak concentrations as specified in Appendix A, B, C, D, and E of this document. These inventories are shown as reference points on the retrieval leak impact graphs presented in the appendices. Comparison tables showing the DST supernate inventories and the RPP-13774 raw water inventories are also presented in the appendices. Because human health impacts are proportional to source inventory, the tables provide an indication of potential differences in impacts between the two sluicing scenarios. Generally, the estimated DST supernate inventories were two to eight times higher than the corresponding raw water inventories. In several cases, the DST supernate leak inventories were approximately the same as or slightly lower than the raw water leak inventories. The single biggest difference was in tank C-102 which has a low starting inventory of technetium-99, where the DST supernate technetium-99 inventory was two orders of magnitude higher than the raw water technetium-99 inventory and exceeded the current tank C-102 technetium-99 inventory.

The RPP-13774 base case simulation results indicate the peak groundwater concentrations from retrieval leaks would occur at the WMA C downgradient fenceline in the year 2082. Groundwater concentrations were calculated as cumulative fenceline average concentrations over the entire downgradient length of the WMA C fenceline. The peak groundwater concentrations from retrieval leaks were projected to overlap in time and be additive with the peak groundwater concentrations from past leaks but were not projected to be additive with the peaks from residual waste.

The RPP-13774 retrieval leak assessment results shown in Table 7-4 included an 8,000-gal. retrieval leak from tank C-106. Subsequent to the completion of the RPP-13774 analysis, a waste retrieval campaign was completed for tank C-106 using modified sluicing and acid dissolution. No leakage from tank C-106 was detected during that campaign. Results of a tank C-106 post-retrieval risk assessment are reported in RPP-20577, *Stage II Retrieval Data Report for Single-Shell Tank 241-C-106*.

7.1.3.2. Residual Waste. Potential WMA C residual tank waste impacts are summarized in Table 7-5 from the results of the base case analysis presented in RPP-13774. The table shows the predicted peak groundwater concentration, radiological ILCR, nonradiological ILCR, and noncarcinogenic chemical HI for the indicator contaminants at the downgradient fenceline from the WMA C residual tank waste source term.

The RPP-13774 simulation results indicate the peak groundwater concentrations from residual tank waste would arrive at the fenceline approximately 3,600 years after closure (in the year 5614). The peak groundwater concentrations from residual tank waste were not projected to overlap in time or be additive with the peak groundwater concentrations from retrieval leaks or past leaks.

Table 7-5. Peak Impacts at the Waste Management Area C Fenceline from Potential Residual Tank Waste.

Contaminant	Time of Peak (Yr AD) [a]	Incremental Lifetime Cancer Risk [b]		Hazard Index [c]		Groundwater Concentration [d]	Drinking Water Standard (MCL)
		Industrial	Residential	Industrial	Residential		
Technetium-99	5610	9.0E-07	2.2E-05	NA	NA	66 pCi/L	900 pCi/L
Hexavalent chromium	5614	2.8E-08	6.3E-08	4.5E-03	2.5E-02	0.001 mg/L	0.1 mg/L [e]
Nitrite	5614	NA	NA	3.4E-03	2.2E-02	0.034 mg/L	3.3 mg/L [f]
Total radiological	5614	1.0E-06	2.3E-05	NA	NA	NA	NA
Total nonradiological	5614	2.8E-08	6.3E-08	9.4E-03	5.7E-02	NA	NA

EPA = U.S. Environmental Protection Agency.
MCL = maximum contaminant level.
NA = not applicable.

[a] Source: RPP-13774, Addendum C1, Tables 30 and 31.
[b] Source: RPP-13774, Addendum C1, Table 30.
[c] Source: RPP-13774, Addendum C1, Table 31.
[d] Source: RPP-13774, Addendum C1, Table 38.
[e] The MCL for chromium is for total chromium. No MCL for hexavalent chromium has been published by EPA.
[f] Concentration for nitrite reported as the ion. The MCL for nitrite reported as nitrogen is 1 mg/L.

RPP-13774, 2004, *Single-Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

The base case residual waste simulations used a diffusion-dominated release model for 360 ft^3 and 30 ft^3 of post-retrieval residual tank waste in the twelve C farm 100-series tanks and four C farm 200-series tanks, respectively. The residual waste inventories were estimated using the selective phase removal method, which takes into account removal of selected phases of waste (e.g., sludge, supernate) during retrieval. Groundwater concentrations were calculated as cumulative fenceline average concentrations over the entire downgradient length of the WMA C fenceline.

The nature and amount of waste left in WMA C ancillary equipment and pipelines is unknown. The RPP-13774 analysis included an assumed inventory for the waste in these components to show their expected relative contribution to the total WMA C impacts. Waste in the ancillary equipment tanks (244-CR vault and C-301 catch tank) was assumed to be retrieved to a residual volume proportional to that required under the HFFACO for the 200-series tanks. The ancillary equipment tanks are smaller than the 200-series tanks and the ancillary tank residual volume was calculated by multiplying the 200-series tanks residual volume goal (30 ft^3) by the ratio of the volume of the ancillary equipment tank to the 200-series tanks (55,000 gal.). Currently, there is no BBI inventory associated with these ancillary tanks. Ancillary tank residual inventories were calculated as the product of the residual volume and the averaged contaminant-specific concentration from the combined contents of the C farm 100- and 200-series tank solids.

The WMA C piping system comprises multiple layers of waste transfer piping that were installed over time within WMA C. An estimated total volume of 1,000 ft^3 of waste transfer piping was assumed for the RPP-13774 analysis. To estimate a residual waste inventory related to the piping system, 25% of the pipe (250 ft^3) was assumed to be plugged and filled with residual solids. Currently, there is no BBI inventory associated with the ancillary piping components. Contaminant concentrations in the residual solids were calculated from the combined contents of the C farm 100- and 200-series tank waste solids.

The impacts shown in Table 7-5 are for residual tank waste and do not include the contributions from residual waste in WMA C ancillary equipment and pipelines. The residual waste in those components was estimated to cause a small increase to the impacts shown in Table 7-5. For example, for the industrial scenario, the total radiological ILCR increased to 1.1×10^{-6}, the total nonradiological ILCR increased to 3.1×10^{-8}, and the total HI increased to 1.0×10^{-2}. The RPP-13774 analysis indicated the peak impacts from ancillary tank residuals would arrive coincident with the peak from SST residuals (in the year 5614) and the peak from piping system residuals would arrive approximately 700 years earlier than the peak from SST residuals.

The diffusion-dominated residual waste release model used in the base case simulations was representative of a stabilized, grouted waste form. Additional sensitivity cases were simulated using an advection-dominated residual waste release model representative of an unstabilized waste form covered with backfill sand and gravel or failed grout. Peak groundwater concentrations for the advection-dominated release model were projected to arrive at the WMA C fenceline approximately 1,000 years earlier (in the year 4653) and be approximately an order of magnitude higher than the peaks for the base case diffusion-dominated release model.

Subsequent to the completion of the RPP-13774 analysis, a waste retrieval campaign was completed for tank C-106 using modified sluicing and acid dissolution. No leakage from tank C-106 was detected during that retrieval campaign. Results of a tank C-106 post-retrieval risk assessment based on samples collected from the residual waste remaining in tank C-106 following the retrieval campaign are reported in RPP-20577. The RPP-20577 analysis results indicate that the impacts from tank C-106 residual waste would be a factor of four lower than the corresponding impacts calculated in the RPP-13774 analysis.

7.1.3.3. Past Leaks. WMA C past leak impacts are summarized in Table 7-6 from the results of the base case analysis presented in RPP-13774. The table shows the predicted peak groundwater concentration, radiological ILCR, nonradiological ILCR, and noncarcinogenic chemical HI for the indicator contaminants at the downgradient fenceline from the WMA C past leak source term.

The RPP-13774 base case simulation results indicate the peak groundwater concentrations from past leaks would arrive at the WMA C downgradient fenceline in the year 2092 for past tank leaks and the year 2117 for past ancillary equipment leaks. The past leaks source term was based on vadose zone contamination associated with past UPRs in the vicinity of tank C-105 and three ancillary pipelines (UPR-200-E-81, UPR-200-E82, UPR-200-E-86). Other reported unplanned ancillary equipment releases in WMA C were considered but disregarded in the RPP-13774 analysis because they were determined not to represent significant sources of contamination compared to the sources analyzed. Table 5 in Addendum C1 of RPP-13774 lists sources included in the WMA C risk assessment conceptual model. This same table indicates whether the source was included in the risk assessment itself and, if not included, the reason why. Three UPRs that occurred in the general area of the five SSTs whose retrieval is described in this plan were not included in the risk assessment. These are UPR-200-E-16, UPR-200-E-118, and UPR-200-E-136. (Depending on future sampling or closure decisions, these UPRs may be included in future C farm risk assessments.) The reasons given in Table 5 of RPP-13774, Addendum C1 of why UPRs were not included in the risk assessment are:

- **UPR-200-E-16** – A small (approximately 50-gal.) overground transfer line leak near the north side of tank C-105. This UPR was not included in the risk analysis because its limited volume was significantly less than that in three other UPRs that were included.

- **UPR-200-E-118** – An airborne release from tank C-107. This UPR was not included in the risk analysis because it was an airborne release that did not result in significant soil contamination.

- **UPR-200-E-136** – A reported 24,000-gal. leak from tank C-101. (The same UPR also includes a reported 400 gal. leak from tank C-203). This UPR was not included in the risk analysis because this reported leak has not been verified through either geophysical logging or sampling in the vadose zone and/or groundwater (see footnote 4 from Table 5 of RPP-13774, Addendum C1 for a more detailed explanation).

Table 7-6. Peak Impacts at the Waste Management Area C Fenceline from Past Leaks.

Contaminant	Time of Peak (Yr AD) [a]	Incremental Lifetime Cancer Risk [b]		Hazard Index [c]		Groundwater Concentration [d]	Drinking Water Standard (MCL)
		Industrial	Residential	Industrial	Residential		
Technetium-99	2117	6.9E-06	1.7E-04	NA	NA	497 pCi/L	900 pCi/L
Hexavalent chromium	2117	1.1E-07	2.4E-07	1.7E-02	9.7E-02	0.004 mg/L	0.1 mg/L [e]
Nitrite	2117	NA	NA	1.4E-02	9.1E-02	0.14 mg/L	3.3 mg/L [f]
Total radiological	2117	8.1E-06	1.8E-04	NA	NA	NA	NA
Total nonradiological	2117	1.1E-07	2.4E-07	3.3E-02	2.0E-01	NA	NA

EPA = U.S. Environmental Protection Agency.
MCL = maximum contaminant level.
NA = not applicable.

[a] Source: RPP-13774, Addendum C1, Tables 33 and 34.

[b] Source: RPP-13774, Addendum C1, Table 33.

[c] Source: RPP-13774, Addendum C1, Table 34.

[d] Source: RPP-13774, Addendum C1, Table 38.

[e] The MCL for chromium is for total chromium. No MCL for hexavalent chromium has been published by EPA.

[f] Concentration for nitrite reported as the ion. The MCL for nitrite reported as nitrogen is 1 mg/L.

RPP-13774, 2004, *Single-Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

Although the peak from the past tank leak was projected to arrive ahead of the peak from the unplanned pipeline releases by approximately 26 years, the contributions from these sources were summed and reported as a single peak arriving in the year 2117. Groundwater concentrations were calculated as cumulative fenceline average concentrations over the entire downgradient length of the WMA C fenceline. The peak groundwater concentrations from past leaks were projected to overlap in time and be additive with the peak groundwater concentrations from retrieval leaks but were not projected to be additive with the peaks from residual waste. The peak from retrieval leaks was projected to arrive in 2082 compared with 2092 for the past tank leak. This occurred because the retrieval leak volume used in the RPP-13774 analysis was 8,000 gal. whereas the past leak (tank C-105) volume was 1,000 gal. An 8,000-gal. volume has a greater driving force and lower tendency to spread laterally in the vadose zone than a 1,000-gal. volume.

Transport of existing vadose zone contamination was simulated in the RPP-13774 analysis based on water flow from natural recharge only (i.e., surface infiltration of meteoric water). The effect on existing contamination of artificial recharge, such as a retrieval leak or water line leak, was not evaluated. Should the fluid released in a retrieval leak intercept an existing vadose zone plume, there is a potential for the contamination to be flushed more quickly to the water table. The effect of the flushing on peak groundwater concentration and arrival time would depend on a number of factors, including initial plume depth and the rate, volume, and location of the retrieval leak. There is no potential for a retrieval leak to affect the movement of contamination from the three unplanned pipeline releases included in the WMA C risk assessment (UPR-200-E-81, UPR-200-E-82, UPR-200-E-86). These releases all occurred along the southwest boundary of WMA C, well away from the nearest tank row. There is a potential for a retrieval leak to affect the movement of the existing vadose zone contamination in the vicinity of tank C-105. If this were to occur, the WMA C past leak impacts could differ from the projected impacts shown in Table 7-6, which were calculated assuming meteoric infiltration.

Seven C farm tanks (C-101, C-110, C-111, and the four C-200-series tanks) are currently classified as assumed leakers in HNF-EP-0182 (see Figure 4-1). However, the past leak source term modeled in the RPP-13774 risk assessment included only leaks and discharges that have been verified either through geophysical logging or sampling in the vadose zone and/or groundwater.

Spectral gamma logging data reported in RPP-14430 shows little evidence of vadose zone contamination consistent with a tank leak in the vicinity of the tanks classified as leakers in HNF-EP-0182. Although no leaks have been reported from tank C-105, there is contamination reported in the vadose zone from routine geophysical monitoring between this tank and tank C-104. The measured vadose zone contamination in the vicinity of tank C-105 was therefore included in the RPP-13774 risk assessment, along with the measured vadose zone contamination associated with three verified leaks from ancillary equipment associated with WMA C. Additional information on WMA C vadose zone contamination can be found in RPP-14430; RPP-15317, *241-C Waste Management Area Inventory Data Package*; GJPO-HAN-18; and GJO-98-39-TARA GJPO-HAN-18, *Vadose Zone Characterization Project at the Hanford Tank Farms, Addendum to the C Tank Farm Report*. Additional perspective on the integrity of tanks in WMA C can be found in RPP-10435.

7.2 INTRUDER RISK

Inadvertent waste site intrusion risk is an assessment of the health impacts from unknowingly intruding into a waste site at some point in the future following closure. Intruder impact estimates are included in this work plan to provide perspective on potential post-closure risks associated with closing tanks C-102, C-104, C-107, C-108, and C-112 assuming waste is retrieved to the HFFACO interim retrieval goal of 360 ft^3 of residual waste and the residuals are closed in place (Ecology et al. 1989).

Inadvertent intruder impacts were analyzed using the same methodology used to analyze WMA C intruder impacts in DOE/ORP-2003-11, *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington*. That report uses exposure scenarios defined in HNF-SD-WM-TI-707 and is based on intruder analyses presented in earlier Hanford Site performance assessments (WHC-EP-0645, *Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*; WHC-EP-0875, *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*; DOE/RL-97-69, *Hanford Immobilized Low-Activity Tank Waste Performance Assessment*; DOE/ORP-2000-24, *Hanford Immobilized Low-Activity Waste Performance Assessment: 2001 Version*).

7.2.1 Intruder Scenarios and Performance Objectives

The DOE/ORP-2003-11 analysis includes several inadvertent intrusion scenarios, all of which assume that no institutional memory of the closed facility remains following closure. The credible post-closure intrusion scenarios identified are:

- An intruder who inadvertently drills into the closed site and brings some of the waste to the surface, receiving an acute dose (driller scenario).
- A post-drilling resident who lives where waste has been exhumed and scattered over the surface, receiving a chronic dose (post-intrusion residential scenarios). Three such residential scenarios were included:
  - Suburban resident with a garden
  - Rural farmer with a dairy cow
  - Commercial farmer.

Detailed descriptions of the scenarios are presented in DOE/ORP-2003-11 and HNF-SD-WM-TI-707. A basement scenario, in which exposure occurs during excavation for a basement or building foundation, is not considered credible in DOE/ORP-2003-11 and is not analyzed. This is because the top of the waste is 35 ft or more below the surface and neither basements for home residences nor foundations for commercial structures are likely to extend this far below the surface.

The performance objective identified in DOE/ORP-2003-11 for the driller scenario is 500 mrem effective dose equivalent for a one-time exposure. The performance objective for the post-intrusion residential scenarios is 100 mrem/yr effective dose equivalent for a continuous exposure. Doses are calculated at 100-year intervals from 0 to 1,000 years after closure. The time of compliance (or soonest time when the intrusion was assumed to occur) for the DOE/ORP-2003-11 analysis is 500 years after closure and closure is assumed to occur in the year 2050.

7.2.2 Methodology

The main elements of the intruder calculation method used for this analysis can be summarized as follows:

- Use a time of compliance of 500 years after closure (consistent with DOE/ORP-2003-11)
- Use radiological dose as the health impact metric
- Calculate acute dose using the driller scenario
- Calculate chronic dose using the suburban resident with a garden and rural farmer with a dairy cow scenarios
- Assume the borehole diameter is 6.5 in. for well driller and suburban resident with a garden and 10.5 in. for rural farmer with a dairy cow
- Assume the tanks each contain a volume of 360 ft^3 of residual waste at closure
- Assume the residual tank waste is embedded in a grout matrix that renders a fraction of the exhumed waste unavailable for inhalation and ingestion
- Assume intrusion occurs before contaminants have migrated from the closed facility in any significant quantity.

The commercial farmer scenario was disregarded for this analysis. The commercial farmer is identified in the DOE/ORP-2003-11 analysis as the most likely exposure scenario given the present day land use in the Hanford environs; however, the DOE/ORP-2003-11 analysis uses the rural farmer with a dairy cow for purposes of assessing compliance with performance objectives. The rural farmer with a dairy cow is more conservative than the commercial farmer but less conservative than the suburban resident with a garden. The DOE/ORP-2003-11 analysis considers a rural farmer with a dairy cow a more appropriate scenario for assessing performance than a suburban resident with a vegetable garden. The DOE/ORP-2003-11 analysis results indicate the commercial farmer dose would be a factor of 50 below that of the rural farmer with a dairy cow. Both the suburban resident with a garden scenario and the rural farmer with a dairy cow scenario are evaluated in this tank waste retrieval work plan.

Sections 7.2.2.1 and 7.2.2.2 discuss the calculation methodology for the two primary components of the intruder calculation, inventory, and dose. Tank-specific results for tanks C-102, C-104, C-107, C-108, and C-112 are provided in Appendices A through E, respectively. Calculation detail is provided in RPP-22392.

7.2.2.1. Inventory. The starting inventories for the intruder calculation were the estimated radionuclide inventories remaining in the tanks following retrieval to the HFFACO interim retrieval goal of 360 ft^3 of residual waste. These inventories were taken from RPP-15317 and are based on the selective phase removal inventory estimation method. Inventories for all 46 radionuclides reported in the BBI are provided in RPP-15317 and were used in the calculation. Tank-specific residual waste starting inventories are given in the appendices.

Exhumed inventories were calculated by assuming the waste in the borehole has the same contaminant concentrations as the tank residuals, and that the height of the waste in the borehole is the same as the height of the waste in the tank residuals. Using these assumptions, the undecayed exhumed inventories for each radionuclide were estimated by multiplying the tank residual inventory by the square of the ratio of the borehole radius to the tank radius.
The mathematical basis for this is shown in Equations 7-2 through 7-5.

$$I_{EX} / V_{EX} = I_T / V_T \tag{7-2}$$

$$I_{EX} / (\pi\, r^2 h) = I_T / (\pi\, R^2 h) \tag{7-3}$$

$$I_{EX} = I_T\, (\pi\, r^2 h) / (\pi\, R^2 h) \tag{7-4}$$

$$I_{EX} = I_T\, (r / R)^2 \tag{7-5}$$

Where:

I_{EX} = exhumed inventory (undecayed) (Ci)
I_T = tank residual inventory (Ci)
V_{EX} = exhumed volume (m^3)
V_T = tank residual volume (m^3)
r = borehole radius (m)
R = tank radius (m)
h = waste height (m).

To account for radiological decay, the exhumed inventory was multiplied by a radiological decay factor, as shown in Equation 7-6.

$$I_{EX}(t) = I_{EX}\, \mathrm{Exp}(-\lambda t) \tag{7-6}$$

Where:

$I_{EX}(t)$ = exhumed inventory decayed as a function of time (Ci)

I_{EX} = exhumed inventory (undecayed) (Ci)

Exp = exponential function (natural logarithm base (e) raised to some power)

λ = radioactive decay constant, per year, calculated as ln(2)=0.6931 divided by the radionuclide half life in years

t = elapsed time since closure in years.

7.2.2.2. Dose. For each intruder scenario considered, the dose contribution from each radionuclide was calculated by multiplying the exhumed inventory (decayed) by a unit dose factor. The total dose for each scenario was then calculated as the sum of the dose contributions from all radionuclides included in the starting inventory. Unit dose factors for each radionuclide under each intruder scenario were taken from HNF-SD-WM-TI-707. Unit dose factors for the subset of radionuclides that drive intruder doses are shown in Table 7-7. Complete intruder scenario descriptions and unit dose factor calculations are provided in HNF-SD-WM-TI-707.

Table 7-7. Unit Dose Factors for Inadvertent Intruder Scenarios. [a]

Radionuclide	Driller (mrem per Ci/kg) [b]	Suburban Resident with a Garden (mrem/yr per Ci exhumed) [b]	Rural Farmer with a Dairy Cow (mrem/yr per Ci exhumed) [b]
Strontium-90+D	8.12E+04	3.59E+03	9.73E+01
Technetium-99	5.66E+02	5.06E+02	2.54E+00
Tin-126+D	3.09E+07	9.66E+03	3.86E+02
Cesium-137+D	8.78E+06	3.13E+03	1.25E+02
Plutonium-239	3.86E+05	7.02E+02	1.21E+01
Plutonium-240+D	3.86E+05	7.02E+02	1.21E+01
Americium-241	5.83E+05	7.60E+02	1.41E+01

+D = includes short-lived radioactive progeny in secular equilibrium with parent nuclide.

[a] Tables 7, 8, and 10 of HNF-SD-WM-TI-707, 2004, *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessment*, Rev. 4, CH2M HILL Hanford Group, Inc., Richland, Washington.

[b] Values shown are total dose (sum of internal and external dose) after reducing internal dose by 90% to account for the waste form.

The total dose factors (sum of internal and external doses) given in HNF-SD-WM-TI-707 for the driller scenario assume 100% of the exhumed waste is available for inhalation and ingestion. The residual waste grout matrix is assumed to prevent a fraction of the exhumed inventory from being inhaled or ingested. Internal dose factors used in this calculation were therefore reduced by 90% (multiplied by 0.1) to account for the grouted waste form, as recommended in HNF-SD-WM-TI-707.

The driller scenario unit dose factors are given in terms of the dose per unit contaminant concentration in the drill cuttings (mrem per Ci/kg) (Table 7-7). The radiation dose to this individual is the dose (effective dose equivalent) from acute exposure over a 40-hour drilling operation. The driller dose factors were multiplied by the average radionuclide concentration in the drill cuttings (Ci/kg) to obtain the dose. The average radionuclide concentrations in the drill cuttings were calculated by dividing the exhumed inventories (decayed) by the mass exhumed. The mass exhumed was calculated using Equation 7-7.

$$M_{EX} = \pi\, r^2\, h\, \rho \tag{7-7}$$

Where:

M_{EX} = exhumed mass (kg)
r = borehole radius (m)
h = borehole height (depth to water table) (m)
ρ = average density of well cuttings (kg/m^3).

As for the driller scenario, the total dose factors (sum of internal and external doses) given in HNF-SD-WM-TI-707 for the two post-intruder resident scenarios (suburban resident with a garden and rural farmer with a dairy cow) were adjusted downward to account for a grout matrix by applying a waste form factor of 0.1 to the internal dose factors.

The post-intruder resident scenario unit dose factors are given in terms of the dose received during the first year per curie exhumed (mrem/yr per Ci) (Table 7-7). The radiation dose to this individual is the 50-year committed effective dose equivalent from the first year of exposure. The post-intruder dose factors were multiplied by the curies exhumed (decayed) to obtain the dose.

The post-intruder dose factors consider the decrease in soil concentration during the year due to radioactive decay and leaching from irrigation (HNF-SD-WM-TI-707). Irrigation is assumed to occur only during the first half of the year. External exposure, soil ingestion, and soil inhalation occur only during the irrigation period, with none during the second half of the year. Vegetables, fruit, and grain in the suburban resident with a garden scenario and animal fodder (hay and grain) in the rural farmer with a dairy cow scenario are assumed to be harvested throughout the irrigation season. To represent this, harvest is assumed to occur midway through the irrigation season (at 0.25 year). Plant concentrations are proportional to soil concentrations at this time.

7.2.3 Intruder Analysis Results

Tank-specific intruder impacts generated using the methodology described above are provided in Appendices A through E for tanks C-102, C-104, C-107, C-108, and C-112, respectively. Each appendix provides total dose values for the driller, suburban resident with a garden, and rural farmer with a dairy cow intrusion scenarios, along with the radionuclide-specific dose contributions from the radionuclides that dominate the total dose.

8.0 LESSONS LEARNED

A comprehensive lessons-learned effort was completed to meet the requirements of RPP-10901, *S-102 Initial Waste Retrieval Functions and Requirements*. RPP-10901 summarizes lessons learned from the Hanford Site, DOE, and general industries applicable to waste retrieval from underground storage tanks. Additionally, lessons learned from RPP-18629, *Performance Evaluation for C-106, S-102/112 and C-200 Series Tank Retrieval Activities*, were reviewed. The lessons learned identified in RPP-10901 and RPP-18629 were reviewed and the following have been incorporated into the tanks C-102, C-104, C-107, C-108, and C-112 system design:

- Select equipment materials compatible with the environmental conditions of their intended application to minimize failures resulting from corrosion, stress, and exposure to radiation. Provide adequate temperature controls (e.g., heat tracing, air conditioning) to ensure equipment performs as designed. Select radiation resistance sealants and gaskets.
- Cold test all fluid connections and components before deployment to ensure leak tightness.
- Incorporate features to flush components that transport slurries to prevent/correct blockages. Design the features to operate with minimal changes to the system and operator intervention.
- Design systems to facilitate maintenance and support functions while incorporating safety and ALARA features.
- Provide access to instrumentation and other components requiring servicing and maintenance that does not require breaching the confinement system.
- Simplify system control screens to maximize operator efficiency and recognition of key operational parameters/data.
- Incorporate features to unplug piping systems in the event of a line blockage.
- Conduct comprehensive field walkdowns before system design to validate design assumptions and document as-found field conditions.
- Identify and specify equipment shipping, handling, and lifting requirements to facilitate safe and efficient handling and deployment of equipment.
- Conduct comprehensive post-shipping inspections to identify equipment damage and defects.
- Minimize the use of threaded joints in equipment design.
- Identify and obtain all spare parts required for system maintenance, and for equipment repairs for anticipated failures.

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APPENDIX A

TANK C-102 LONG-TERM HUMAN HEALTH RISK

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LIST OF TERMS

Terms

None required; terms are defined within the document text.

Abbreviations, Acronyms, and Initialisms

DST	double-shell tank
ILCR	incremental lifetime cancer risk
WMA	waste management area

Units

Ci	curie
Ci/L	curies per liter
ft^3	cubic feet
g/L	grams per liter
gal.	gallon
kg	kilogram
kg/L	kilograms per liter
mg/L	milligrams per liter
mrem/yr	millirem per year
pCi/L	picocuries per liter

A1.0 TANK C-102 PRE-RETRIEVAL RISK ASSESSMENT RESULTS

This appendix provides tank-specific pre-retrieval risk assessment results for tank C-102. The information presented was developed using the methodology described in Section 7.0. Groundwater pathway impacts are presented in Section A2.0. Inadvertent intruder impacts are presented in Section A3.0.

A2.0 GROUNDWATER PATHWAY IMPACTS

The groundwater pathway evaluation involved the development of a set of graphical tools to provide a basis for making informed decisions in the event a leak is detected or unexpected retrieval conditions arise during waste retrieval operations. This section provides and discusses the retrieval leak impact graphs generated for tank C-102. The methodology used to generate the graphs is described in Section 7.1.1. Calculation detail for the graphs is provided in RPP-22521 Rev. 6, *Tanks C-101, C-102, C-105, C-110, and C-111 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan*.

A2.1 RETRIEVAL LEAK IMPACT GRAPHS

Figures A-1 through A-3 provide the tank C-102 waste retrieval leak impact graphs for the three indicator contaminants (technetium-99, hexavalent chromium, and nitrite) identified in Section 7.1.1.1.

Figure A-1. Tank C-102 Technetium-99 Risk Plot.

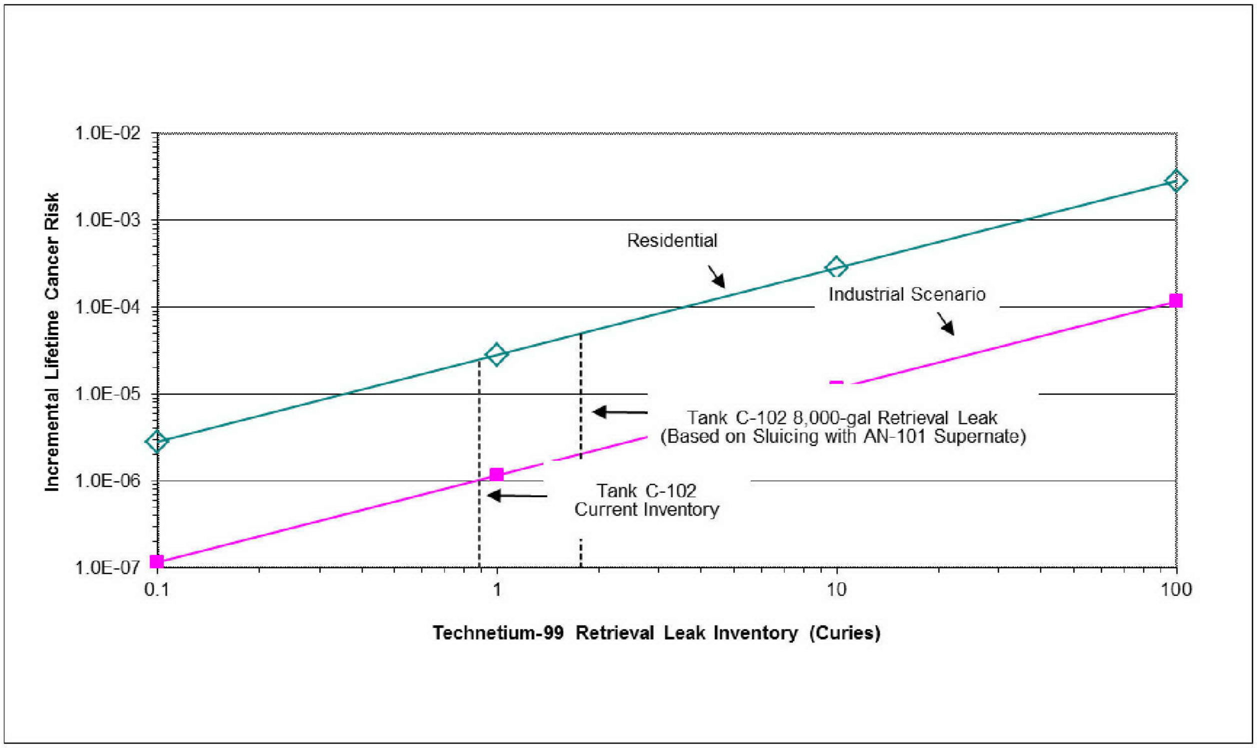

Figure A-2. Tank C-102 Hexavalent Chromium Hazard Quotient Plot.

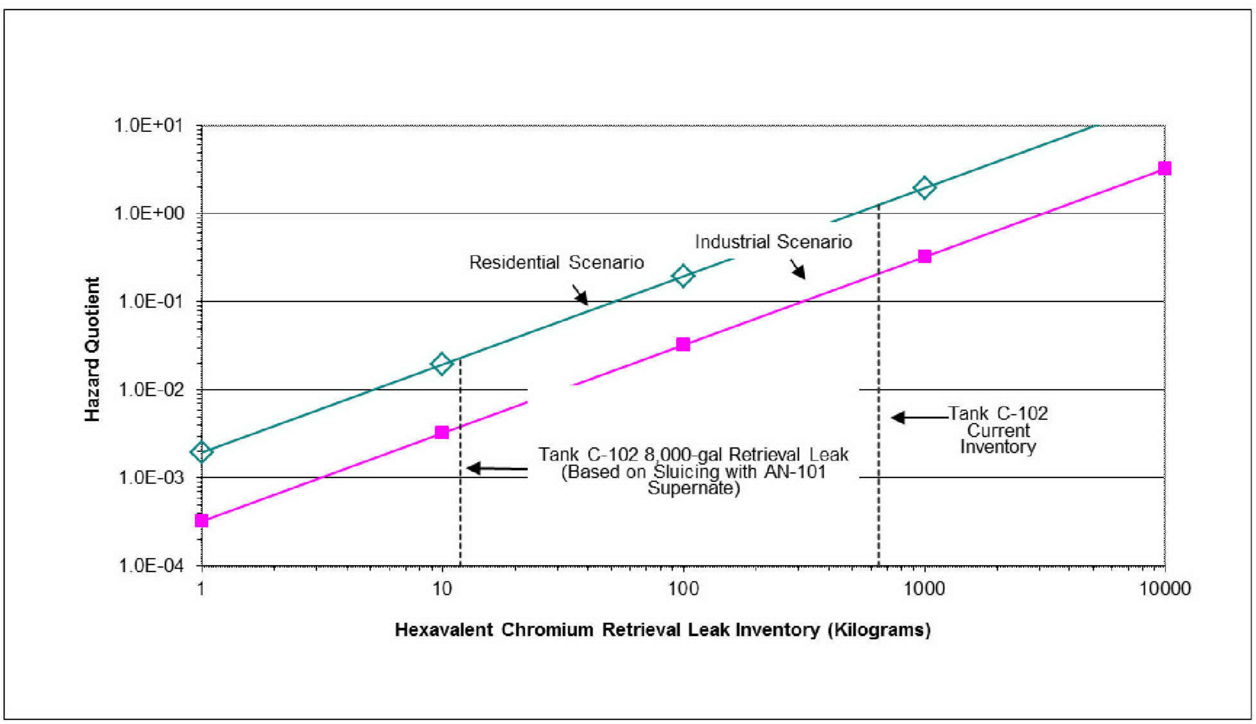

Figure A-3. Tank C-102 Nitrite Hazard Quotient Plot.

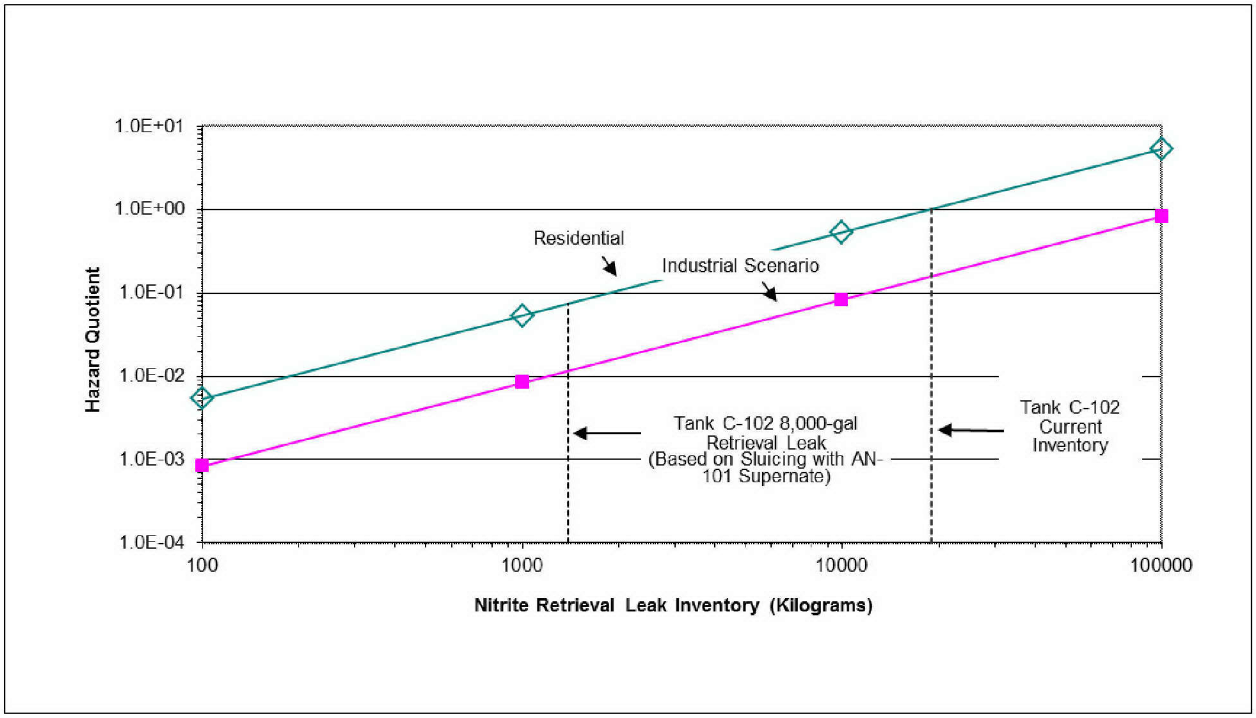

Figure A-1 shows the peak groundwater pathway incremental lifetime cancer risk (ILCR) from technetium-99 as a function of the amount of technetium-99 leaked from tank C-102 during waste retrieval. Figures A-2 and A-3 show the peak groundwater pathway hazard quotient from hexavalent chromium and nitrite, respectively, as a function of the amount of hexavalent chromium and nitrite leaked from tank C-102 during waste retrieval.

The ILCR and hazard quotient values shown on the graphs were based on the predicted peak groundwater concentrations at the waste management area (WMA) C downgradient fenceline. As discussed in Section 7.1.1.3, the projected arrival time of the peaks is approximately the year 2082 based on the supporting contaminant transport analysis in RPP-13774, *Single-Shell Tank System Closure Plan*. The graphs provide a retrieval leak risk picture for tank C-102 but do not include contributions from other WMA C sources. Projected impacts from other WMA C sources are discussed in Section 7.1.3.

Two sloped lines representing the industrial and residential scenarios were plotted on each graph. The datapoints for these lines were calculated as described in Section 7.1.1 over a range of technetium-99, hexavalent chromium, and nitrite values. Because potential retrieval leak volumes are uncertain, the inventory range was selected to encompass a small leak on the low end and a large leak on the high end. Selection of the inventory range was arbitrary and independent of any assumption on the type of retrieval fluid used (raw water or supernate).

Vertical dashed lines were added to each graph as points of reference to show the estimated current tank C-102 inventory and the inventory associated with a potential 8,000-gal. base case retrieval leak and an estimated worst case 8,000-gal. retrieval leak. The 8,000-gal. volume was a hypothetical volume used only as a point of reference and for consistency with previous analyses. It was not intended to represent anticipated retrieval leak volumes or leak detection limits for tank C-102.

In the event a leak is detected during waste retrieval, the leak monitoring system would be used to estimate the leak volume. The potential human health impacts from the leak could then be evaluated from the leak volume and estimated contaminant concentrations in the leak along with the graphs shown in Figures A-1, A-2, and A-3. Using the graphs, the impacts from leak inventories greater or lesser than those shown for the 8,000-gal. reference volume can be estimated rapidly by extrapolating from the impacts shown for the reference volume.

A2.2 INVENTORY

The reference lines shown in Figures A-1, A-2, and A-3 to indicate current inventory and retrieval leak inventory were developed from the best available data and information. Current inventories were taken from the best-basis inventory by downloading from the Tank Waste Information Network System (TWINS) database (http://twinsweb.pnl.gov/twins.htm). Retrieval leak inventories were calculated by multiplying the hypothetical retrieval leak volume (8,000 gal.) by the estimated retrieval leak fluid concentration. Waste was assumed to be retrieved from tank C-102 by sluicing with recycled supernate from DST AN-101. The retrieval leak fluid concentrations for this retrieval scenario were developed using data from RPP-22521 Rev. 6 and are shown in Table A-1.

Table A-1. Tank C-102 Retrieval Leak Inventory Estimate.

Contaminant	Leak Fluid Concentration *	Inventory in 8,000-gal. Retrieval Leak
Technetium-99	5.84E-05 Ci/L	1.77E+00 Ci
Hexavalent Chromium	3.9E-04 kg/L	1.18E+01 kg
Nitrite	4.59E-02 kg/L	1.39E+03 kg

* Concentrations from Table D-9 of RPP-22521, *Tanks C-101, C-102, C-105, C-110, and C-111 Long Term Waste Retrieval Work Plan*

A2.3 SUMMARY OF IMPACTS FROM HYPOTHETICAL 8,000-GALLON RETRIEVAL LEAK

The technetium-99 inventory associated with a hypothetical 8,000-gal. retrieval leak from tank C-102 was estimated to be approximately 1.77 Ci (RPP-22521 Rev. 6). As shown in Figure A-1, this corresponds to an ILCR of approximately 2.05×10^{-6} for the industrial scenario and 4.99×10^{-5} for the residential scenario. The peak technetium-99 groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately149 pCi/L.

The hexavalent chromium inventory associated with a hypothetical 8,000-gal. retrieval leak from tank C-102 was estimated to be approximately 11.8 kg (RPP-22521 Rev. 6). As shown in Figure A-2, this corresponds to a hazard quotient of approximately 4.00×10^{-3} for the industrial scenario and 2.30×10^{-2} for the residential scenario. The peak hexavalent chromium groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 1.00×10^{-3} mg/L.

The nitrite inventory associated with an 8,000-gal. retrieval leak from tank C-102 was estimated to be approximately 1390 kg (RPP-22392). As shown in Figure A-3, this corresponds to a hazard quotient of approximately 1.15×10^{-2} for the industrial scenario and 7.40×10^{-2} for the residential scenario. The peak nitrite groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 1.17×10^{-1} mg/L.

A2.4 EXAMPLE CALCULATION

To illustrate the calculation method used for the retrieval leak impact graphs, the following example is provided. The example uses the industrial scenario ILCR result of 2.05×10^{-6}. Using Equation 7-1 from Section 7.1.1, the industrial scenario ILCR was calculated as the product of the technetium-99 inventory (Table A-1), the technetium-99 retrieval leak unit groundwater concentration factor (Table 7-2), and the technetium-99 industrial scenario unit risk factor (Table 7-3), as follows:

$$\text{ILCR} = (1.77\ \text{Ci}) \cdot (8.4 \times 10^{1}\ \text{pCi/L per Ci}) \cdot (1.38 \times 10^{-8}\ \text{ILCR per pCi/L}) = 1.42 \times 10^{-6}$$

Complete calculation details are provided in RPP-22392.

A3.0 INADVERTENT INTRUDER IMPACTS

The starting inventories for the tank C-102 intruder calculation were the estimated radionuclide inventories remaining in the tank following retrieval to the Ecology et al. (1989), *Hanford Federal Facility Agreement and Consent Order* (HFFACO) interim retrieval goal of 360 ft^3 of residual waste. These inventories were taken from RPP-15317, *241-C Waste Management Area Inventory Data Package*, and are based on the selective phase removal inventory estimation method. Inventories for all 46 radionuclides reported in the best-basis inventory are provided in RPP-15317 and were used in the calculation (RPP-22392). Inventories for the subset of best-basis inventory radionuclides that were shown in DOE/ORP-2003-11, *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington*, to dominate intruder doses at 500 years after closure are shown in Table A-2.

Table A-2. Tank C-102 Inventory of Dose-Driving Contaminants in 360 ft^3 of Residual Waste.

Radionuclide	Units	Tank C-102
Strontium-90	Ci	5.06E+03
Technetium-99	Ci	1.13E-02
Tin-126	Ci	2.25E-04
Cesium-137	Ci	2.54E+02
Plutonium-239	Ci	2.88E+01
Plutonium-240	Ci	5.28E+00
Americium-241	Ci	9.87E+00

Note: Table 7-1 from RPP-15317, 2003, *241-C Waste Management Area Inventory Data Package*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

Table A-3 summarizes the intruder analysis results for tank C-102. These results were generated using the methodology described in Section 7.2. Complete calculation detail is provided in RPP-22392. Contaminant-specific doses are shown for the subset of radionuclides that dominate the total dose. The total dose shown represents the sum of the dose contributions from all radionuclides considered.

Table A-3. Tank C-102 Intruder Dose.

Radionuclide	Well Driller (mrem EDE)	Suburban Resident with a Garden (mrem/yr EDE)	Rural Farmer with a Dairy Cow (mrem/yr EDE)
Strontium-90	0.000	0.004	0.000
Technetium-99	0.000	0.000	0.000
Tin-126	0.000	0.000	0.000
Cesium-137	0.000	0.000	0.000
Plutonium-239	0.185	1.040	0.047
Plutonium-240	0.033	0.183	0.008
Americium-241	0.044	0.176	0.009
Other radionuclides	0.007	0.032	0.002
TOTAL	0.269	1.435	0.065

Note: The number of significant digits shown in Table A-3 is not intended to imply a level of accuracy greater than the input values.
EDE = effective dose equivalent.

The dose values in Table A-3 are for intrusion at 500 years after closure assuming a grout-stabilized residual waste volume of 360 ft^3. Table A-3 indicates that tank C-102 would not exceed the performance objectives of 500 mrem effective dose equivalent for acute exposure and 100 mrem/yr effective dose equivalent for chronic exposure at 500 years after closure. The total doses at 500 years after closure would be dominated by plutonium-239, plutonium-240, and americium-241.

A4.0 REFERENCES

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APPENDIX B

TANK C-104 LONG TERM HUMAN HEALTH RISK

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LIST OF TERMS

Terms

None required; terms are defined within the document text.

Abbreviations, Acronyms, and Initialisms

DST	double-shell tank
ILCR	incremental lifetime cancer risk
WMA	waste management area

Units

Ci	curie
Ci/L	curies per liter
ft^3	cubic feet
g/L	grams per liter
gal.	gallon
kg	kilogram
kg/L	kilograms per liter
mg/L	milligrams per liter
mrem/yr	millirem per year
pCi/L	picocuries per liter

B1.0 TANK C-104 PRE-RETRIEVAL RISK ASSESSMENT RESULTS

This appendix provides tank-specific pre-retrieval risk assessment results for tank C-104. The information presented was developed using the methodology described in Section 7.0. Groundwater pathway impacts are presented in Section B2.0. Inadvertent intruder impacts are presented in Section B3.0.

B2.0 GROUNDWATER PATHWAY IMPACTS

The groundwater pathway evaluation involved the development of a set of graphical tools to provide a basis for making informed decisions in the event a leak is detected or unexpected retrieval conditions arise during waste retrieval operations. This section provides and discusses the retrieval leak impact graphs generated for tank C-104. The methodology used to generate the graphs is described in Section 7.1.1. Calculation detail for the graphs is provided in RPP-22392, *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan*.

B2.1 RETRIEVAL LEAK IMPACT GRAPHS

Figures B-1 through B-3 provide the tank C-104 waste retrieval leak impact graphs for the three indicator contaminants (technetium-99, hexavalent chromium, and nitrite) identified in Section 7.1.1.1.

Figure B-1. Tank C-104 Technetium-99 Risk Plot.

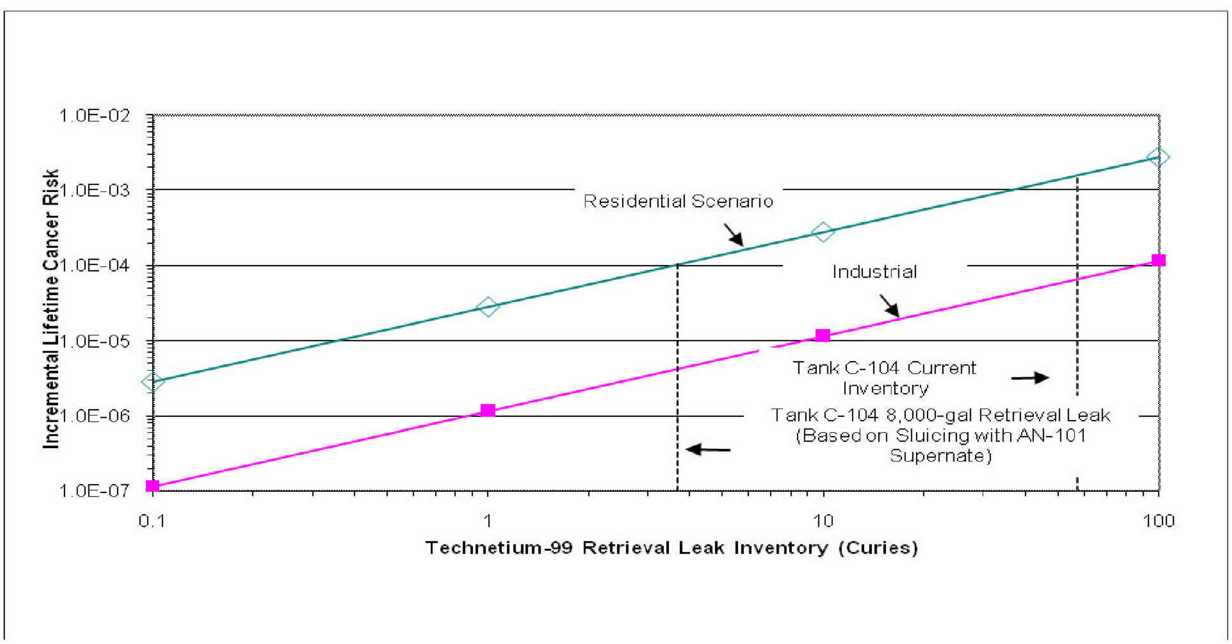

Figure B-2. Tank C-104 Hexavalent Chromium Hazard Quotient Plot.

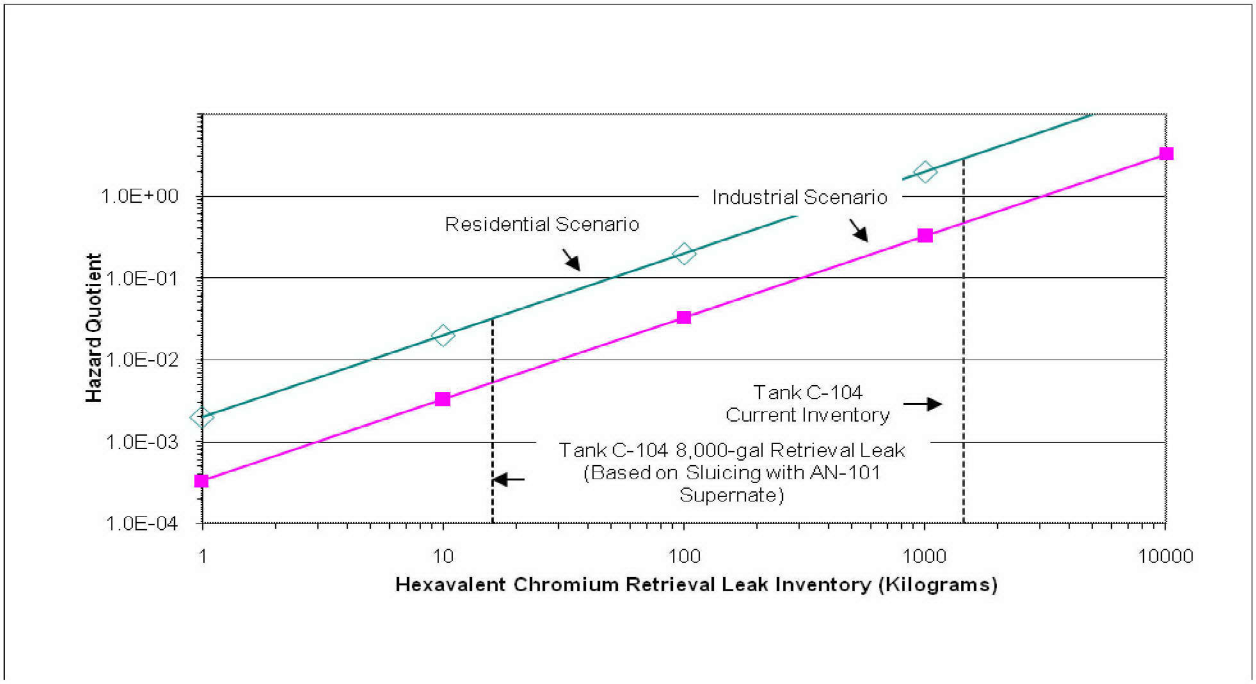

Figure B-3. Tank C-104 Nitrite Hazard Quotient Plot.

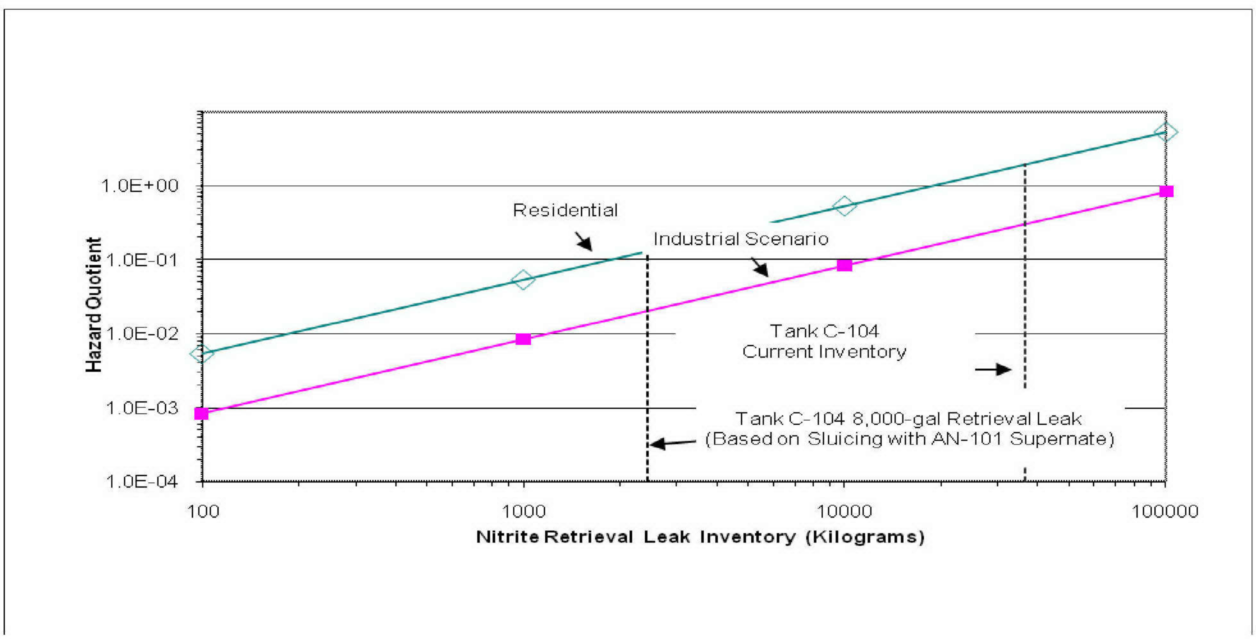

Figure B-1 shows the peak groundwater pathway incremental lifetime cancer risk (ILCR) from technetium-99 as a function of the amount of technetium-99 leaked from tank C-104 during waste retrieval. Figures B-2 and B-3 show the peak groundwater pathway hazard quotient from hexavalent chromium and nitrite, respectively, as a function of the amount of hexavalent chromium and nitrite leaked from tank C-104 during waste retrieval.

The ILCR and hazard quotient values shown on the graphs were based on the predicted peak groundwater concentrations at the waste management area (WMA) C downgradient fenceline. As discussed in Section 7.1.1.3, the projected arrival time of the peaks is approximately the year 2082 based on the supporting contaminant transport analysis in RPP-13774, *Single-Shell Tank System Closure Plan*. The graphs provide a retrieval leak risk picture for tank C-104 but do not include contributions from other WMA C sources. Projected impacts from other WMA C sources are discussed in Section 7.1.3.

Two sloped lines representing the industrial and residential scenarios were plotted on each graph. The datapoints for these lines were calculated as described in Section 7.1.1 over a range of technetium-99, hexavalent chromium, and nitrite values. Because potential retrieval leak volumes are uncertain, the inventory range was selected to encompass a small leak on the low end and a large leak on the high end.

Vertical dashed lines were added to each graph as points of reference to show the estimated current tank C-104 inventory and the inventory associated with a potential 8,000-gal. retrieval leak. The 8,000-gal. volume was a hypothetical volume used only as a point of reference and for consistency with previous analyses. It was not intended to represent anticipated retrieval leak volumes or leak detection limits for tank C-104.

Should the retrieval plan vary from that in Section 3.1.1, the Washington State Department of Ecology will be notified of the change via a change notice form, per Section 9.3 of the HFFACO Action Plan. A retrieval plan variation means: (1) altering the designated DST receiver tank for a given single-shell tank, or (2) making transfers from DSTs other than those listed in Section 3.1.1 into one of the Section 3.1.1 receiver DSTs, which will result in key indicator contaminant concentrations in the receiver DST liquid phase greater than those specified in RPP-22392 for the starting DST supernate concentration. If the 8,000-gal. retrieval leak risk for a revised retrieval plan is not bounded by the impact shown in Figures B-1, B-2, and B-3, revised risk impacts will be provided.

In the event a leak is detected during waste retrieval, the leak monitoring system would be used to estimate the leak volume. The potential human health impacts from the leak could then be evaluated from the leak volume and estimated contaminant concentrations in the leak along with the graphs shown in Figures B-1, B-2, and B-3. Using the graphs, the impacts from leak inventories greater or lesser than those shown for the 8,000-gal. reference volume can be estimated rapidly by extrapolating from the impacts shown for the reference volume.

B2.2 INVENTORY

The reference lines shown in Figures B-1, B-2, and B-3 to indicate current inventory and retrieval leak inventory were developed from the best available data and information. Current inventories were taken from the best-basis inventory by downloading from the Tank Waste Information Network System (TWINS) database (http://twinsweb.pnl.gov/twins.htm). Retrieval leak inventories were calculated by multiplying the hypothetical retrieval leak volume (8,000 gal.) by the estimated retrieval leak fluid concentration. Waste was assumed to be retrieved from tank C-104 by sluicing with recycled supernate from DST AN-101. The retrieval leak fluid concentrations for this retrieval scenario are provided in RPP-22392.

The predicted liquid phase concentrations and resulting tank C-104 leak inventories for the DST AN-101 recycled supernate retrieval scenario are shown in Table B-1. The table also shows leak inventories for a raw water retrieval scenario.

Table B-1. Tank C-104 Retrieval Leak Inventory Comparison for Different Sluicing Fluids.

Contaminant	Leak Fluid Concentration			Inventory in 8,000-gal. Retrieval Leak		
	Tank AN-101 Supernate [a]	Raw Water [b]	Units	Tank AN-101 Supernate	Raw Water	Units
Technetium-99	1.21E-04	1.92E-05	Ci/L	3.66E+00	5.81E-01	Ci
Hexavalent chromium	5.28E-04	4.84E-04	kg/L	1.60E+01	1.47E+01	kg
Nitrite	8.01E-02	1.21E-03	kg/L	2.43E+03	3.66E+02	kg

[a] From RPP-22392, 2009, *Tanks C-102, C-104, C-0107, C-108 and C-112 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan*, Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington.

[b] Addendum C1, Table 9 from RPP-13774, 2004, *Single-Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

Raw water retrieval leak inventories are given in Table B-1 to provide a perspective on the potential effects on retrieval leak impacts caused by sluicing with recirculated DST supernate. The raw water inventories shown are the inventories used for the RPP-13774 base case risk analysis. Those inventories were based on a hypothetical 8,000-gal. retrieval leak volume and retrieval leak fluid concentrations estimated using the Hanford Tank Waste Operations Simulator (HTWOS) model. Because retrieval leak human health impacts are proportional to inventory, comparing the inventory differences provides an indication of the differences in impacts between the two sluicing fluids. Table B-1 indicates raw water leak inventories would be lower than the supernate leak inventories for technetium-99, nitrite, and hexavalent chromium.

B2.3 SUMMARY OF IMPACTS FROM HYPOTHETICAL 8,000-GALLON RETRIEVAL LEAK

The technetium-99 inventory associated with a hypothetical 8,000-gal. retrieval leak from tank C-104 was estimated to be approximately 3.66E+00 Ci (RPP-22392). As shown in Figure B-1, this corresponds to an ILCR of approximately 4.25×10^{-6} for the industrial scenario and 1.03×10^{-4} for the residential scenario. The peak technetium-99 groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 3.08E+02 pCi/L.

The hexavalent chromium inventory associated with a hypothetical 8,000-gal. retrieval leak from tank C-104 was estimated to be approximately 1.6E+01 kg (RPP-22392). As shown in Figure B-2, this corresponds to a hazard quotient of approximately 5.2E-03 for the industrial scenario and 3.1E-02 for the residential scenario. The peak hexavalent chromium groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 1.3E-03 mg/L.

The nitrite inventory associated with an 8,000-gal. retrieval leak from tank C-104 was estimated to be approximately 2.43E+03 kg (RPP-22392). As shown in Figure B-3, this corresponds to a hazard quotient of approximately 2.0E-02 for the industrial scenario and 1.3E-01 for the residential scenario. The peak nitrite groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 2.0E-01 mg/L.

B2.4 EXAMPLE CALCULATION

To illustrate the calculation method used for the retrieval leak impact graphs, the following example is provided. The example uses the industrial scenario ILCR result of 4.25 × 10-6. Using Equation 7-1 from Section 7.1.1, the industrial scenario ILCR was calculated as the product of the technetium-99 inventory (Table B-1), the technetium-99 retrieval leak unit groundwater concentration factor (Table 7-2), and the technetium-99 industrial scenario unit risk factor (Table 7-3), as follows:

$$\text{ILCR} = (3.66\ \text{Ci}) \cdot (8.4 \times 10^{1}\ \text{pCi/L per Ci}) \cdot (1.38 \times 10^{-8}\ \text{ILCR per pCi/L}) = 4.25 \times 10^{-6}$$

Complete calculation details are provided in RPP-22392.

B3.0 INADVERTENT INTRUDER IMPACTS

The starting inventories for the tank C-104 intruder calculation were the estimated radionuclide inventories remaining in the tank following retrieval to the Ecology et al. (1989), *Hanford Federal Facility Agreement and Consent Order* (HFFACO) interim retrieval goal of 360 ft^3 of residual waste. These inventories were taken from RPP-15317, *241-C Waste Management Area Inventory Data Package*, and are based on the selective phase removal inventory estimation method. Inventories for all 46 radionuclides reported in the best-basis inventory are provided in RPP-15317 and were used in the calculation (RPP-22392). Inventories for the subset of best-basis inventory radionuclides that were shown in DOE/ORP-2003-11, *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington*, to dominate intruder doses at 500 years after closure are shown in Table B-2.

Table B-3 summarizes the intruder analysis results for tank C-104. These results were generated using the methodology described in Section 7.2. Complete calculation detail is provided in RPP-22392. Contaminant-specific doses are shown for the subset of radionuclides that dominate the total dose. The total dose shown represents the sum of the dose contributions from all radionuclides considered.

Table B-2. Tank C-104 Inventory of Dose-Driving Contaminants in 360 ft^3 of Residual Waste.

Radionuclide	Units	Tank C-104
Strontium-90	Ci	5.04E+03
Technetium-99	Ci	6.02E-01
Tin-126	Ci	1.79E-02
Cesium-137	Ci	9.93E+02
Plutonium-239	Ci	5.69E+01
Plutonium-240	Ci	1.12E+01
Americium-241	Ci	6.60E+01

Note: Table 7-1 from RPP-15317, 2003, *241-C Waste Management Area Inventory Data Package*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

Table B-3. Tank C-104 Intruder Dose.

Radionuclide	Well Driller (mrem EDE)	Suburban Resident with a Garden (mrem/yr EDE)	Rural Farmer with a Dairy Cow (mrem/yr EDE)
Strontium-90	0.000	0.004	0.000
Technetium-99	0.000	0.016	0.000
Tin-126	0.009	0.009	0.001
Cesium-137	0.001	0.001	0.000
Plutonium-239	0.365	2.054	0.092
Plutonium-240	0.069	0.389	0.018
Americium-241	0.291	1.171	0.057
Other radionuclides	0.079	0.315	0.017
TOTAL	0.814	3.959	0.185

Note: The number of significant digits shown in Table B-3 is not intended to imply a level of accuracy greater than the input values.
EDE = effective dose equivalent.

The dose values in Table B-3 are for intrusion at 500 years after closure assuming a grout-stabilized residual waste volume of 360 ft^3. Table B-3 indicates that tank C-104 would not exceed the performance objectives of 500 mrem effective dose equivalent for acute exposure and 100 mrem/yr effective dose equivalent for chronic exposure at 500 years after closure. The total doses at 500 years after closure would be dominated by plutonium-239, plutonium-240, and americium-241.

B4.0 REFERENCES

DOE/ORP-2003-11, 2003, *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

RPP-13774, 2004, *Single-Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

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APPENDIX C

TANK C-107 LONG-TERM HUMAN HEALTH RISK

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LIST OF TERMS

Terms

None required; terms are defined within the document text.

Abbreviations, Acronyms, and Initialisms

DST	double-shell tank
ILCR	incremental lifetime cancer risk
WMA	waste management area

Units

Ci	curie
Ci/L	curies per liter
ft^3	cubic feet
g/L	grams per liter
gal.	gallon
kg	kilogram
kg/L	kilograms per liter
mg/L	milligrams per liter
mrem/yr	millirem per year
pCi/L	picocuries per liter

C1.0 TANK C-107 PRE-RETRIEVAL RISK ASSESSMENT RESULTS

This appendix provides tank-specific pre-retrieval risk assessment results for tank C-107. The information presented was developed using the methodology described in Section 7.0. Groundwater pathway impacts are presented in Section C2.0. Inadvertent intruder impacts are presented in Section C3.0.

C2.0 GROUNDWATER PATHWAY IMPACTS

The groundwater pathway evaluation involved the development of a set of graphical tools to provide a basis for making informed decisions in the event a leak is detected or unexpected retrieval conditions arise during waste retrieval operations. This section provides and discusses the retrieval leak impact graphs generated for tank C-107. The methodology used to generate the graphs is described in Section 7.1.1. Calculation detail for the graphs is provided in RPP-22392, *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan*.

C2.1 RETRIEVAL LEAK IMPACT GRAPHS

Figures C-1 through C-3 provide the tank C-107 waste retrieval leak impact graphs for the three indicator contaminants (technetium-99, hexavalent chromium, and nitrite) identified in Section 7.1.1.1.

Figure C-1. Tank C-107 Technetium-99 Risk Plot.

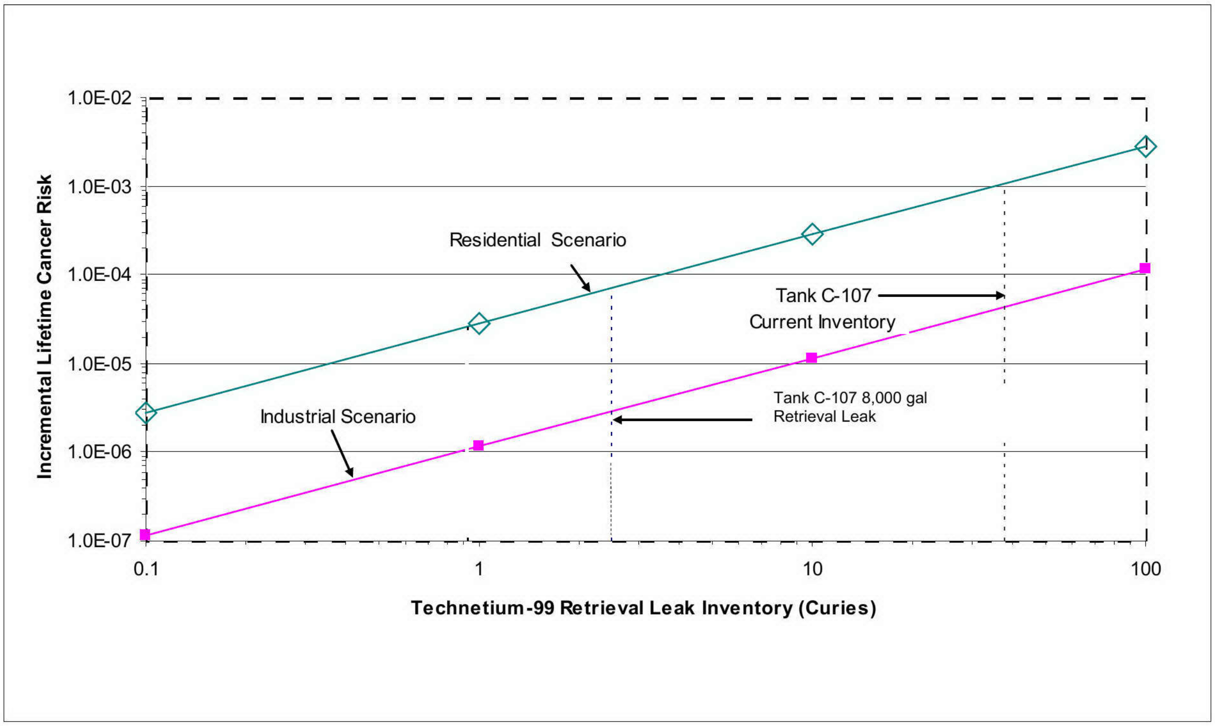

Figure C-2. Tank C-107 Hexavalent Chromium Hazard Quotient Plot.

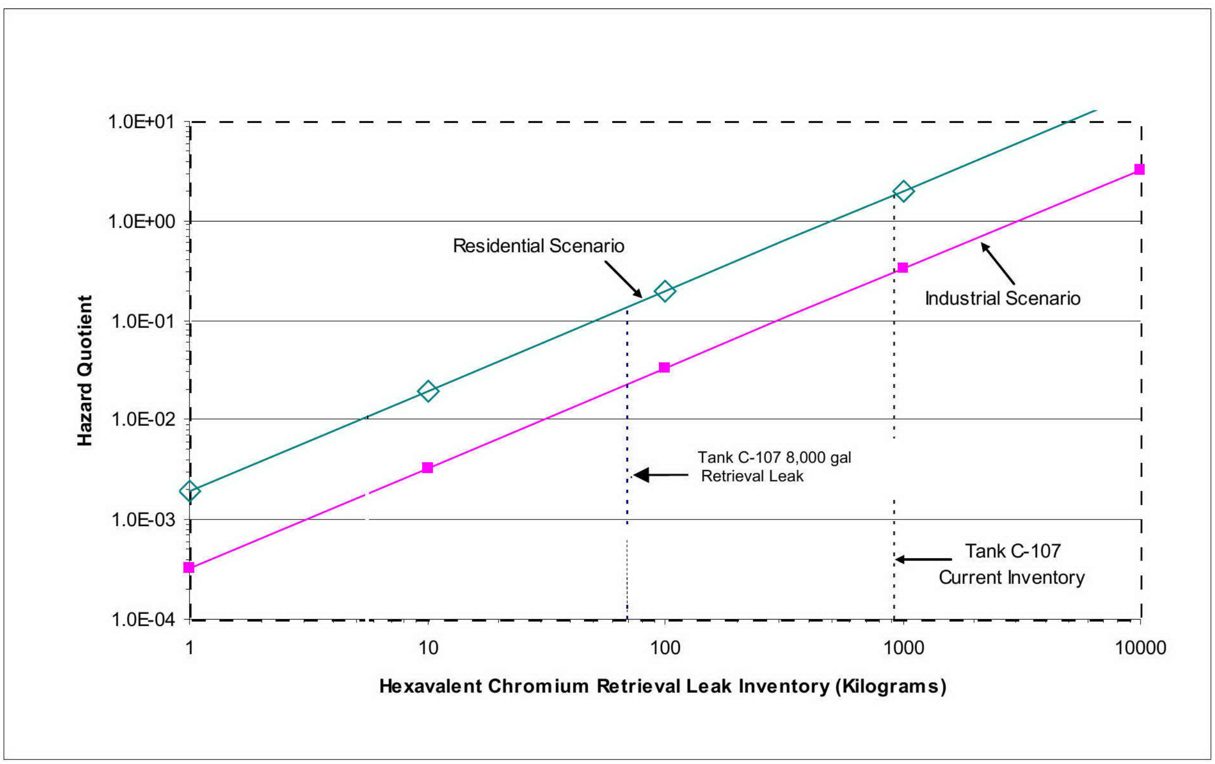

Figure C-3. Tank C-107 Nitrite Hazard Quotient Plot.

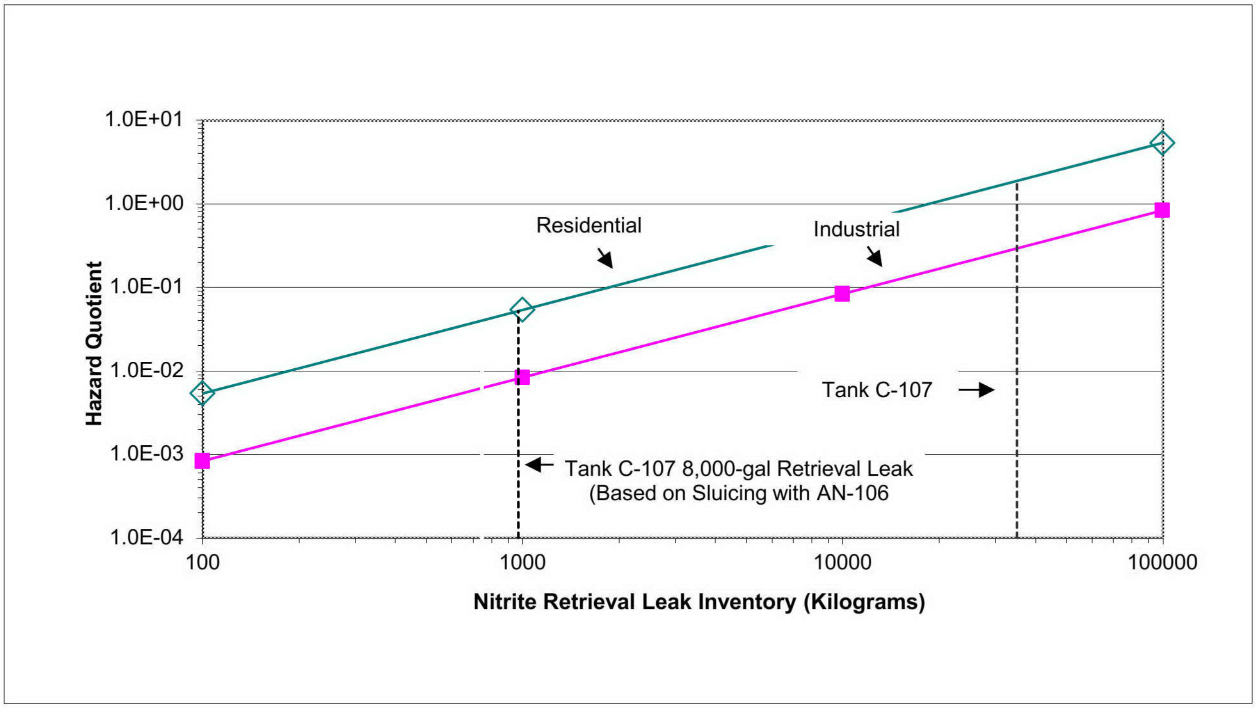

Figure C-1 shows the peak groundwater pathway incremental lifetime cancer risk (ILCR) from technetium-99 as a function of the amount of technetium-99 leaked from tank C-107 during waste retrieval. Figures C-2 and C-3 show the peak groundwater pathway hazard quotient from hexavalent chromium and nitrite, respectively, as a function of the amount of hexavalent chromium and nitrite leaked from tank C-107 during waste retrieval.

The ILCR and hazard quotient values shown on the graphs were based on the predicted peak groundwater concentrations at the waste management area (WMA) C downgradient fenceline. As discussed in Section 7.1.1.3, the projected arrival time of the peaks is approximately the year 2082 based on the supporting contaminant transport analysis in RPP-13774, *Single-Shell Tank System Closure Plan*. The graphs provide a retrieval leak risk picture for tank C-107 but do not include contributions from other WMA C sources. Projected impacts from other WMA C sources are discussed in Section 7.1.3.

Two sloped lines representing the industrial and residential scenarios were plotted on each graph. The datapoints for these lines were calculated as described in Section 7.1.1 over a range of technetium-99, hexavalent chromium, and nitrite values. Because potential retrieval leak volumes are uncertain, the inventory range was selected to encompass a small leak on the low end and a large leak on the high end.

Vertical dashed lines were added to each graph as points of reference to show the estimated current tank C-107 inventory and the inventory associated with a potential 8,000-gal. retrieval leak. The 8,000-gal. volume was a hypothetical volume used only as a point of reference and for consistency with previous analyses. It was not intended to represent anticipated retrieval leak volumes or leak detection limits for tank C-107.

Should the retrieval plan vary from that in Section 3.1.1, the Washington State Department of Ecology will be notified of the change via a change notice form, per Section 9.3 of the HFFACO Action Plan. A retrieval plan variation means: (1) altering the designated DST receiver tank for a given single-shell tank, or (2) making transfers from DSTs other than those listed in Section 3.1.1 into one of the Section 3.1.1 receiver DSTs, which will result in key indicator contaminant concentrations in the receiver DST liquid phase greater than those specified in RPP-22392 for the starting DST supernate concentration. If the 8,000-gal. retrieval leak risk for a revised retrieval plan is not be bounded by the assumed worst case impact shown in Figures C-1, C-2, and C-3, revised risk impacts will be provided.

In the event a leak is detected during waste retrieval, the leak monitoring system would be used to estimate the leak volume. The potential human health impacts from the leak could then be evaluated from the leak volume and estimated contaminant concentrations in the leak along with the graphs shown in Figures C-1, C-2, and C-3. Using the graphs, the impacts from leak inventories greater or lesser than those shown for the 8,000-gal. reference volume can be estimated rapidly by extrapolating from the impacts shown for the reference volume.

C2.2 INVENTORY

The reference lines shown in Figures C-1, C-2, and C-3 to indicate current inventory and retrieval leak inventory were developed from the best available data and information. Current inventories were taken from the best-basis inventory by downloading from the Tank Waste Information Network System (TWINS) database (http://twinsweb.pnl.gov/twins.htm). Retrieval leak inventories were calculated by multiplying the hypothetical retrieval leak volume (8,000 gal.) by the estimated retrieval leak fluid concentration. Waste was assumed to be retrieved from tank C-107 by sluicing with recycled supernate from DST AN-106. The retrieval leak fluid concentrations for this retrieval scenario are provided in RPP-22392.

The predicted liquid phase concentrations and resulting tank C-107 leak inventories for the DST AN-106 recycled supernate retrieval scenario are shown in Table C-1. The table also shows leak inventories for a raw water retrieval scenario.

Table C-1. Tank C-107 Retrieval Leak Inventory Comparison for Different Sluicing Fluids.

Contaminant	Leak Fluid Concentration			Inventory in 8,000-gal. Retrieval Leak		
	Tank AN-106 Supernate [a]	Raw Water [b]	Units	Tank AN-106 Supernate	Raw Water	Units
Technetium-99	3.08E-05	1.75E-05	Ci/L	9.33E-01	5.30E-01	Ci
Hexavalent Chromium	1.86E-04	4.29E-04	kg/L	5.62E+00	1.30E+01	kg
Nitrite	3.2E-02	1.63E-03	kg/L	9.69E+02	4.94E+02	kg

[a] From RPP-22392, 2009, *Tanks C-102, C-104, C-107, C-108 and C-112 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan*, Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington. [b] Addendum C1, Table 9 from RPP-13774, 2004, *Single-Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

Raw water retrieval leak inventories are given in Table C-1 to provide a perspective on the potential effects on retrieval leak impacts caused by sluicing with recirculated DST supernate. The raw water inventories shown are the inventories used for the RPP-13774 base case risk analysis. Those inventories were based on a hypothetical 8,000-gal. retrieval leak volume and retrieval leak fluid concentrations estimated using the Hanford Tank Waste Operations Simulator (HTWOS) model. Because retrieval leak human health impacts are proportional to inventory, comparing the inventory differences provides an indication of the differences in impacts between the two sluicing fluids. Table C-1 indicates raw water leak inventories would be slightly lower than the supernate leak inventories for technetium-99 and nitrite and slightly higher for hexavalent chromium.

C2.3 SUMMARY OF IMPACTS FROM HYPOTHETICAL 8,000-GALLON RETRIEVAL LEAK

The technetium-99 inventory associated with a hypothetical 8,000-gal. retrieval leak from tank C-107 was estimated to be approximately 0.933 Ci (RPP-22392). As shown in Figure C-1, this corresponds to an ILCR of approximately 1.08×10^{-6} for the industrial scenario and 2.63×10^{-5} for the residential scenario. The peak technetium-99 groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 78.4 pCi/L.

The hexavalent chromium inventory associated with a hypothetical 8,000-gal. retrieval leak from tank C-107 was estimated to be approximately 5.6 kg (RPP-22392). As shown in Figure C-2, this corresponds to a hazard quotient of approximately 0.0018 for the industrial scenario and 0.011 for the residential scenario. The peak hexavalent chromium groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 0.00047 mg/L.

The nitrite inventory associated with an 8,000-gal. retrieval leak from tank C-107 was estimated to be approximately 969 kg (RPP-22392). As shown in Figure C-3, this corresponds to a hazard quotient of approximately 0.0080 for the industrial scenario and 0.051 for the residential scenario. The peak nitrite groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 0.081 mg/L.

C2.4 EXAMPLE CALCULATION

To illustrate the calculation method used for the retrieval leak impact graphs, the following example is provided. The example uses the industrial scenario ILCR result of 1.08×10^{-6}. Using Equation 7-1 from Section 7.1.1, the industrial scenario ILCR was calculated as the product of the technetium-99 inventory (Table C-1), the technetium-99 retrieval leak unit groundwater concentration factor (Table 7-2), and the technetium-99 industrial scenario unit risk factor (Table 7-3), as follows:

$$\text{ILCR} = (0.933\ \text{Ci}) \cdot (8.4 \times 10^{1}\ \text{pCi/L per Ci}) \cdot (1.38 \times 10^{-8}\ \text{ILCR per pCi/L}) = 1.08 \times 10^{-6}$$

Complete calculation details are provided in RPP-22392.

C3.0 INADVERTENT INTRUDER IMPACTS

The starting inventories for the tank C-107 intruder calculation were the estimated radionuclide inventories remaining in the tank following retrieval to the Ecology et al. (1989), *Hanford Federal Facility Agreement and Consent Order* (HFFACO) interim retrieval goal of 360 ft^3 of residual waste. These inventories were taken from RPP-15317, *241-C Waste Management Area Inventory Data Package*, and are based on the selective phase removal inventory estimation method. Inventories for all 46 radionuclides reported in the best-basis inventory are provided in RPP-15317 and were used in the calculation (RPP-22392). Inventories for the subset of best-basis inventory radionuclides that were shown in DOE/ORP-2003-11, *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington*, to dominate intruder doses at 500 years after closure are shown in Table C-2.

Table C-2. Tank C-107 Inventory of Dose-Driving Contaminants in 360 ft^3 of Residual Waste.

Radionuclide	Units	Tank C-107
Strontium-90	Ci	2.43E+04
Technetium-99	Ci	4.11E-01
Tin-126	Ci	6.91E-01
Cesium-137	Ci	6.89E+02
Plutonium-239	Ci	2.34E+01
Plutonium-240	Ci	4.27E+00
Americium-241	Ci	7.32E+01

Note: Table 7-1 from RPP-15317, 2003, *241-C Waste Management Area Inventory Data Package*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

Table C-3 summarizes the intruder analysis results for tank C-107. These results were generated using the methodology described in Section 7.2. Complete calculation detail is provided in RPP-22392. Contaminant-specific doses are shown for the subset of radionuclides that dominate the total dose. The total dose shown represents the sum of the dose contributions from all radionuclides considered.

Table C-3. Tank C-107 Intruder Dose.

Radionuclide	Well Driller (mrem EDE)	Suburban Resident with a Garden (mrem/yr EDE)	Rural Farmer with a Dairy Cow (mrem/yr EDE)
Strontium-90	0.000	0.020	0.001
Technetium-99	0.000	0.011	0.000
Tin-126	0.359	0.348	0.036
Cesium-137	0.001	0.001	0.000
Plutonium-239	0.150	0.845	0.038
Plutonium-240	0.026	0.148	0.007
Americium-241	0.323	1.302	0.063
Other radionuclides	0.001	0.005	0.001
TOTAL	0.860	2.680	0.146

Note: The number of significant digits shown in Table C-3 is not intended to imply a level of accuracy greater than the input values.
EDE = effective dose equivalent.

The dose values in Table C-3 are for intrusion at 500 years after closure assuming a grout-stabilized residual waste volume of 360 ft^3. Table C-3 indicates that tank C-107 would not exceed the performance objectives of 500 mrem effective dose equivalent for acute exposure and 100 mrem/yr effective dose equivalent for chronic exposure at 500 years after closure. The total doses at 500 years after closure would be dominated by tin-126, plutonium-239, and americium-241.

C4.0 REFERENCES

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APPENDIX D

TANK C-108 LONG-TERM HUMAN HEALTH RISK

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Terms

None required; terms are defined within the document text.

Abbreviations, Acronyms, and Initialisms

DST	double-shell tank
ILCR	incremental lifetime cancer risk
WMA	waste management area

Units

Ci	curie
Ci/L	curies per liter
ft^3	cubic feet
g/L	grams per liter
gal.	gallon
kg	kilogram
kg/L	kilograms per liter
mg/L	milligrams per liter
mrem/yr	millirem per year
pCi/L	picocuries per liter

D1.0 TANK C-108 PRE-RETRIEVAL RISK ASSESSMENT RESULTS

This appendix provides tank-specific pre-retrieval risk assessment results for tank C-108. The information presented was developed using the methodology described in Section 7.0. Groundwater pathway impacts are presented in Section D2.0. Inadvertent intruder impacts are presented in Section D3.0.

D2.0 GROUNDWATER PATHWAY IMPACTS

The groundwater pathway evaluation involved the development of a set of graphical tools to provide a basis for making informed decisions in the event a leak is detected or unexpected retrieval conditions arise during waste retrieval operations. This section provides and discusses the retrieval leak impact graphs generated for tank C-108. The methodology used to generate the graphs is described in Section 7.1.1. Calculation detail for the graphs is provided in RPP-22392, *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan*.

D2.1 RETRIEVAL LEAK IMPACT GRAPHS

Figures D-1 through D-3 provide the tank C-108 waste retrieval leak impact graphs for the three indicator contaminants (technetium-99, hexavalent chromium, and nitrite) identified in Section 7.1.1.1.

Figure D-1. Tank C-108 Technetium-99 Risk Plot.

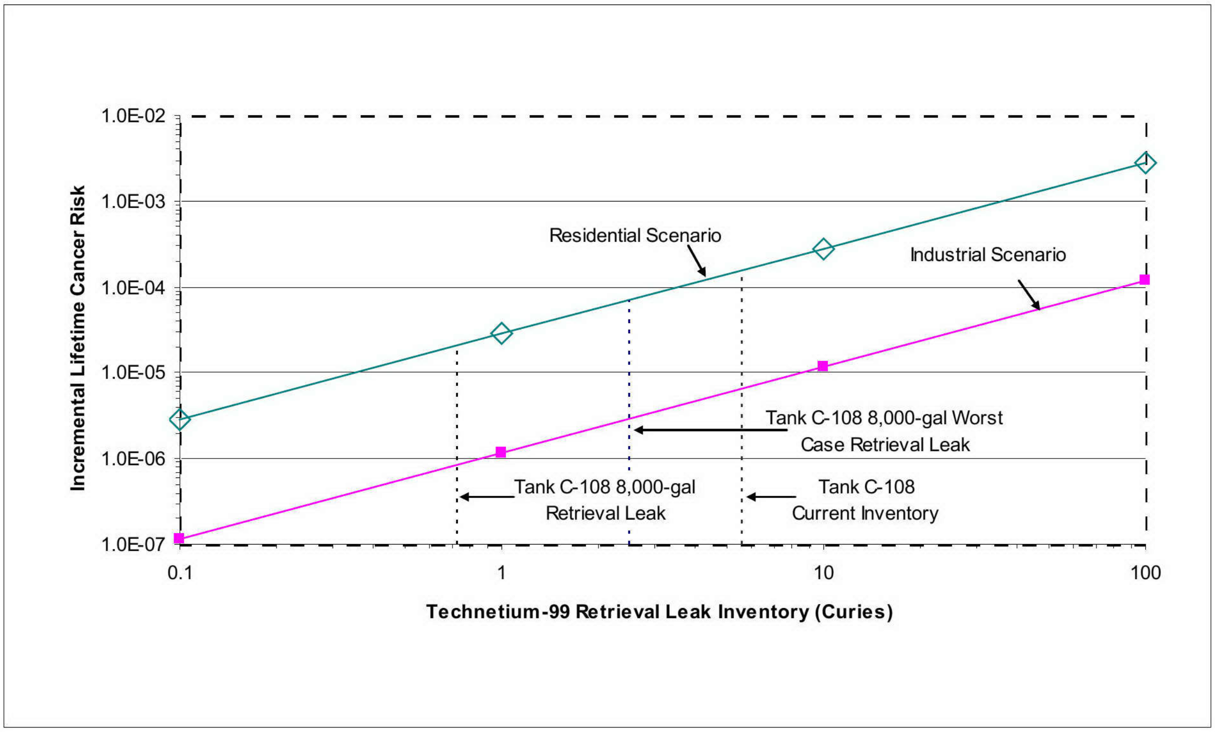

Figure D-2. Tank C-108 Hexavalent Chromium Hazard Quotient Plot.

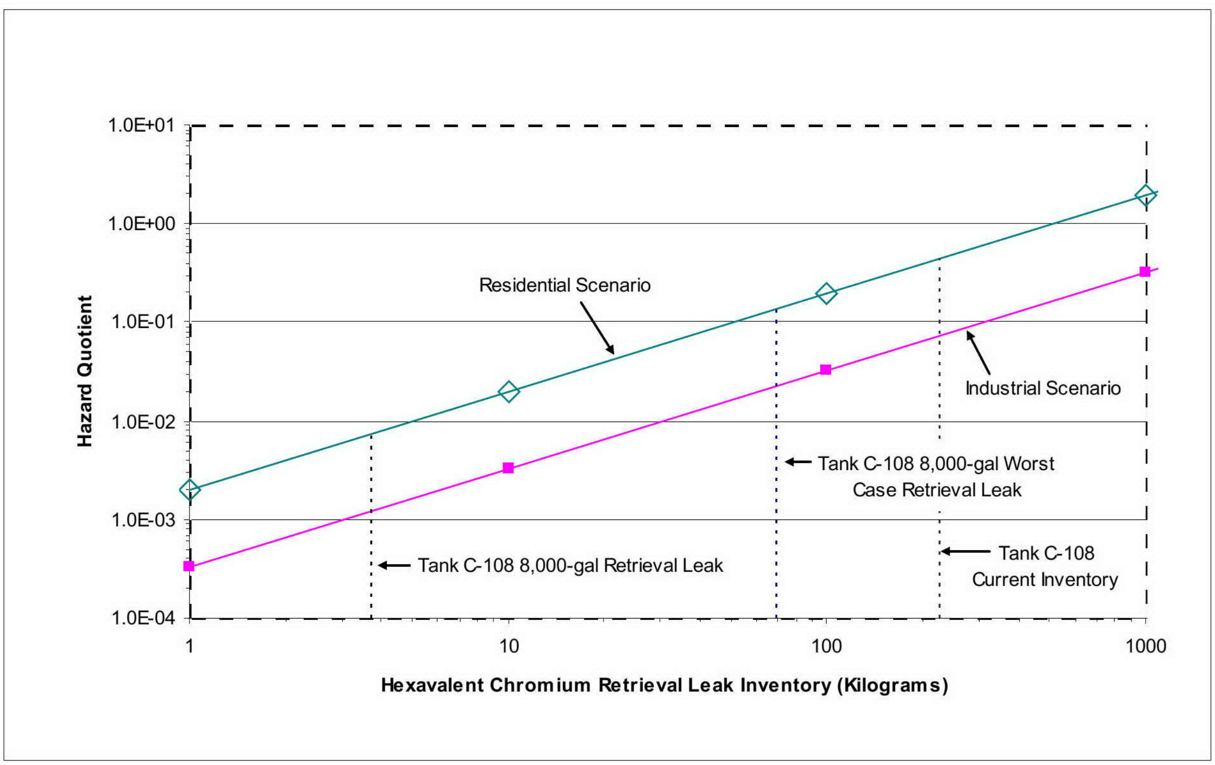

Figure D-3. Tank C-108 Nitrite Hazard Quotient Plot.

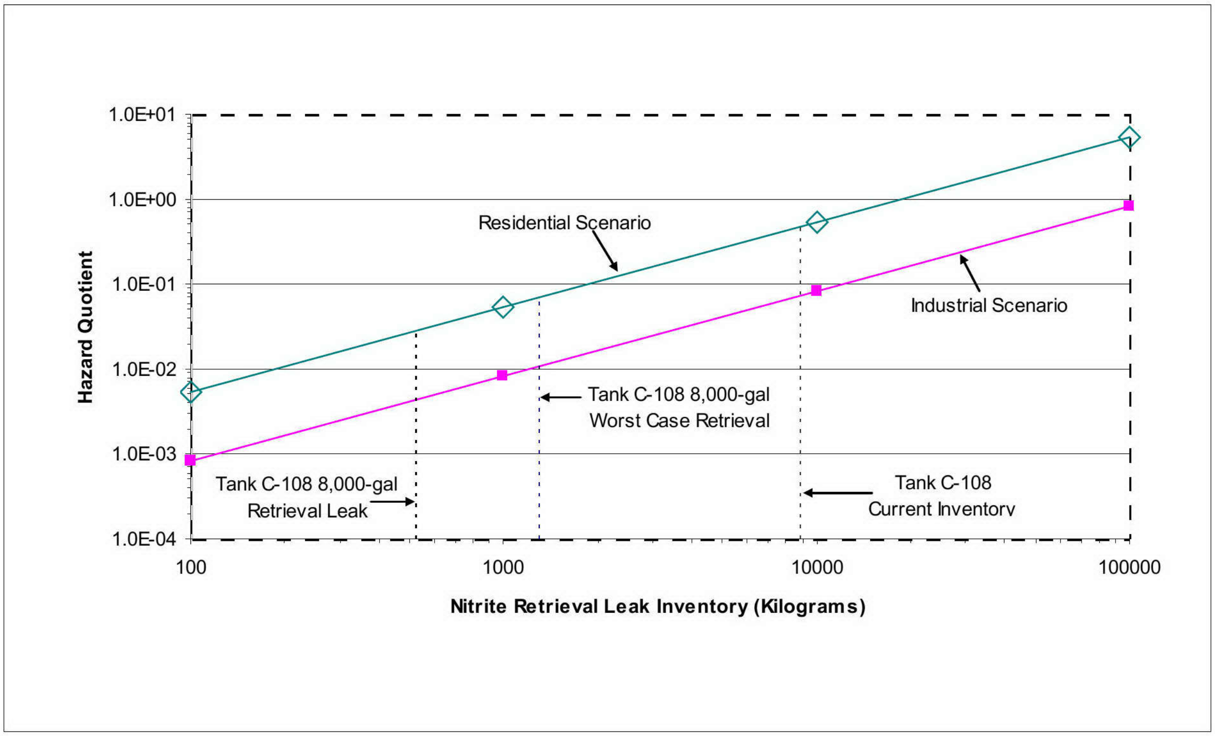

Figure D-1 shows the peak groundwater pathway incremental lifetime cancer risk (ILCR) from technetium-99 as a function of the amount of technetium-99 leaked from tank C-108 during waste retrieval. Figures D-2 and D-3 show the peak groundwater pathway hazard quotient from hexavalent chromium and nitrite, respectively, as a function of the amount of hexavalent chromium and nitrite leaked from tank C-108 during waste retrieval.

The ILCR and hazard quotient values shown on the graphs were based on the predicted peak groundwater concentrations at the waste management area (WMA) C downgradient fenceline. As discussed in Section 7.1.1.3, the projected arrival time of the peaks is approximately the year 2082 based on the supporting contaminant transport analysis in RPP-13774, *Single-Shell Tank System Closure Plan*. The graphs provide a retrieval leak risk picture for tank C-108 but do not include contributions from other WMA C sources. Projected impacts from other WMA C sources are discussed in Section 7.1.3.

Two sloped lines representing the industrial and residential scenarios were plotted on each graph. The datapoints for these lines were calculated as described in Section 7.1.1 over a range of technetium-99, hexavalent chromium, and nitrite values. Because potential retrieval leak volumes are uncertain, the inventory range was selected to encompass a small leak on the low end and a large leak on the high end. Selection of the inventory range was arbitrary and independent of any assumption on the type of retrieval fluid used (raw water or supernate).

Vertical dashed lines were added to each graph as points of reference to show the estimated current tank C-108 inventory and the inventory associated with a potential 8,000-gal. base case retrieval leak and an estimated worst case 8,000-gal. retrieval leak. The 8,000-gal. volume was a hypothetical volume used only as a point of reference and for consistency with previous analyses. It was not intended to represent anticipated retrieval leak volumes or leak detection limits for tank C-108.

The planning for tanks C-102, C-104, C-107, C-108, and C-112 waste retrieval as of mid March 2005 is given in Section 3.1.1. RPP-21753, *C Farm 100-Series Tanks, Retrieval Process Flowsheet Description*, provides an estimated flowsheet for the C tank farm waste retrieval process based upon this planning. However, there are numerous possible combinations of which single-shell tanks can go to which double-shell tanks (DSTs) and in which order.
These combinations are further complicated with the retrieval of other C farm tanks not included in this tank waste retrieval work plan. It is impractical to provide flowsheets and preliminary risk evaluations that look at all possible combinations of tanks and tank retrieval order when the end result is not expected to cause any significant change in the risk associated with the overall waste retrieval process. Therefore, the dotted lines in Figures D-1, D-2, and D-3 provide the calculated risk impacts for an 8,000-gal. retrieval leak based upon the retrieval plan in Section 3.1.1, and an assumed worst case 8,000-gal. retrieval leak.

The base case 8,000-gal. leak uses concentrations obtained from RPP-21753, with the sluicing supernate coming from the DSTs specified in Section 3.1.1. The assumed worst case 8,000-gal. leak for technetium-99 is based upon sluicing with a technetium-99 concentration of 8.3×10^{-5} Ci/L. The assumed worst case 8,000-gal. leak for chromium is based upon sluicing with a chromium concentration of 2.3 g/L. The assumed worst case 8,000-gal. leak for nitrite is based upon sluicing with a nitrite concentration of 43 g/L.

The worst case technetium-99 concentration assumes sluicing with tank AY-101 supernate following waste retrieval from tank C-112. The worst case chromium concentration assumes sluicing with tank AY-101 supernate only (the tank AY-101 supernate chromium concentration is sufficiently high that the supernate chromium concentration will be reduced as single-shell tank waste retrieval proceeds). The worst case nitrite concentration assumes sluicing with tank AY-101 supernate following waste retrieval from tanks C-104 and C-107. The worst case concentrations are estimates only and can vary with the amount of raw water added during waste retrieval or a number of other factors. The worst case concentrations are not based upon any planned waste retrieval sequence, they just represent more restrictive mixes of the five single-shell tanks with a receiver DST for the tanks discussed in this tank waste retrieval work plan.

Should the retrieval plan vary from that in Section 3.1.1, the Washington State Department of Ecology will be notified of the change via a change notice form, per Section 9.3 of the HFFACO Action Plan. A retrieval plan variation means: (1) altering the designated DST receiver tank for a given single-shell tank, or (2) making transfers from DSTs other than those listed in Section 3.1.1 into one of the Section 3.1.1 receiver DSTs, which will result in key indicator contaminant concentrations in the receiver DST liquid phase greater than those specified in RPP-21753 for the starting DST supernate concentration. A statement will be included on the change notice form that the estimated risk associated with the revised waste retrieval plan is bounded by the assumed worst case impact shown in Figures D-1, D-2, and D-3. Alternatively, if the 8,000-gal. retrieval leak risk for a revised retrieval plan may not be bounded by the assumed worst case impact shown in Figures D-1, D-2, and D-3, revised risk impacts will be provided.

In the event a leak is detected during waste retrieval, the leak monitoring system would be used to estimate the leak volume. The potential human health impacts from the leak could then be evaluated from the leak volume and estimated contaminant concentrations in the leak along with the graphs shown in Figures D-1, D-2, and D-3. Using the graphs, the impacts from leak inventories greater or lesser than those shown for the 8,000-gal. reference volume can be estimated rapidly by extrapolating from the impacts shown for the reference volume.

D2.2 INVENTORY

The reference lines shown in Figures D-1, D-2, and D-3 to indicate current inventory and retrieval leak inventory were developed from the best available data and information. Current inventories were taken from the best-basis inventory by downloading from the Tank Waste Information Network System (TWINS) database (http://twinsweb.pnl.gov/twins.htm). Retrieval leak inventories were calculated by multiplying the hypothetical retrieval leak volume (8,000 gal.) by the estimated retrieval leak fluid concentration. Waste was assumed to be retrieved from tank C-108 by sluicing with recycled supernate from DST AN-106. The retrieval leak fluid concentrations for this retrieval scenario were developed using data from RPP-21753.

The RPP-21753 flowsheet description provides calculated time-phased contaminant concentrations in both the recycled supernate and the retrieved slurry. The flowsheet assumes a retrieval sequence and includes DST-to-DST transfers necessary to maintain waste volume within overall DST space limits. The flowsheet also includes planned near-term waste retrieval actions that would affect the tank inventory (e.g., C farm 200-series tanks waste retrieval).

The retrieval leak fluid concentrations used to develop the estimated leak inventories shown on the graphs were taken from the predicted liquid phase concentrations given in RPP-21753. The predicted liquid phase concentrations and resulting tank C-108 leak inventories for the DST AN-106 recycled supernate retrieval scenario are shown in Table D-1. The table also shows leak inventories for a raw water retrieval scenario.

Table D-1. Tank C-108 Retrieval Leak Inventory Comparison for Different Sluicing Fluids.

Contaminant	Leak Fluid Concentration			Inventory in 8,000-gal. Retrieval Leak		
	Tank AN-106 Supernate [a]	Raw Water [b]	Units	Tank AN-106 Supernate	Raw Water	Units
Technetium-99	2.41E-05	6.64E-06	Ci/L	7.29E-01	2.01E-01	Ci
Hexavalent chromium	1.24E-04	2.49E-04	kg/L	3.74E+00	7.54E+00	kg
Nitrite	1.75E-02	9.38E-03	kg/L	5.29E+02	2.84E+02	kg

[a] Appendix D, Table D-3 from RPP-21753, 2005, *C-Farm 100 Series Tanks, Retrieval Process Flowsheet Description*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

[b] Addendum C1, Table 9 from RPP-13774, 2004, *Single-Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

Raw water retrieval leak inventories are given in Table D-1 to provide a perspective on the potential effects on retrieval leak impacts caused by sluicing with recirculated DST supernate. The raw water inventories shown are the inventories used for the RPP-13774 base case risk analysis. Those inventories were based on a hypothetical 8,000-gal. retrieval leak volume and retrieval leak fluid concentrations estimated using the Hanford Tank Waste Operations Simulator (HTWOS) model. Because retrieval leak human health impacts are proportional to inventory, comparing the inventory differences provides an indication of the differences in impacts between the two sluicing fluids. Table D-1 indicates raw water leak inventories would be slightly lower than the supernate leak inventories for technetium-99 and nitrite and slightly higher for hexavalent chromium.

D2.3 SUMMARY OF IMPACTS FROM HYPOTHETICAL 8,000-GALLON RETRIEVAL LEAK

The technetium-99 inventory associated with a hypothetical 8,000-gal. retrieval leak from tank C-108 was estimated to be approximately 0.729 Ci (RPP-22392). As shown in Figure D-1, this corresponds to an ILCR of approximately 8.46×10^{-7} for the industrial scenario and 2.06×10^{-5} for the residential scenario. The peak technetium-99 groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 61.3 pCi/L.

The hexavalent chromium inventory associated with a hypothetical 8,000-gal. retrieval leak from tank C-108 was estimated to be approximately 3.7 kg (RPP-22392). As shown in Figure D-2, this corresponds to a hazard quotient of approximately 0.001 for the industrial scenario and 0.007 for the residential scenario. The peak hexavalent chromium groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 0.0003 mg/L.

The nitrite inventory associated with an 8,000-gal. retrieval leak from tank C-108 was estimated to be approximately 529 kg (RPP-22392). As shown in Figure D-3, this corresponds to a hazard quotient of approximately 0.004 for the industrial scenario and 0.028 for the residential scenario. The peak nitrite groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 0.044 mg/L.

D2.4 EXAMPLE CALCULATION

To illustrate the calculation method used for the retrieval leak impact graphs, the following example is provided. The example uses the industrial scenario ILCR result of 8.46×10^{-7}. Using Equation 7-1 from Section 7.1.1, the industrial scenario ILCR was calculated as the product of the technetium-99 inventory (Table D-1), the technetium-99 retrieval leak unit groundwater concentration factor (Table 7-2), and the technetium-99 industrial scenario unit risk factor (Table 7-3), as follows:

$$\text{ILCR} = (0.7295\ \text{Ci}) \cdot (8.4 \times 10^{1}\ \text{pCi/L per Ci}) \cdot (1.38 \times 10^{-8}\ \text{ILCR per pCi/L}) = 8.46 \times 10^{-7}$$

Complete calculation details are provided in RPP-22392.

D3.0 INADVERTENT INTRUDER IMPACTS

The starting inventories for the tank C-108 intruder calculation were the estimated radionuclide inventories remaining in the tank following retrieval to the Ecology et al. (1989), *Hanford Federal Facility Agreement and Consent Order* (HFFACO) interim retrieval goal of 360 ft^3 of residual waste. These inventories were taken from RPP-15317, *241-C Waste Management Area Inventory Data Package*, and are based on the selective phase removal inventory estimation method. Inventories for all 46 radionuclides reported in the best-basis inventory are provided in RPP-15317 and were used in the calculation (RPP-22392). Inventories for the subset of best-basis inventory radionuclides that were shown in DOE/ORP-2003-11, *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington*, to dominate intruder doses at 500 years after closure are shown in Table D-2.

Table D-2. Tank C-108 Inventory of Dose-Driving Contaminants in 360 ft^3 of Residual Waste.

Radionuclide	Units	Tank C-108
Strontium-90	Ci	3.44E+02
Technetium-99	Ci	2.52E-01
Tin-126	Ci	5.22E-04
Cesium-137	Ci	3.33E+03
Plutonium-239	Ci	1.30E-01
Plutonium-240	Ci	8.40E-03
Americium-241	Ci	2.68E-01

Note: Table 7-1 from RPP-15317, 2003, *241-C Waste Management Area Inventory Data Package*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

Table D-3 summarizes the intruder analysis results for tank C-108. These results were generated using the methodology described in Section 7.2. Complete calculation detail is provided in RPP-22392. Contaminant-specific doses are shown for the subset of radionuclides that dominate the total dose. The total dose shown represents the sum of the dose contributions from all radionuclides considered.

Table D-3. Tank C-108 Intruder Dose.

Radionuclide	Well Driller (mrem EDE)	Suburban Resident with a Garden (mrem/yr EDE)	Rural Farmer with a Dairy Cow (mrem/yr EDE)
Strontium-90	0.000	0.000	0.000
Technetium-99	0.000	0.007	0.000
Tin-126	0.000	0.000	0.000
Cesium-137	0.005	0.005	0.001
Plutonium-239	0.001	0.005	0.000
Plutonium-240	0.000	0.000	0.000
Americium-241	0.001	0.005	0.000
Other radionuclides	0.000	0.000	0.000
TOTAL	0.007	0.022	0.001

Note: The number of significant digits shown in Table D-3 is not intended to imply a level of accuracy greater than the input values.
EDE = effective dose equivalent.

The dose values in Table D-3 are for intrusion at 500 years after closure assuming a grout-stabilized residual waste volume of 360 ft^3. Table D-3 indicates that tank C-108 would not exceed the performance objectives of 500 mrem effective dose equivalent for acute exposure and 100 mrem/yr effective dose equivalent for chronic exposure at 500 years after closure. The total doses at 500 years after closure would be dominated by technetium-99, cesium-137, plutonium-239, and americium-241.

D4.0 REFERENCES

DOE/ORP-2003-11, 2003, *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

RPP-13774, 2004, *Single-Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-15317, 2003, *241-C Waste Management Area Inventory Data Package*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-21753, 2005, *C-Farm 100 Series Tanks, Retrieval Process Flowsheet Description*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-22392, 2005, *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

APPENDIX E

TANK C-112 LONG TERM HUMAN HEALTH RISK

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LIST OF FIGURES

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LIST OF TERMS

Terms

None required; terms are defined within the document text.

Abbreviations, Acronyms, and Initialisms

DST	double-shell tank
ILCR	incremental lifetime cancer risk
WMA	waste management area

Units

Ci	curie
Ci/L	curies per liter
ft^3	cubic feet
g/L	grams per liter
gal.	gallon
kg	kilogram
kg/L	kilograms per liter
mg/L	milligrams per liter
mrem/yr	millirem per year
pCi/L	picocuries per liter

E1.0 TANK C-112 PRE-RETRIEVAL RISK ASSESSMENT RESULTS

This appendix provides tank-specific pre-retrieval risk assessment results for tank C-112. The information presented was developed using the methodology described in Section 7.0. Groundwater pathway impacts are presented in Section E2.0. Inadvertent intruder impacts are presented in Section E3.0.

E2.0 GROUNDWATER PATHWAY IMPACTS

The groundwater pathway evaluation involved the development of a set of graphical tools to provide a basis for making informed decisions in the event a leak is detected or unexpected retrieval conditions arise during waste retrieval operations. This section provides and discusses the retrieval leak impact graphs generated for tank C-112. The methodology used to generate the graphs is described in Section 7.1.1. Calculation detail for the graphs is provided in RPP-22392, *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan*.

E2.1 RETRIEVAL LEAK IMPACT GRAPHS

Figures E-1 through E-3 provide the tank C-112 waste retrieval leak impact graphs for the three indicator contaminants (technetium-99, hexavalent chromium, and nitrite) identified in Section 7.1.1.1.

Figure E-1. Tank C-112 Technetium-99 Risk Plot.

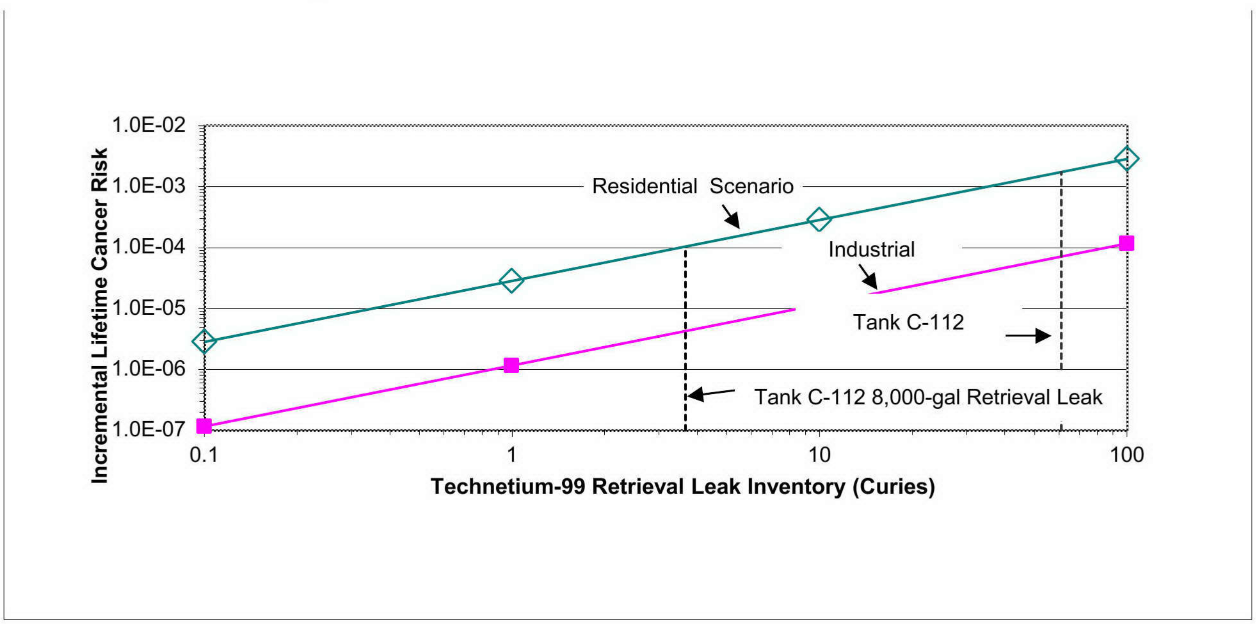

Figure E-2. Tank C-112 Hexavalent Chromium Hazard Quotient Plot.

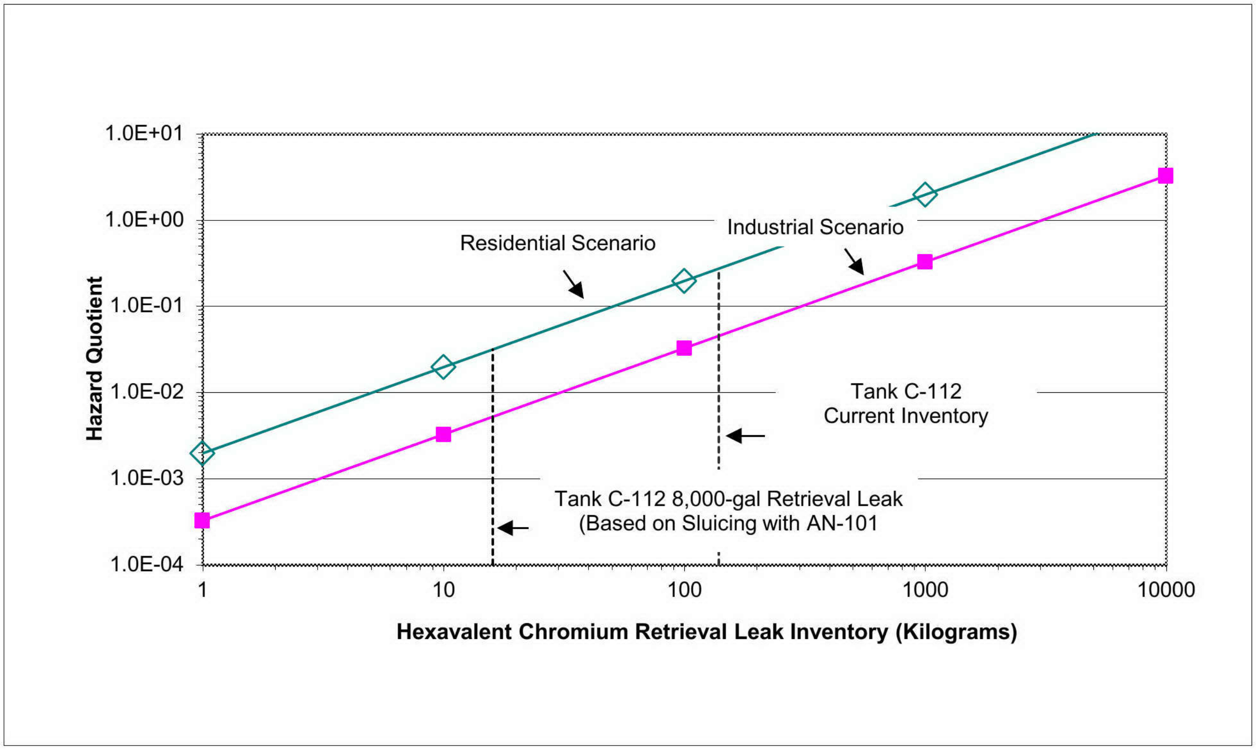

Figure E-3. Tank C-112 Nitrite Hazard Quotient Plot.

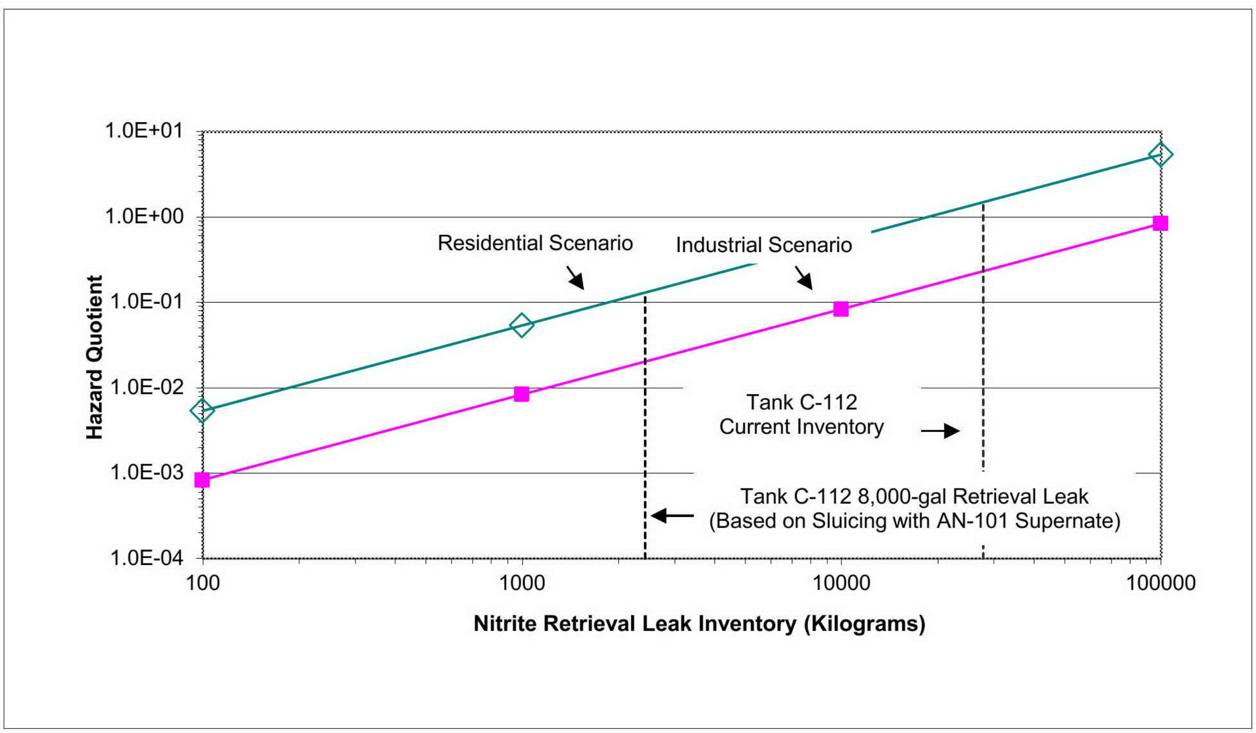

Figure E-1 shows the peak groundwater pathway incremental lifetime cancer risk (ILCR) from technetium-99 as a function of the amount of technetium-99 leaked from tank C-112 during waste retrieval. Figures E-2 and E-3 show the peak groundwater pathway hazard quotient from hexavalent chromium and nitrite, respectively, as a function of the amount of hexavalent chromium and nitrite leaked from tank C-112 during waste retrieval.

The ILCR and hazard quotient values shown on the graphs were based on the predicted peak groundwater concentrations at the waste management area (WMA) C downgradient fenceline. As discussed in Section 7.1.1.3, the projected arrival time of the peaks is approximately the year 2082 based on the supporting contaminant transport analysis in RPP-13774, *Single-Shell Tank System Closure Plan*. The graphs provide a retrieval leak risk picture for tank C-112 but do not include contributions from other WMA C sources. Projected impacts from other WMA C sources are discussed in Section 7.1.3.

Two sloped lines representing the industrial and residential scenarios were plotted on each graph. The datapoints for these lines were calculated as described in Section 7.1.1 over a range of technetium-99, hexavalent chromium, and nitrite values. Because potential retrieval leak volumes are uncertain, the inventory range was selected to encompass a small leak on the low end and a large leak on the high end.

Vertical dashed lines were added to each graph as points of reference to show the estimated current tank C-112 inventory and the inventory associated with a potential 8,000-gal. retrieval leak. The 8,000-gal. volume was a hypothetical volume used only as a point of reference and for consistency with previous analyses. It was not intended to represent anticipated retrieval leak volumes or leak detection limits for tank C-112.

Should the retrieval plan vary from that in Section 3.1.1, the Washington State Department of Ecology will be notified of the change via a change notice form, per Section 9.3 of the HFFACO Action Plan. A retrieval plan variation means: (1) altering the designated DST receiver tank for a given single-shell tank, or (2) making transfers from DSTs other than those listed in Section 3.1.1 into one of the Section 3.1.1 receiver DSTs, which will result in key indicator contaminant concentrations in the receiver DST liquid phase greater than those specified in RPP-22392 for the starting DST supernate concentration. If the 8,000-gal. retrieval leak risk for a revised retrieval plan is not bounded by the impact shown in Figures E-1, E-2, and E-3, revised risk impacts will be provided.

In the event a leak is detected during waste retrieval, the leak monitoring system would be used to estimate the leak volume. The potential human health impacts from the leak could then be evaluated from the leak volume and estimated contaminant concentrations in the leak along with the graphs shown in Figures E-1, E-2, and E-3. Using the graphs, the impacts from leak inventories greater or lesser than those shown for the 8,000-gal. reference volume can be estimated rapidly by extrapolating from the impacts shown for the reference volume.

E2.2 INVENTORY

The reference lines shown in Figures E-1, E-2, and E-3 to indicate current inventory and retrieval leak inventory were developed from the best available data and information. Current inventories were taken from the best-basis inventory by downloading from the Tank Waste Information Network System (TWINS) database (http://twinsweb.pnl.gov/twins.htm). Retrieval leak inventories were calculated by multiplying the hypothetical retrieval leak volume (8,000 gal.) by the estimated retrieval leak fluid concentration. Waste was assumed to be retrieved from tank C-112 by sluicing with recycled supernate from DST AN-101. The retrieval leak fluid concentrations for this retrieval scenario are provided in RPP-22392.

The predicted liquid phase concentrations and resulting tank C-112 leak inventories for the DST AN-101 recycled supernate retrieval scenario are shown in Table E-1. The table also shows leak inventories for a raw water retrieval scenario.

Table E-1. Tank C-112 Retrieval Leak Inventory Comparison for Different Sluicing Fluids.

Contaminant	Leak Fluid Concentration			Inventory in 8,000-gal. Retrieval Leak		
	Tank AN-101 Supernate [a]	Raw Water [b]	Units	Tank AN-101 Supernate	Raw Water	Units
Technetium-99	1.21E-04	4.24E-05	Ci/L	3.66E+00	1.28E+00	Ci
Hexavalent chromium	5.28E-04	9.67E-05	kg/L	1.60E+01	2.93E+00	kg
Nitrite	8.01E-02	1.93E-02	kg/L	2.43E+03	5.84E+02	kg

[a] From RPP-22392, 2009, *Tanks C-102, C-104, C-0107, C-108 and C-112 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan*, Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington..

[b] Addendum C1, Table 9 from RPP-13774, 2004, *Single-Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

Raw water retrieval leak inventories are given in Table E-1 to provide a perspective on the potential effects on retrieval leak impacts caused by sluicing with recirculated DST supernate. The raw water inventories shown are the inventories used for the RPP-13774 base case risk analysis. Those inventories were based on a hypothetical 8,000-gal. retrieval leak volume and retrieval leak fluid concentrations estimated using the Hanford Tank Waste Operations Simulator (HTWOS) model. Because retrieval leak human health impacts are proportional to inventory, comparing the inventory differences provides an indication of the differences in impacts between the two sluicing fluids. Table E-1 indicates raw water leak inventories would be lower than the supernate leak inventories.

E2.3 SUMMARY OF IMPACTS FROM HYPOTHETICAL 8,000-GALLON RETRIEVAL LEAK

The technetium-99 inventory associated with a hypothetical 8,000-gal. retrieval leak from tank C-112 was estimated to be approximately 3.66 Ci (RPP-22392). As shown in Figure E-1, this corresponds to an ILCR of approximately 4.25×10^{-6} for the industrial scenario and 1.03×10^{-4} for the residential scenario. The peak technetium-99 groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 3.08E+02 pCi/L.

The hexavalent chromium inventory associated with a hypothetical 8,000-gal. retrieval leak from tank C-112 was estimated to be approximately 1.6E+01 kg (RPP-22392). As shown in Figure E-2, this corresponds to a hazard quotient of approximately 5.2E-03 for the industrial scenario and 3.1E-02 for the residential scenario. The peak hexavalent chromium groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 1.3E-03 mg/L.

The nitrite inventory associated with an 8,000-gal. retrieval leak from tank C-112 was estimated to be approximately 2.43E+03 kg (RPP-22392). As shown in Figure E-3, this corresponds to a hazard quotient of approximately 2.0E-02 for the industrial scenario and 1.3E-01 for the residential scenario. The peak nitrite groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 2.0E-01 mg/L.

E2.4 EXAMPLE CALCULATION

To illustrate the calculation method used for the retrieval leak impact graphs, the following example is provided. The example uses the industrial scenario ILCR result of 4.25×10^{-6}. Using Equation 7-1 from Section 7.1.1, the industrial scenario ILCR was calculated as the product of the technetium-99 inventory (Table E-1), the technetium-99 retrieval leak unit groundwater concentration factor (Table 7-2), and the technetium-99 industrial scenario unit risk factor (Table 7-3), as follows:

$$\text{ILCR} = (3.66\ \text{Ci}) \cdot (8.4 \times 10^{1}\ \text{pCi/L per Ci}) \cdot (1.38 \times 10^{-8}\ \text{ILCR per pCi/L}) = 4.25 \times 10^{-6}$$

Complete calculation details are provided in RPP-22392.

E3.0 INADVERTENT INTRUDER IMPACTS

The starting inventories for the tank C-112 intruder calculation were the estimated radionuclide inventories remaining in the tank following retrieval to the Ecology et al. (1989), *Hanford Federal Facility Agreement and Consent Order* (HFFACO) interim retrieval goal of 360 ft^3 of residual waste. These inventories were taken from RPP-15317, *241-C Waste Management Area Inventory Data Package*, and are based on the selective phase removal inventory estimation method. Inventories for all 46 radionuclides reported in the best-basis inventory are provided in RPP-15317 and were used in the calculation (RPP-22392). Inventories for the subset of best-basis inventory radionuclides that were shown in DOE/ORP-2003-11, *Preliminary Performance Assessment for Waste Management Area C at the Hanford Site, Washington*, to dominate intruder doses at 500 years after closure are shown in Table E-2.

Table E-2. Tank C-112 Inventory of Dose-Driving Contaminants in 360 ft^3 of Residual Waste.

Radionuclide	Units	Tank C-112
Strontium-90	Ci	1.68E+04
Technetium-99	Ci	1.59E+00
Tin-126	Ci	1.08E-03
Cesium-137	Ci	7.39E+03
Plutonium-239	Ci	2.12E+00
Plutonium-240	Ci	3.38E-01
Americium-241	Ci	1.23E+01

Note: Table 7-1 from RPP-15317, 2003, *241-C Waste Management Area Inventory Data Package*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

Table E-3 summarizes the intruder analysis results for tank C-112. These results were generated using the methodology described in Section 7.2. Complete calculation detail is provided in RPP-22392. Contaminant-specific doses are shown for the subset of radionuclides that dominate the total dose. The total dose shown represents the sum of the dose contributions from all radionuclides considered.

Table E-3. Tank C-112 Intruder Dose.

Radionuclide	Well Driller (mrem EDE)	Suburban Resident with a Garden (mrem/yr EDE)	Rural Farmer with a Dairy Cow (mrem/yr EDE)
Strontium-90	0.001	0.014	0.001
Technetium-99	0.000	0.042	0.001
Tin-126	0.001	0.001	0.000
Cesium-137	0.011	0.012	0.001
Plutonium-239	0.014	0.077	0.003
Plutonium-240	0.002	0.012	0.001
Americium-241	0.054	0.219	0.011
Other radionuclides	0.001	0.008	0.001
TOTAL	0.084	0.385	0.019

Note: The number of significant digits shown in Table E-3 is not intended to imply a level of accuracy greater than the input values.

EDE = effective dose equivalent.

The dose values in Table E-3 are for intrusion at 500 years after closure assuming a grout-stabilized residual waste volume of 360 ft^3. Table E-3 indicates that tank C-112 would not exceed the performance objectives of 500 mrem effective dose equivalent for acute exposure and 100 mrem/yr effective dose equivalent for chronic exposure at 500 years after closure. The total doses at 500 years after closure would be dominated by technetium-99, plutonium-239, and americium-241.

E4.0 REFERENCES

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APPENDIX F

AVAILABLE INVENTORY AND INVENTORY UNCERTAINTY DATA

LIST OF TABLES

Table F-1. Tank C-102 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{106}Ru	Sludge	CWP1 (Solid)	9.74E-11	not reported	Ci
	Sludge	CWP2 (Solid)	8.70E-08	not reported	Ci
	Sludge	CWZr1 (Solid)	8.30E-08	not reported	Ci
	Sludge	MW1 (Solid)	1.01E-16	not reported	Ci
	Sludge	TBP (Solid)	9.77E-15	not reported	Ci
	Sludge	TH1 (Solid)	6.20E-09	not reported	Ci
	Total		1.76E-07	--	Ci
^{113m}Cd	Sludge	CWP1 (Solid)	3.50E-01	not reported	Ci
	Sludge	CWP2 (Solid)	1.65E+00	not reported	Ci
	Sludge	CWZr1 (Solid)	1.25E-02	not reported	Ci
	Sludge	MW1 (Solid)	1.48E-03	not reported	Ci
	Sludge	TBP (Solid)	6.57E-03	not reported	Ci
	Sludge	TH1 (Solid)	7.27E-02	not reported	Ci
	Total		2.09E+00	--	Ci
^{125}Sb	Sludge	CWP1 (Solid)	4.16E-04	not reported	Ci
	Sludge	CWP2 (Solid)	9.33E-03	not reported	Ci
	Sludge	CWZr1 (Solid)	9.39E-03	not reported	Ci
	Sludge	MW1 (Solid)	1.06E-05	not reported	Ci
	Sludge	TBP (Solid)	1.06E-04	not reported	Ci
	Sludge	TH1 (Solid)	1.78E-02	not reported	Ci
	Total		3.70E-02	--	Ci
^{126}Sn	Sludge	CWP1 (Solid)	5.20E-04	not reported	Ci
	Sludge	CWP2 (Solid)	1.88E-03	not reported	Ci
	Sludge	CWZr1 (Solid)	7.06E-04	not reported	Ci
	Sludge	MW1 (Solid)	2.63E-04	not reported	Ci
	Sludge	TBP (Solid)	9.59E-04	not reported	Ci
	Sludge	TH1 (Solid)	5.25E-03	not reported	Ci
	Total		9.58E-03	--	Ci
^{129}I	Sludge	TH1 (Solid)	1.71E-05	not reported	Ci
	Sludge	CWP1 (Solid)	6.62E-02	not reported	Ci
	Sludge	CWP2 (Solid)	1.65E-01	not reported	Ci
	Sludge	CWZr1 (Solid)	5.24E-04	not reported	Ci
	Sludge	MW1 (Solid)	1.56E-05	not reported	Ci
	Sludge	TBP (Solid)	1.13E-04	not reported	Ci
	Total		2.32E-01	--	Ci

Table F-1. Tank C-102 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{134}Cs	Sludge	CWP1 (Solid)	8.71E-06	not reported	Ci
	Sludge	CWP2 (Solid)	4.68E-04	not reported	Ci
	Sludge	CWZr1 (Solid)	5.97E-03	not reported	Ci
	Sludge	MW1 (Solid)	3.52E-08	not reported	Ci
	Sludge	TBP (Solid)	8.81E-07	not reported	Ci
	Sludge	TH1 (Solid)	4.20E-04	not reported	Ci
	Total		6.87E-03	--	Ci
^{137}Cs	Sludge	CWP1 (Solid)	1.24E+04	1.90E+04	Ci
	Sludge	CWP2 (Solid)	1.11E+04	not reported	Ci
	Sludge	CWZr1 (Solid)	4.92E+02	not reported	Ci
	Sludge	MW1 (Solid)	6.70E+01	not reported	Ci
	Sludge	TBP (Solid)	1.06E+03	1.06E+03	Ci
	Sludge	TH1 (Solid)	8.05E+02	not reported	Ci
	Total		2.59E+04	--	Ci
^{137m}Ba	Sludge	CWP1 (Solid)	1.17E+04	not reported	Ci
	Sludge	CWP2 (Solid)	1.04E+04	not reported	Ci
	Sludge	CWZr1 (Solid)	4.64E+02	not reported	Ci
	Sludge	MW1 (Solid)	6.33E+01	not reported	Ci
	Sludge	TBP (Solid)	1.00E+03	not reported	Ci
	Sludge	TH1 (Solid)	7.60E+02	not reported	Ci
	Total		2.45E+04	--	Ci
^{14}C	Sludge	CWP1 (Solid)	3.06E-01	not reported	Ci
	Sludge	CWP2 (Solid)	1.01E+00	not reported	Ci
	Sludge	CWZr1 (Solid)	1.15E-01	not reported	Ci
	Sludge	MW1 (Solid)	2.82E-03	not reported	Ci
	Sludge	TBP (Solid)	5.62E-03	not reported	Ci
	Sludge	TH1 (Solid)	9.40E-06	not reported	Ci
	Total		1.44E+00	--	Ci
^{151}Sm	Sludge	CWP1 (Solid)	5.22E+00	not reported	Ci
	Sludge	CWP2 (Solid)	1.84E+01	not reported	Ci
	Sludge	CWZr1 (Solid)	4.29E+00	not reported	Ci
	Sludge	MW1 (Solid)	2.69E+00	not reported	Ci
	Sludge	TBP (Solid)	9.20E+00	not reported	Ci
	Sludge	TH1 (Solid)	1.78E+01	not reported	Ci
	Total		5.76E+01	--	Ci

Table F-1. Tank C-102 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{152}Eu	Sludge	CWP2 (Solid)	4.15E-03	not reported	Ci
	Sludge	CWZr1 (Solid)	5.47E-03	not reported	Ci
	Sludge	MW1 (Solid)	2.93E-05	not reported	Ci
	Sludge	TBP (Solid)	2.95E-04	not reported	Ci
	Sludge	TH1 (Solid)	4.42E-03	not reported	Ci
	Sludge	CWP1 (Solid)	6.26E-04	not reported	Ci
	Total		1.50E-02	--	Ci
^{154}Eu	Sludge	CWZr1 (Solid)	1.09E+00	not reported	Ci
	Sludge	MW1 (Solid)	2.60E-03	not reported	Ci
	Sludge	TBP (Solid)	2.05E-02	not reported	Ci
	Sludge	TH1 (Solid)	1.61E-01	not reported	Ci
	Sludge	CWP1 (Solid)	4.16E-02	not reported	Ci
	Sludge	CWP2 (Solid)	2.45E+01	not reported	Ci
	Total		2.58E+01	--	Ci
^{155}Eu	Sludge	CWP1 (Solid)	1.49E-02	not reported	Ci
	Sludge	CWP2 (Solid)	1.35E+01	not reported	Ci
	Sludge	CWZr1 (Solid)	5.99E-01	not reported	Ci
	Sludge	MW1 (Solid)	1.73E-03	not reported	Ci
	Sludge	TBP (Solid)	9.84E-03	not reported	Ci
	Sludge	TH1 (Solid)	4.73E-02	not reported	Ci
	Total		1.41E+01	--	Ci
^{226}Ra	Sludge	CWZr1 (Solid)	4.59E-08	not reported	Ci
	Sludge	MW1 (Solid)	6.42E-06	not reported	Ci
	Sludge	TBP (Solid)	1.21E-06	not reported	Ci
	Sludge	TH1 (Solid)	5.39E-06	not reported	Ci
	Sludge	CWP1 (Solid)	1.66E-07	not reported	Ci
	Sludge	CWP2 (Solid)	2.17E-06	not reported	Ci
	Total		1.54E-05	--	Ci
^{227}Ac	Sludge	CWP1 (Solid)	8.97E-07	not reported	Ci
	Sludge	CWP2 (Solid)	3.28E-02	not reported	Ci
	Sludge	CWZr1 (Solid)	3.15E-07	not reported	Ci
	Sludge	MW1 (Solid)	2.00E-05	not reported	Ci
	Sludge	TBP (Solid)	5.33E-06	not reported	Ci
	Sludge	TH1 (Solid)	1.37E+00	not reported	Ci
	Total		1.41E+00	--	Ci

Table F-1. Tank C-102 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{228}Ra	Sludge	CWZr1 (Solid)	2.00E-12	not reported	Ci
	Sludge	MW1 (Solid)	1.53E-11	not reported	Ci
	Sludge	TBP (Solid)	4.64E-12	not reported	Ci
	Sludge	TH1 (Solid)	1.46E-01	not reported	Ci
	Sludge	CWP1 (Solid)	1.91E-12	not reported	Ci
	Sludge	CWP2 (Solid)	2.46E-01	not reported	Ci
	Total		3.92E-01	--	Ci
^{229}Th	Sludge	CWP1 (Solid)	2.79E-10	not reported	Ci
	Sludge	CWP2 (Solid)	1.69E-01	not reported	Ci
	Sludge	CWZr1 (Solid)	2.04E-10	not reported	Ci
	Sludge	MW1 (Solid)	8.55E-11	not reported	Ci
	Sludge	TBP (Solid)	2.70E-10	not reported	Ci
	Sludge	TH1 (Solid)	3.89E-01	not reported	Ci
	Total		5.59E-01	--	Ci
^{231}Pa	Sludge	CWP1 (Solid)	1.78E-06	not reported	Ci
	Sludge	CWP2 (Solid)	1.71E-03	not reported	Ci
	Sludge	CWZr1 (Solid)	7.06E-07	not reported	Ci
	Sludge	MW1 (Solid)	2.13E-08	not reported	Ci
	Sludge	TBP (Solid)	5.04E-08	not reported	Ci
	Sludge	TH1 (Solid)	1.09E-01	not reported	Ci
	Total		1.11E-01	--	Ci
^{232}Th	Sludge	TBP (Solid)	2.29E-12	not reported	Ci
	Sludge	TH1 (Solid)	4.28E-01	not reported	Ci
	Sludge	CWP1 (Solid)	2.20E-12	not reported	Ci
	Sludge	CWP2 (Solid)	7.73E-01	not reported	Ci
	Sludge	CWZr1 (Solid)	2.43E-12	not reported	Ci
	Sludge	MW1 (Solid)	7.18E-13	not reported	Ci
	Total		1.20E+00	--	Ci
^{232}U	Sludge	CWP1 (Solid)	5.14E-05	not reported	Ci
	Sludge	CWP2 (Solid)	8.70E-02	not reported	Ci
	Sludge	CWZr1 (Solid)	1.02E-05	not reported	Ci
	Sludge	MW1 (Solid)	2.47E-05	not reported	Ci
	Sludge	TBP (Solid)	4.16E-06	not reported	Ci
	Sludge	TH1 (Solid)	1.67E+00	not reported	Ci
	Total		1.76E+00	--	Ci

Table F-1. Tank C-102 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{233}U	Sludge	CWP1 (Solid)	2.51E-06	not reported	Ci
	Sludge	CWP2 (Solid)	5.40E+00	not reported	Ci
	Sludge	CWZr1 (Solid)	1.58E-07	not reported	Ci
	Sludge	MW1 (Solid)	2.26E-06	not reported	Ci
	Sludge	TBP (Solid)	3.49E-07	not reported	Ci
	Sludge	TH1 (Solid)	1.10E+02	not reported	Ci
	Total		1.15E+02	--	Ci
^{234}U	Sludge	CWP2 (Solid)	7.45E-01	not reported	Ci
	Sludge	CWZr1 (Solid)	4.24E-02	not reported	Ci
	Sludge	MW1 (Solid)	2.92E+00	not reported	Ci
	Sludge	TBP (Solid)	3.43E-01	not reported	Ci
	Sludge	TH1 (Solid)	8.30E-01	not reported	Ci
	Sludge	CWP1 (Solid)	1.13E+00	not reported	Ci
	Total		6.00E+00	--	Ci
^{235}U	Sludge	CWP1 (Solid)	4.81E-02	not reported	Ci
	Sludge	CWP2 (Solid)	2.91E-02	not reported	Ci
	Sludge	CWZr1 (Solid)	1.97E-03	not reported	Ci
	Sludge	MW1 (Solid)	1.32E-01	not reported	Ci
	Sludge	TBP (Solid)	1.53E-02	not reported	Ci
	Sludge	TH1 (Solid)	2.95E-06	not reported	Ci
	Total		2.26E-01	--	Ci
^{236}U	Sludge	TBP (Solid)	3.93E-03	not reported	Ci
	Sludge	TH1 (Solid)	5.14E-07	not reported	Ci
	Sludge	CWP1 (Solid)	2.57E-02	not reported	Ci
	Sludge	CWP2 (Solid)	1.84E-02	not reported	Ci
	Sludge	CWZr1 (Solid)	2.98E-03	not reported	Ci
	Sludge	MW1 (Solid)	2.49E-02	not reported	Ci
	Total		7.58E-02	--	Ci
^{237}Np	Sludge	CWP1 (Solid)	3.69E-04	not reported	Ci
	Sludge	CWP2 (Solid)	1.26E-03	not reported	Ci
	Sludge	CWZr1 (Solid)	2.47E-04	not reported	Ci
	Sludge	MW1 (Solid)	1.99E-04	not reported	Ci
	Sludge	TBP (Solid)	7.01E-04	not reported	Ci
	Sludge	TH1 (Solid)	2.01E-08	not reported	Ci
	Total		2.78E-03	--	Ci

Table F-1. Tank C-102 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{238}Pu	Sludge	CWP1 (Solid)	3.90E+00	not reported	Ci
	Sludge	CWP2 (Solid)	7.21E+01	not reported	Ci
	Sludge	CWZr1 (Solid)	1.20E+01	not reported	Ci
	Sludge	MW1 (Solid)	6.98E-05	not reported	Ci
	Sludge	TBP (Solid)	6.99E-03	not reported	Ci
	Sludge	TH1 (Solid)	3.34E-06	not reported	Ci
	Total		8.80E+01	--	Ci
^{238}U	Sludge	CWP2 (Solid)	6.71E-01	not reported	Ci
	Sludge	CWZr1 (Solid)	2.97E-02	not reported	Ci
	Sludge	MW1 (Solid)	2.97E+00	not reported	Ci
	Sludge	TBP (Solid)	3.50E-01	not reported	Ci
	Sludge	TH1 (Solid)	4.59E-14	not reported	Ci
	Sludge	CWP1 (Solid)	1.16E+00	not reported	Ci
	Total		5.17E+00	--	Ci
^{239}Pu	Sludge	CWZr1 (Solid)	1.21E+02	not reported	Ci
	Sludge	MW1 (Solid)	2.07E-02	not reported	Ci
	Sludge	TBP (Solid)	1.00E+00	not reported	Ci
	Sludge	TH1 (Solid)	1.73E-10	not reported	Ci
	Sludge	CWP1 (Solid)	2.26E+02	not reported	Ci
	Sludge	CWP2 (Solid)	3.05E+03	not reported	Ci
	Total		3.40E+03	--	Ci
^{240}Pu	Sludge	CWP1 (Solid)	4.71E+01	not reported	Ci
	Sludge	CWP2 (Solid)	7.21E+02	not reported	Ci
	Sludge	CWZr1 (Solid)	4.68E+01	not reported	Ci
	Sludge	MW1 (Solid)	1.39E-03	not reported	Ci
	Sludge	TBP (Solid)	1.08E-01	not reported	Ci
	Sludge	TH1 (Solid)	1.19E-11	not reported	Ci
	Total		8.15E+02	--	Ci
^{241}Am	Sludge	TH1 (Solid)	6.81E-12	not reported	Ci
	Sludge	CWP1 (Solid)	4.28E+00	not reported	Ci
	Sludge	CWP2 (Solid)	9.50E+02	not reported	Ci
	Sludge	CWZr1 (Solid)	6.73E+01	not reported	Ci
	Sludge	TBP (Solid)	5.52E-01	not reported	Ci
	Sludge	MW1 (Solid)	4.29E-03	not reported	Ci
	Total		1.02E+03	--	Ci

Table F-1. Tank C-102 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{241}Pu	Sludge	CWP1 (Solid)	1.76E+02	not reported	Ci
	Sludge	CWP2 (Solid)	4.51E+03	not reported	Ci
	Sludge	CWZr1 (Solid)	8.27E+02	not reported	Ci
	Sludge	MW1 (Solid)	1.17E-03	not reported	Ci
	Sludge	TBP (Solid)	1.82E-01	not reported	Ci
	Sludge	TH1 (Solid)	3.97E-11	not reported	Ci
	Total		5.51E+03	--	Ci
^{242}Cm	Sludge	CWZr1 (Solid)	7.32E-03	not reported	Ci
	Sludge	MW1 (Solid)	3.21E-07	not reported	Ci
	Sludge	CWP1 (Solid)	6.28E-05	not reported	Ci
	Sludge	TBP (Solid)	1.33E-04	not reported	Ci
	Sludge	TH1 (Solid)	4.40E-17	not reported	Ci
	Sludge	CWP2 (Solid)	5.91E-02	not reported	Ci
	Total		6.66E-02	--	Ci
^{242}Pu	Sludge	TBP (Solid)	1.48E-06	not reported	Ci
	Sludge	TH1 (Solid)	9.75E-17	not reported	Ci
	Sludge	CWP1 (Solid)	1.47E-03	not reported	Ci
	Sludge	CWP2 (Solid)	3.66E-02	not reported	Ci
	Sludge	CWZr1 (Solid)	9.04E-03	not reported	Ci
	Sludge	MW1 (Solid)	6.33E-09	not reported	Ci
	Total		4.71E-02	--	Ci
^{243}Am	Sludge	CWP1 (Solid)	3.75E-05	not reported	Ci
	Sludge	CWP2 (Solid)	3.83E-02	not reported	Ci
	Sludge	CWZr1 (Solid)	4.83E-03	not reported	Ci
	Sludge	MW1 (Solid)	1.86E-07	not reported	Ci
	Sludge	TBP (Solid)	7.83E-05	not reported	Ci
	Sludge	TH1 (Solid)	2.37E-17	not reported	Ci
	Total		4.33E-02	--	Ci
^{243}Cm	Sludge	MW1 (Solid)	1.80E-09	not reported	Ci
	Sludge	TBP (Solid)	1.49E-06	not reported	Ci
	Sludge	TH1 (Solid)	8.36E-19	not reported	Ci
	Sludge	CWP1 (Solid)	1.11E-06	not reported	Ci
	Sludge	CWP2 (Solid)	2.91E-03	not reported	Ci
	Sludge	CWZr1 (Solid)	1.94E-03	not reported	Ci
	Total		4.86E-03	--	Ci

Table F-1. Tank C-102 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{244}Cm	Sludge	CWP1 (Solid)	2.78E-05	not reported	Ci
	Sludge	CWP2 (Solid)	8.65E-02	not reported	Ci
	Sludge	CWZr1 (Solid)	4.00E-02	not reported	Ci
	Sludge	MW1 (Solid)	4.02E-08	not reported	Ci
	Sludge	TBP (Solid)	3.35E-05	not reported	Ci
	Sludge	TH1 (Solid)	1.74E-17	not reported	Ci
	Total		1.27E-01	--	Ci
^{3}H	Sludge	CWP2 (Solid)	4.14E+00	4.15E+00	Ci
	Sludge	CWZr1 (Solid)	4.46E+00	not reported	Ci
	Sludge	MW1 (Solid)	5.03E-02	not reported	Ci
	Sludge	TBP (Solid)	1.23E-01	not reported	Ci
	Sludge	TH1 (Solid)	1.90E-02	not reported	Ci
	Sludge	CWP1 (Solid)	2.74E+01	not reported	Ci
	Total		3.62E+01	--	Ci
^{59}Ni	Sludge	CWP1 (Solid)	1.20E+00	not reported	Ci
	Sludge	CWP2 (Solid)	7.40E+00	not reported	Ci
	Sludge	CWZr1 (Solid)	5.73E-03	not reported	Ci
	Sludge	MW1 (Solid)	4.27E-04	not reported	Ci
	Sludge	TBP (Solid)	1.47E-03	not reported	Ci
	Sludge	TH1 (Solid)	4.67E-03	not reported	Ci
	Total		8.61E+00	--	Ci
^{60}Co	Sludge	TBP (Solid)	2.94E-03	not reported	Ci
	Sludge	TH1 (Solid)	4.64E-04	not reported	Ci
	Sludge	CWP1 (Solid)	1.61E+00	not reported	Ci
	Sludge	CWP2 (Solid)	8.84E+01	not reported	Ci
	Sludge	CWZr1 (Solid)	3.93E+00	not reported	Ci
	Sludge	MW1 (Solid)	5.21E-04	not reported	Ci
	Total		9.39E+01	--	Ci
^{63}Ni	Sludge	CWP1 (Solid)	1.10E+02	not reported	Ci
	Sludge	CWP2 (Solid)	6.98E+02	not reported	Ci
	Sludge	CWZr1 (Solid)	4.89E-01	not reported	Ci
	Sludge	MW1 (Solid)	3.55E-02	not reported	Ci
	Sludge	TBP (Solid)	1.26E-01	not reported	Ci
	Sludge	TH1 (Solid)	3.89E-01	not reported	Ci
	Total		8.09E+02	--	Ci

Table F-1. Tank C-102 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{79}Se	Sludge	CWP2 (Solid)	4.55E-04	not reported	Ci
	Sludge	CWZr1 (Solid)	1.49E-04	not reported	Ci
	Sludge	MW1 (Solid)	7.28E-05	not reported	Ci
	Sludge	TBP (Solid)	2.54E-04	not reported	Ci
	Sludge	TH1 (Solid)	1.60E-03	not reported	Ci
	Sludge	CWP1 (Solid)	1.26E-04	not reported	Ci
	Total		2.66E-03	--	Ci
^{90}Sr	Sludge	CWP1 (Solid)	1.15E+02	not reported	Ci
	Sludge	CWP2 (Solid)	4.72E+02	not reported	Ci
	Sludge	CWZr1 (Solid)	9.74E+02	not reported	Ci
	Sludge	MW1 (Solid)	1.32E+03	not reported	Ci
	Sludge	TBP (Solid)	9.84E+03	6.97E+03	Ci
	Sludge	TH1 (Solid)	1.53E+04	not reported	Ci
	Total		2.80E+04	--	Ci
^{90}Y	Sludge	CWP1 (Solid)	1.15E+02	not reported	Ci
	Sludge	CWP2 (Solid)	4.72E+02	not reported	Ci
	Sludge	CWZr1 (Solid)	9.74E+02	not reported	Ci
	Sludge	MW1 (Solid)	1.32E+03	not reported	Ci
	Sludge	TBP (Solid)	9.84E+03	not reported	Ci
	Sludge	TH1 (Solid)	1.53E+04	not reported	Ci
	Total		2.80E+04	--	Ci
^{93m}Nb	Sludge	CWP1 (Solid)	6.46E-03	not reported	Ci
	Sludge	CWP2 (Solid)	2.14E-02	not reported	Ci
	Sludge	CWZr1 (Solid)	1.23E-01	not reported	Ci
	Sludge	MW1 (Solid)	1.80E-05	not reported	Ci
	Sludge	TBP (Solid)	6.12E-05	not reported	Ci
	Sludge	TH1 (Solid)	3.45E-02	not reported	Ci
	Total		1.85E-01	--	Ci
^{93}Zr	Sludge	CWP1 (Solid)	7.54E-03	not reported	Ci
	Sludge	CWP2 (Solid)	2.63E-02	not reported	Ci
	Sludge	CWZr1 (Solid)	1.54E-01	not reported	Ci
	Sludge	MW1 (Solid)	1.97E-05	not reported	Ci
	Sludge	TBP (Solid)	6.81E-05	not reported	Ci
	Sludge	TH1 (Solid)	4.27E-02	not reported	Ci
	Total		2.30E-01	--	Ci

Table F-1. Tank C-102 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{99}Tc *	Sludge	CWZr1 (Solid)	3.37E-01	not reported	Ci
	Sludge	MW1 (Solid)	3.52E-02	not reported	Ci
	Sludge	TBP (Solid)	8.83E-02	not reported	Ci
	Sludge	TH1 (Solid)	1.81E-01	not reported	Ci
	Sludge	CWP1 (Solid)	5.50E-02	not reported	Ci
	Sludge	CWP2 (Solid)	1.90E-01	not reported	Ci
	Total		8.87E-01	--	Ci
Al	Sludge	CWP1 (Solid)	3.77E+04	8.21E+03	kg
	Sludge	CWP2 (Solid)	5.21E+04	not reported	kg
	Sludge	CWZr1 (Solid)	2.31E+03	not reported	kg
	Sludge	MW1 (Solid)	0.00E+00	not reported	kg
	Sludge	TBP (Solid)	1.61E+02	5.60E+01	kg
	Sludge	TH1 (Solid)	1.80E+03	not reported	kg
	Total		9.40E+04	--	kg
Bi	Sludge	TH1 (Solid)	0.00E+00	not reported	kg
	Sludge	CWP1 (Solid)	0.00E+00	not reported	kg
	Sludge	CWP2 (Solid)	2.28E+03	not reported	kg
	Sludge	CWZr1 (Solid)	1.01E+02	not reported	kg
	Sludge	MW1 (Solid)	3.37E-01	not reported	kg
	Sludge	TBP (Solid)	4.53E+01	1.20E+01	kg
	Total		2.42E+03	--	kg
Ca	Sludge	CWP1 (Solid)	5.52E+02	5.54E+02	kg
	Sludge	CWP2 (Solid)	4.52E+03	not reported	kg
	Sludge	CWZr1 (Solid)	2.01E+02	not reported	kg
	Sludge	MW1 (Solid)	9.34E+01	not reported	kg
	Sludge	TBP (Solid)	2.35E+02	9.31E+01	kg
	Sludge	TH1 (Solid)	1.01E+03	not reported	kg
	Total		6.61E+03	--	kg
Cl	Sludge	CWP1 (Solid)	5.30E+01	9.58E+01	kg
	Sludge	CWP2 (Solid)	1.36E+03	not reported	kg
	Sludge	CWZr1 (Solid)	6.06E+01	not reported	kg
	Sludge	MW1 (Solid)	6.46E-01	not reported	kg
	Sludge	TBP (Solid)	1.26E+02	8.17E+01	kg
	Sludge	TH1 (Solid)	1.88E+02	not reported	kg
	Total		1.79E+03	--	kg
CN	No values reported in BBI.				

Table F-1. Tank C-102 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
Cr *	Sludge	TH1 (Solid)	3.48E+01	not reported	kg
	Sludge	CWP1 (Solid)	9.21E+01	2.57E+02	kg
	Sludge	CWP2 (Solid)	4.79E+02	not reported	kg
	Sludge	CWZr1 (Solid)	2.13E+01	not reported	kg
	Sludge	MW1 (Solid)	9.37E-01	not reported	kg
	Sludge	TBP (Solid)	1.47E+01	7.80E+00	kg
	Total		6.43E+02	--	kg
F	Sludge	CWP1 (Solid)	2.00E+02	1.50E+03	kg
	Sludge	CWP2 (Solid)	3.53E+03	not reported	kg
	Sludge	CWZr1 (Solid)	1.57E+02	not reported	kg
	Sludge	MW1 (Solid)	0.00E+00	not reported	kg
	Sludge	TBP (Solid)	7.04E+01	1.14E+02	kg
	Sludge	TH1 (Solid)	1.91E+02	not reported	kg
	Total		4.14E+03	--	kg
Fe	Sludge	CWP1 (Solid)	1.47E+03	1.58E+03	kg
	Sludge	CWP2 (Solid)	7.91E+03	not reported	kg
	Sludge	CWZr1 (Solid)	3.52E+02	not reported	kg
	Sludge	MW1 (Solid)	1.27E+02	not reported	kg
	Sludge	TBP (Solid)	1.78E+03	2.89E+02	kg
	Sludge	TH1 (Solid)	5.99E+03	not reported	kg
	Total		1.76E+04	--	kg
Hg	Sludge	CWP1 (Solid)	0.00E+00	not reported	kg
	Sludge	CWP2 (Solid)	0.00E+00	not reported	kg
	Sludge	CWZr1 (Solid)	0.00E+00	not reported	kg
	Sludge	MW1 (Solid)	0.00E+00	not reported	kg
	Sludge	TBP (Solid)	6.05E+00	not reported	kg
	Sludge	TH1 (Solid)	0.00E+00	not reported	kg
	Total		6.05E+00	--	kg
K	Sludge	MW1 (Solid)	1.55E-01	not reported	kg
	Sludge	TBP (Solid)	1.77E+01	9.22E+00	kg
	Sludge	CWP1 (Solid)	1.15E+01	not reported	kg
	Sludge	CWP2 (Solid)	1.03E+03	not reported	kg
	Sludge	CWZr1 (Solid)	4.58E+01	not reported	kg
	Sludge	TH1 (Solid)	9.09E+01	not reported	kg
	Total		1.20E+03	--	kg

Table F-1. Tank C-102 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
La	Sludge	CWP1 (Solid)	0.00E+00	not reported	kg
	Sludge	CWZr1 (Solid)	4.91E+00	not reported	kg
	Sludge	MW1 (Solid)	0.00E+00	not reported	kg
	Sludge	TBP (Solid)	3.17E+00	3.18E+00	kg
	Sludge	TH1 (Solid)	0.00E+00	not reported	kg
	Sludge	CWP2 (Solid)	1.10E+02	not reported	kg
	Total		1.18E+02	--	kg
Mn	Sludge	CWP1 (Solid)	6.19E+01	5.70E+01	kg
	Sludge	CWP2 (Solid)	1.36E+03	not reported	kg
	Sludge	CWZr1 (Solid)	6.05E+01	not reported	kg
	Sludge	MW1 (Solid)	0.00E+00	not reported	kg
	Sludge	TBP (Solid)	1.45E+01	5.15E+00	kg
	Sludge	TH1 (Solid)	0.00E+00	not reported	kg
	Total		1.50E+03	--	kg
Na	Sludge	CWP2 (Solid)	7.35E+04	not reported	kg
	Sludge	CWZr1 (Solid)	3.27E+03	not reported	kg
	Sludge	MW1 (Solid)	2.30E+03	not reported	kg
	Sludge	TBP (Solid)	9.77E+03	1.88E+03	kg
	Sludge	TH1 (Solid)	9.16E+03	not reported	kg
	Sludge	CWP1 (Solid)	8.35E+03	7.35E+03	kg
	Total		1.06E+05	--	kg
Ni	Sludge	CWZr1 (Solid)	2.62E+02	not reported	kg
	Sludge	MW1 (Solid)	5.30E-01	not reported	kg
	Sludge	TBP (Solid)	6.64E+00	1.07E+00	kg
	Sludge	TH1 (Solid)	2.28E+02	not reported	kg
	Sludge	CWP1 (Solid)	1.75E+01	not reported	kg
	Sludge	CWP2 (Solid)	5.89E+03	not reported	kg
	Total		6.41E+03	--	kg
NO_2 *	Sludge	CWP1 (Solid)	1.51E+03	3.15E+03	kg
	Sludge	CWP2 (Solid)	1.20E+04	not reported	kg
	Sludge	CWZr1 (Solid)	5.31E+02	not reported	kg
	Sludge	MW1 (Solid)	1.86E+01	not reported	kg
	Sludge	TBP (Solid)	1.15E+03	8.36E+02	kg
	Sludge	TH1 (Solid)	3.83E+03	not reported	kg
	Total		1.90E+04	--	kg

Table F-1. Tank C-102 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
NO_3	Sludge	CWP1 (Solid)	1.10E+03	4.34E+03	kg
	Sludge	CWP2 (Solid)	3.66E+04	not reported	kg
	Sludge	CWZr1 (Solid)	1.63E+03	not reported	kg
	Sludge	MW1 (Solid)	3.93E+01	not reported	kg
	Sludge	TBP (Solid)	1.67E+04	5.25E+03	kg
	Sludge	TH1 (Solid)	9.18E+03	not reported	kg
	Total		6.52E+04	--	kg
Oxalate	Sludge	TBP (Solid)	3.66E+01	not reported	kg
	Sludge	TH1 (Solid)	1.87E+01	not reported	kg
	Sludge	CWP1 (Solid)	2.13E+02	not reported	kg
	Sludge	CWP2 (Solid)	4.34E+02	not reported	kg
	Sludge	CWZr1 (Solid)	2.96E+01	not reported	kg
	Sludge	MW1 (Solid)	0.00E+00	not reported	kg
	Total		7.31E+02	--	kg
Pb	Sludge	TH1 (Solid)	0.00E+00	not reported	kg
	Sludge	CWP1 (Solid)	7.76E+02	2.28E+03	kg
	Sludge	CWP2 (Solid)	7.62E+02	not reported	kg
	Sludge	CWZr1 (Solid)	3.39E+01	not reported	kg
	Sludge	MW1 (Solid)	0.00E+00	not reported	kg
	Sludge	TBP (Solid)	4.21E+01	2.64E+01	kg
	Total		1.61E+03	--	kg
PO_4	Sludge	CWP1 (Solid)	5.11E+02	2.72E+03	kg
	Sludge	CWP2 (Solid)	2.49E+03	not reported	kg
	Sludge	CWZr1 (Solid)	1.11E+02	not reported	kg
	Sludge	MW1 (Solid)	1.77E+03	not reported	kg
	Sludge	TBP (Solid)	7.72E+03	2.87E+03	kg
	Sludge	TH1 (Solid)	3.76E+03	not reported	kg
	Total		1.64E+04	--	kg
Si	Sludge	CWP1 (Solid)	1.70E+03	1.22E+03	kg
	Sludge	CWP2 (Solid)	3.20E+04	not reported	kg
	Sludge	CWZr1 (Solid)	1.42E+03	not reported	kg
	Sludge	MW1 (Solid)	6.33E-01	not reported	kg
	Sludge	TBP (Solid)	4.89E+01	2.42E+01	kg
	Sludge	TH1 (Solid)	0.00E+00	not reported	kg
	Total		3.52E+04	--	kg

Table F-1. Tank C-102 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
SO_4	Sludge	CWP1 (Solid)	4.12E+02	2.61E+02	kg
	Sludge	CWP2 (Solid)	3.08E+03	not reported	kg
	Sludge	CWZr1 (Solid)	1.37E+02	not reported	kg
	Sludge	MW1 (Solid)	1.56E+03	not reported	kg
	Sludge	TBP (Solid)	1.57E+03	1.80E+03	kg
	Sludge	TH1 (Solid)	4.35E+02	not reported	kg
	Total		7.20E+03	--	kg
Sr	Sludge	CWP1 (Solid)	4.18E+01	4.31E+01	kg
	Sludge	CWP2 (Solid)	6.20E+01	not reported	kg
	Sludge	CWZr1 (Solid)	2.76E+00	not reported	kg
	Sludge	MW1 (Solid)	3.17E-02	not reported	kg
	Sludge	TBP (Solid)	4.75E+01	1.60E+01	kg
	Sludge	TH1 (Solid)	3.01E-01	not reported	kg
	Total		1.54E+02	--	kg
TIC as CO_3	Sludge	CWP2 (Solid)	6.71E+04	not reported	kg
	Sludge	CWZr1 (Solid)	2.98E+03	not reported	kg
	Sludge	MW1 (Solid)	4.51E+02	not reported	kg
	Sludge	TBP (Solid)	1.34E+02	6.73E+01	kg
	Sludge	TH1 (Solid)	1.50E+03	not reported	kg
	Sludge	CWP1 (Solid)	3.40E+03	2.32E+03	kg
	Total		7.55E+04	--	kg
TOC	Sludge	CWP1 (Solid)	6.83E+02	1.14E+03	kg
	Sludge	CWP2 (Solid)	1.02E+03	not reported	kg
	Sludge	CWZr1 (Solid)	4.54E+01	not reported	kg
	Sludge	MW1 (Solid)	0.00E+00	not reported	kg
	Sludge	TBP (Solid)	6.10E+01	2.06E+01	kg
	Sludge	TH1 (Solid)	4.73E+01	not reported	kg
	Total		1.86E+03	--	kg
U_{TOTAL}	Sludge	CWZr1 (Solid)	8.93E+01	not reported	kg
	Sludge	MW1 (Solid)	8.89E+03	not reported	kg
	Sludge	CWP2 (Solid)	2.01E+03	not reported	kg
	Sludge	TBP (Solid)	1.05E+03	4.15E+02	kg
	Sludge	TH1 (Solid)	1.17E+01	not reported	kg
	Sludge	CWP1 (Solid)	3.46E+03	6.01E+04	kg
	Total		1.55E+04	--	kg

Table F-1. Tank C-102 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
Zr	Sludge	TH1 (Solid)	0.00E+00	not reported	kg
	Sludge	CWP1 (Solid)	9.76E+01	1.54E+02	kg
	Sludge	CWP2 (Solid)	4.85E+03	not reported	kg
	Sludge	CWZr1 (Solid)	2.16E+02	not reported	kg
	Sludge	MW1 (Solid)	0.00E+00	not reported	kg
	Sludge	TBP (Solid)	7.71E-01	3.68E-01	kg
	Total		5.16E+03	--	kg

Note: Reference download from http://twinsweb.pnl.gov/data dated 2/1/05.

CWP1 = aluminum cladding waste.
TBP = tributyl phosphate.
TIC = total inorganic carbon.
TOC = total organic carbon.

* Indicator constituents as identified in Section 7.1.1.1.

Table F-2. Tank C-104 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{106}Ru	Sludge	CWP1 (Solid)	2.05E-10	not reported	Ci
	Sludge	CWP2 (Solid)	2.05E-08	not reported	Ci
	Sludge	CWZr1 (Solid)	3.82E-07	not reported	Ci
	Sludge	NA	1.80E-04	not reported	Ci
	Sludge	OWW3 (Solid)	2.49E-09	not reported	Ci
	Sludge	TH2 (Solid)	9.31E-08	not reported	Ci
	Total		1.80E-04	--	Ci
^{113m}Cd	Sludge	CWP1 (Solid)	7.35E-01	not reported	Ci
	Sludge	CWP2 (Solid)	3.89E-01	not reported	Ci
	Sludge	CWZr1 (Solid)	5.76E-02	not reported	Ci
	Sludge	NA	1.79E+00	not reported	Ci
	Sludge	OWW3 (Solid)	2.22E-04	not reported	Ci
	Sludge	TH2 (Solid)	1.30E-01	not reported	Ci
	Total		3.10E+00	--	Ci
^{125}Sb	Sludge	CWP1 (Solid)	2.75E+01	6.64E+00	Ci
	Sludge	CWP2 (Solid)	1.93E+01	4.66E+00	Ci
	Sludge	CWZr1 (Solid)	7.59E+00	1.83E+00	Ci
	Sludge	NA	1.28E+01	3.09E+00	Ci
	Sludge	OWW3 (Solid)	8.69E+00	2.10E+00	Ci
	Sludge	TH2 (Solid)	6.75E+00	1.63E+00	Ci
	Total		8.27E+01	--	Ci
^{126}Sn	Sludge	NA	7.01E-02	not reported	Ci
	Sludge	OWW3 (Solid)	1.26E-05	not reported	Ci
	Sludge	TH2 (Solid)	8.06E-03	not reported	Ci
	Sludge	CWP1 (Solid)	1.09E-03	not reported	Ci
	Sludge	CWP2 (Solid)	4.45E-04	not reported	Ci
	Sludge	CWZr1 (Solid)	3.25E-03	not reported	Ci
	Total		8.29E-02	--	Ci
^{129}I	Sludge	CWP1 (Solid)	2.49E-01	3.30E-02	Ci
	Sludge	CWP2 (Solid)	1.75E-01	2.32E-02	Ci
	Sludge	CWZr1 (Solid)	6.88E-02	9.13E-03	Ci
	Sludge	NA	1.16E-01	1.54E-02	Ci
	Sludge	OWW3 (Solid)	7.87E-02	1.04E-02	Ci
	Sludge	TH2 (Solid)	6.12E-02	8.12E-03	Ci
	Total		7.49E-01	--	Ci

Table F-2. Tank C-104 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{134}Cs	Sludge	NA	2.46E-02	not reported	Ci
	Sludge	OWW3 (Solid)	1.17E-05	not reported	Ci
	Sludge	TH2 (Solid)	1.90E-03	not reported	Ci
	Sludge	CWP1 (Solid)	1.83E-05	not reported	Ci
	Sludge	CWP2 (Solid)	1.11E-04	not reported	Ci
	Sludge	CWZr1 (Solid)	2.75E-02	not reported	Ci
	Total		5.41E-02	--	Ci
^{137}Cs	Sludge	CWP1 (Solid)	2.95E+04	6.96E+03	Ci
	Sludge	CWP2 (Solid)	2.07E+04	4.89E+03	Ci
	Sludge	CWZr1 (Solid)	8.14E+03	1.92E+03	Ci
	Sludge	TH2 (Solid)	7.23E+03	1.71E+03	Ci
	Sludge	NA	1.37E+04	3.23E+03	Ci
	Sludge	OWW3 (Solid)	9.31E+03	2.20E+03	Ci
	Total		8.86E+04	--	Ci
^{137m}Ba	Sludge	CWP1 (Solid)	2.78E+04	not reported	Ci
	Sludge	CWP2 (Solid)	1.95E+04	not reported	Ci
	Sludge	CWZr1 (Solid)	7.68E+03	not reported	Ci
	Sludge	NA	1.30E+04	not reported	Ci
	Sludge	OWW3 (Solid)	8.79E+03	not reported	Ci
	Sludge	TH2 (Solid)	6.83E+03	not reported	Ci
	Total		8.36E+04	--	Ci
^{14}C	Sludge	OWW3 (Solid)	1.94E-01	1.95E-01	Ci
	Sludge	TH2 (Solid)	1.50E-01	1.51E-01	Ci
	Sludge	CWP1 (Solid)	6.13E-01	6.15E-01	Ci
	Sludge	CWP2 (Solid)	4.31E-01	4.33E-01	Ci
	Sludge	CWZr1 (Solid)	1.69E-01	1.70E-01	Ci
	Sludge	NA	2.86E-01	2.87E-01	Ci
	Total		1.84E+00	--	Ci
^{151}Sm	Sludge	CWZr1 (Solid)	1.97E+01	not reported	Ci
	Sludge	NA	5.72E+04	not reported	Ci
	Sludge	OWW3 (Solid)	1.11E-01	not reported	Ci
	Sludge	TH2 (Solid)	2.80E+01	not reported	Ci
	Sludge	CWP1 (Solid)	1.10E+01	not reported	Ci
	Sludge	CWP2 (Solid)	4.34E+00	not reported	Ci
	Total		5.73E+04	--	Ci

Table F-2. Tank C-104 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{152}Eu	Sludge	CWP1 (Solid)	1.31E-03	not reported	Ci
	Sludge	CWP2 (Solid)	9.81E-04	not reported	Ci
	Sludge	CWZr1 (Solid)	2.51E-02	not reported	Ci
	Sludge	NA	1.53E+01	not reported	Ci
	Sludge	OWW3 (Solid)	6.25E-05	not reported	Ci
	Sludge	TH2 (Solid)	7.93E-03	not reported	Ci
	Total		1.53E+01	--	Ci
^{154}Eu	Sludge	CWP1 (Solid)	2.84E+02	2.52E+01	Ci
	Sludge	CWP2 (Solid)	2.00E+02	1.77E+01	Ci
	Sludge	CWZr1 (Solid)	7.85E+01	6.96E+00	Ci
	Sludge	NA	1.33E+02	1.18E+01	Ci
	Sludge	OWW3 (Solid)	8.98E+01	7.96E+00	Ci
	Sludge	TH2 (Solid)	6.97E+01	6.17E+00	Ci
	Total		8.54E+02	--	Ci
^{155}Eu	Sludge	CWP1 (Solid)	1.71E+02	1.53E+01	Ci
	Sludge	CWP2 (Solid)	1.20E+02	1.08E+01	Ci
	Sludge	CWZr1 (Solid)	4.72E+01	4.23E+00	Ci
	Sludge	NA	7.97E+01	7.14E+00	Ci
	Sludge	OWW3 (Solid)	5.40E+01	4.84E+00	Ci
	Sludge	TH2 (Solid)	4.20E+01	3.76E+00	Ci
	Total		5.14E+02	--	Ci
^{226}Ra	Sludge	CWP1 (Solid)	3.49E-07	not reported	Ci
	Sludge	CWP2 (Solid)	5.12E-07	not reported	Ci
	Sludge	CWZr1 (Solid)	2.11E-07	not reported	Ci
	Sludge	NA	5.21E-06	not reported	Ci
	Sludge	OWW3 (Solid)	2.50E-10	not reported	Ci
	Sludge	TH2 (Solid)	1.25E-04	not reported	Ci
	Total		1.31E-04	--	Ci
^{227}Ac	Sludge	CWP1 (Solid)	1.89E-06	not reported	Ci
	Sludge	CWP2 (Solid)	7.75E-03	not reported	Ci
	Sludge	CWZr1 (Solid)	1.45E-06	not reported	Ci
	Sludge	NA	1.33E-04	not reported	Ci
	Sludge	OWW3 (Solid)	7.05E-07	not reported	Ci
	Sludge	TH2 (Solid)	2.01E+00	not reported	Ci
	Total		2.02E+00	--	Ci

Table F-2. Tank C-104 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{228}Ra	Sludge	OWW3 (Solid)	2.07E-01	not reported	Ci
	Sludge	TH2 (Solid)	4.63E-01	not reported	Ci
	Sludge	CWP1 (Solid)	4.37E-01	not reported	Ci
	Sludge	CWP2 (Solid)	3.49E-01	not reported	Ci
	Sludge	CWZr1 (Solid)	2.32E-01	not reported	Ci
	Sludge	NA	2.74E-01	not reported	Ci
	Total		1.96E+00	--	Ci
^{229}Th	Sludge	CWP1 (Solid)	5.87E-10	not reported	Ci
	Sludge	CWP2 (Solid)	4.00E-02	not reported	Ci
	Sludge	CWZr1 (Solid)	9.40E-10	not reported	Ci
	Sludge	NA	1.37E-06	not reported	Ci
	Sludge	OWW3 (Solid)	1.57E-07	not reported	Ci
	Sludge	TH2 (Solid)	5.13E-01	not reported	Ci
	Total		5.53E-01	--	Ci
^{231}Pa	Sludge	CWP1 (Solid)	3.74E-06	not reported	Ci
	Sludge	CWP2 (Solid)	4.04E-04	not reported	Ci
	Sludge	CWZr1 (Solid)	3.25E-06	not reported	Ci
	Sludge	NA	1.19E-03	not reported	Ci
	Sludge	OWW3 (Solid)	1.04E-06	not reported	Ci
	Sludge	TH2 (Solid)	1.68E-01	not reported	Ci
	Total		1.70E-01	--	Ci
^{232}Th	Sludge	CWP1 (Solid)	1.85E+00	1.64E-01	Ci
	Sludge	CWP2 (Solid)	1.30E+00	1.15E-01	Ci
	Sludge	CWZr1 (Solid)	5.10E-01	4.52E-02	Ci
	Sludge	NA	8.61E-01	7.62E-02	Ci
	Sludge	OWW3 (Solid)	5.83E-01	5.16E-02	Ci
	Sludge	TH2 (Solid)	4.53E-01	4.01E-02	Ci
	Total		5.55E+00	--	Ci
^{232}U	Sludge	CWP1 (Solid)	1.34E-04	not reported	Ci
	Sludge	CWP2 (Solid)	6.39E-02	not reported	Ci
	Sludge	CWZr1 (Solid)	1.31E-04	not reported	Ci
	Sludge	NA	2.45E-01	not reported	Ci
	Sludge	OWW3 (Solid)	1.62E-01	not reported	Ci
	Sludge	TH2 (Solid)	1.45E+00	not reported	Ci
	Total		1.92E+00	--	Ci

Table F-2. Tank C-104 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{233}U	Sludge	TH2 (Solid)	3.35E+01	3.09E+00	Ci
	Sludge	OWW3 (Solid)	4.32E+01	3.98E+00	Ci
	Sludge	CWP1 (Solid)	1.37E+02	1.26E+01	Ci
	Sludge	CWP2 (Solid)	9.60E+01	8.85E+00	Ci
	Sludge	CWZr1 (Solid)	3.77E+01	3.47E+00	Ci
	Sludge	NA	6.37E+01	5.87E+00	Ci
	Total		4.11E+02	--	Ci
^{234}U	Sludge	CWP1 (Solid)	6.87E+00	1.47E+00	Ci
	Sludge	CWP2 (Solid)	4.83E+00	1.04E+00	Ci
	Sludge	CWZr1 (Solid)	1.90E+00	4.07E-01	Ci
	Sludge	NA	3.20E+00	6.86E-01	Ci
	Sludge	OWW3 (Solid)	2.17E+00	4.65E-01	Ci
	Sludge	TH2 (Solid)	1.69E+00	3.62E-01	Ci
	Total		2.07E+01	--	Ci
^{235}U	Sludge	CWP1 (Solid)	1.99E-01	1.88E-02	Ci
	Sludge	CWP2 (Solid)	1.40E-01	1.32E-02	Ci
	Sludge	CWZr1 (Solid)	5.50E-02	5.18E-03	Ci
	Sludge	NA	9.29E-02	8.74E-03	Ci
	Sludge	OWW3 (Solid)	6.30E-02	5.93E-03	Ci
	Sludge	TH2 (Solid)	4.89E-02	4.60E-03	Ci
	Total		5.99E-01	--	Ci
^{236}U	Sludge	CWP1 (Solid)	2.26E-01	2.49E-02	Ci
	Sludge	CWP2 (Solid)	1.59E-01	1.75E-02	Ci
	Sludge	CWZr1 (Solid)	6.24E-02	6.86E-03	Ci
	Sludge	NA	1.05E-01	1.15E-02	Ci
	Sludge	OWW3 (Solid)	7.15E-02	7.86E-03	Ci
	Sludge	TH2 (Solid)	5.55E-02	6.10E-03	Ci
	Total		6.80E-01	--	Ci
^{237}Np	Sludge	CWP1 (Solid)	1.45E+00	1.39E-01	Ci
	Sludge	CWP2 (Solid)	1.02E+00	9.81E-02	Ci
	Sludge	CWZr1 (Solid)	4.01E-01	3.85E-02	Ci
	Sludge	NA	6.77E-01	6.50E-02	Ci
	Sludge	OWW3 (Solid)	4.59E-01	4.41E-02	Ci
	Sludge	TH2 (Solid)	3.56E-01	3.42E-02	Ci
	Total		4.36E+00	--	Ci

Table F-2. Tank C-104 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{238}Pu	Sludge	CWP1 (Solid)	3.09E+01	not reported	Ci
	Sludge	CWP2 (Solid)	2.90E+01	not reported	Ci
	Sludge	CWZr1 (Solid)	4.28E+01	not reported	Ci
	Sludge	NA	6.28E+01	not reported	Ci
	Sludge	OWW3 (Solid)	5.59E+01	not reported	Ci
	Sludge	TH2 (Solid)	7.59E+00	not reported	Ci
	Total		2.29E+02	--	Ci
^{238}U	Sludge	CWZr1 (Solid)	1.07E+00	9.49E-02	Ci
	Sludge	TH2 (Solid)	9.52E-01	8.44E-02	Ci
	Sludge	NA	1.81E+00	1.60E-01	Ci
	Sludge	OWW3 (Solid)	1.23E+00	1.09E-01	Ci
	Sludge	CWP1 (Solid)	3.88E+00	3.44E-01	Ci
	Sludge	CWP2 (Solid)	2.72E+00	2.41E-01	Ci
	Total		1.17E+01	--	Ci
^{239}Pu	Sludge	CWP1 (Solid)	1.79E+03	not reported	Ci
	Sludge	CWP2 (Solid)	1.23E+03	not reported	Ci
	Sludge	CWZr1 (Solid)	4.31E+02	not reported	Ci
	Sludge	NA	7.76E+02	not reported	Ci
	Sludge	OWW3 (Solid)	5.07E+02	not reported	Ci
	Sludge	TH2 (Solid)	4.40E+02	not reported	Ci
	Total		5.18E+03	--	Ci
^{240}Pu	Sludge	CWP1 (Solid)	3.73E+02	not reported	Ci
	Sludge	CWP2 (Solid)	2.91E+02	not reported	Ci
	Sludge	CWZr1 (Solid)	1.67E+02	not reported	Ci
	Sludge	NA	2.34E+02	not reported	Ci
	Sludge	OWW3 (Solid)	1.77E+02	not reported	Ci
	Sludge	TH2 (Solid)	9.15E+01	not reported	Ci
	Total		1.33E+03	--	Ci
^{241}Am	Sludge	NA	1.00E+03	1.58E+02	Ci
	Sludge	OWW3 (Solid)	6.88E+02	1.09E+02	Ci
	Sludge	TH2 (Solid)	5.09E+02	8.06E+01	Ci
	Sludge	CWP1 (Solid)	2.07E+03	3.28E+02	Ci
	Sludge	CWP2 (Solid)	1.47E+03	2.33E+02	Ci
	Sludge	CWZr1 (Solid)	6.07E+02	9.62E+01	Ci
	Total		6.34E+03	--	Ci

Table F-2. Tank C-104 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{241}Pu	Sludge	TH2 (Solid)	3.43E+02	not reported	Ci
	Sludge	CWP1 (Solid)	1.40E+03	not reported	Ci
	Sludge	CWP2 (Solid)	1.82E+03	not reported	Ci
	Sludge	CWZr1 (Solid)	2.94E+03	not reported	Ci
	Sludge	NA	3.14E+03	not reported	Ci
	Sludge	OWW3 (Solid)	2.90E+03	not reported	Ci
	Total		1.25E+04	--	Ci
^{242}Cm	Sludge	OWW3 (Solid)	1.01E+00	not reported	Ci
	Sludge	TH2 (Solid)	1.69E-02	not reported	Ci
	Sludge	CWP1 (Solid)	6.90E-02	not reported	Ci
	Sludge	CWP2 (Solid)	6.70E-02	not reported	Ci
	Sludge	CWZr1 (Solid)	9.60E-02	not reported	Ci
	Sludge	NA	8.09E-01	not reported	Ci
	Total		2.07E+00	--	Ci
^{242}Pu	Sludge	NA	3.21E-02	not reported	Ci
	Sludge	OWW3 (Solid)	3.03E-02	not reported	Ci
	Sludge	TH2 (Solid)	2.85E-03	not reported	Ci
	Sludge	CWP1 (Solid)	1.16E-02	not reported	Ci
	Sludge	CWP2 (Solid)	1.48E-02	not reported	Ci
	Sludge	CWZr1 (Solid)	3.22E-02	not reported	Ci
	Total		1.24E-01	--	Ci
^{243}Am	Sludge	CWP1 (Solid)	4.11E-02	not reported	Ci
	Sludge	CWP2 (Solid)	4.35E-02	not reported	Ci
	Sludge	CWZr1 (Solid)	6.34E-02	not reported	Ci
	Sludge	NA	5.91E-01	not reported	Ci
	Sludge	OWW3 (Solid)	6.26E-01	not reported	Ci
	Sludge	TH2 (Solid)	1.01E-02	not reported	Ci
	Total		1.38E+00	--	Ci
^{243}Cm	Sludge	CWZr1 (Solid)	2.55E-02	not reported	Ci
	Sludge	NA	5.82E-02	not reported	Ci
	Sludge	OWW3 (Solid)	9.52E-02	not reported	Ci
	Sludge	TH2 (Solid)	2.99E-04	not reported	Ci
	Sludge	CWP1 (Solid)	1.22E-03	not reported	Ci
	Sludge	CWP2 (Solid)	3.31E-03	not reported	Ci
	Total		1.84E-01	--	Ci

Table F-2. Tank C-104 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{244}Cm	Sludge	CWZr1 (Solid)	5.25E-01	not reported	Ci
	Sludge	NA	1.34E+00	not reported	Ci
	Sludge	OWW3 (Solid)	2.10E+00	not reported	Ci
	Sludge	TH2 (Solid)	7.48E-03	not reported	Ci
	Sludge	CWP1 (Solid)	3.05E-02	not reported	Ci
	Sludge	CWP2 (Solid)	9.81E-02	not reported	Ci
	Total		4.11E+00	--	Ci
^{3}H	Sludge	CWP1 (Solid)	1.57E+01	1.07E+01	Ci
	Sludge	CWP2 (Solid)	1.10E+01	7.52E+00	Ci
	Sludge	CWZr1 (Solid)	4.33E+00	2.96E+00	Ci
	Sludge	NA	7.31E+00	4.99E+00	Ci
	Sludge	OWW3 (Solid)	4.95E+00	3.38E+00	Ci
	Sludge	TH2 (Solid)	3.85E+00	2.63E+00	Ci
	Total		4.71E+01	--	Ci
^{59}Ni	Sludge	CWP1 (Solid)	2.52E+00	not reported	Ci
	Sludge	CWP2 (Solid)	1.75E+00	not reported	Ci
	Sludge	CWZr1 (Solid)	2.64E-02	not reported	Ci
	Sludge	NA	1.38E+00	not reported	Ci
	Sludge	OWW3 (Solid)	9.83E-04	not reported	Ci
	Sludge	TH2 (Solid)	7.15E-03	not reported	Ci
	Total		5.68E+00	--	Ci
^{60}Co	Sludge	CWZr1 (Solid)	1.67E+01	1.48E+00	Ci
	Sludge	NA	2.82E+01	2.49E+00	Ci
	Sludge	OWW3 (Solid)	1.91E+01	1.69E+00	Ci
	Sludge	TH2 (Solid)	1.48E+01	1.31E+00	Ci
	Sludge	CWP1 (Solid)	6.05E+01	5.36E+00	Ci
	Sludge	CWP2 (Solid)	4.25E+01	3.76E+00	Ci
	Total		1.82E+02	--	Ci
^{63}Ni	Sludge	CWP1 (Solid)	2.31E+02	not reported	Ci
	Sludge	CWP2 (Solid)	1.65E+02	not reported	Ci
	Sludge	CWZr1 (Solid)	2.25E+00	not reported	Ci
	Sludge	NA	1.29E+02	not reported	Ci
	Sludge	OWW3 (Solid)	9.27E-02	not reported	Ci
	Sludge	TH2 (Solid)	6.10E-01	not reported	Ci
	Total		5.28E+02	--	Ci

Table F-2. Tank C-104 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{79}Se	Sludge	CWP1 (Solid)	2.12E+00	1.91E-01	Ci
	Sludge	CWP2 (Solid)	1.49E+00	1.35E-01	Ci
	Sludge	CWZr1 (Solid)	5.85E-01	5.28E-02	Ci
	Sludge	NA	9.88E-01	8.91E-02	Ci
	Sludge	OWW3 (Solid)	6.70E-01	6.05E-02	Ci
	Sludge	TH2 (Solid)	5.20E-01	4.69E-02	Ci
	Total		6.37E+00	--	Ci
^{90}Sr	Sludge	CWP1 (Solid)	1.49E+05	1.37E+04	Ci
	Sludge	CWP2 (Solid)	1.04E+05	9.57E+03	Ci
	Sludge	CWZr1 (Solid)	4.11E+04	3.78E+03	Ci
	Sludge	NA	6.93E+04	6.37E+03	Ci
	Sludge	OWW3 (Solid)	4.70E+04	4.32E+03	Ci
	Sludge	TH2 (Solid)	3.65E+04	3.36E+03	Ci
	Total		4.47E+05	--	Ci
^{90}Y	Sludge	TH2 (Solid)	3.65E+04	not reported	Ci
	Sludge	CWP1 (Solid)	1.49E+05	not reported	Ci
	Sludge	CWP2 (Solid)	1.04E+05	not reported	Ci
	Sludge	CWZr1 (Solid)	4.11E+04	not reported	Ci
	Sludge	NA	6.93E+04	not reported	Ci
	Sludge	OWW3 (Solid)	4.70E+04	not reported	Ci
	Total		4.47E+05	--	Ci
^{93m}Nb	Sludge	CWP1 (Solid)	1.36E-02	not reported	Ci
	Sludge	CWP2 (Solid)	5.05E-03	not reported	Ci
	Sludge	CWZr1 (Solid)	5.65E-01	not reported	Ci
	Sludge	NA	8.14E-01	not reported	Ci
	Sludge	OWW3 (Solid)	1.35E-04	not reported	Ci
	Sludge	TH2 (Solid)	5.12E-02	not reported	Ci
	Total		1.45E+00	--	Ci
^{93}Zr	Sludge	CWP1 (Solid)	1.58E-02	not reported	Ci
	Sludge	CWP2 (Solid)	6.21E-03	not reported	Ci
	Sludge	CWZr1 (Solid)	7.07E-01	not reported	Ci
	Sludge	NA	9.95E-01	not reported	Ci
	Sludge	OWW3 (Solid)	1.73E-04	not reported	Ci
	Sludge	TH2 (Solid)	6.54E-02	not reported	Ci
	Total		1.79E+00	--	Ci

Table F-2. Tank C-104 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{99}Tc *	Sludge	CWP1 (Solid)	1.92E+01	1.91E+00	Ci
	Sludge	CWP2 (Solid)	1.35E+01	1.34E+00	Ci
	Sludge	CWZr1 (Solid)	5.29E+00	5.25E-01	Ci
	Sludge	NA	8.94E+00	8.87E-01	Ci
	Sludge	OWW3 (Solid)	6.06E+00	6.01E-01	Ci
	Sludge	TH2 (Solid)	4.70E+00	4.66E-01	Ci
	Total		5.76E+01	--	Ci
Al	Sludge	TH2 (Solid)	7.31E+03	3.19E+03	kg
	Sludge	CWP1 (Solid)	2.98E+04	1.30E+04	kg
	Sludge	CWP2 (Solid)	2.09E+04	9.13E+03	kg
	Sludge	CWZr1 (Solid)	8.23E+03	3.59E+03	kg
	Sludge	NA	1.39E+04	6.07E+03	kg
	Sludge	OWW3 (Solid)	9.42E+03	4.11E+03	kg
	Total		8.96E+04	--	kg
Bi	Sludge	NA	7.01E-01	not reported	kg
	Sludge	CWP1 (Solid)	0.00E+00	not reported	kg
	Sludge	CWP2 (Solid)	0.00E+00	not reported	kg
	Sludge	CWZr1 (Solid)	0.00E+00	not reported	kg
	Sludge	OWW3 (Solid)	0.00E+00	not reported	kg
	Sludge	TH2 (Solid)	0.00E+00	not reported	kg
	Total		7.01E-01	--	kg
Ca	Sludge	OWW3 (Solid)	3.12E+02	5.92E+01	kg
	Sludge	TH2 (Solid)	2.42E+02	4.59E+01	kg
	Sludge	NA	4.60E+02	8.72E+01	kg
	Sludge	CWP1 (Solid)	9.87E+02	1.87E+02	kg
	Sludge	CWP2 (Solid)	6.93E+02	1.31E+02	kg
	Sludge	CWZr1 (Solid)	2.73E+02	5.18E+01	kg
	Total		2.97E+03	--	kg
Cl	Sludge	CWP1 (Solid)	2.65E+02	1.48E+02	kg
	Sludge	CWP2 (Solid)	1.86E+02	1.04E+02	kg
	Sludge	CWZr1 (Solid)	7.30E+01	4.07E+01	kg
	Sludge	NA	1.23E+02	6.85E+01	kg
	Sludge	OWW3 (Solid)	8.36E+01	4.66E+01	kg
	Sludge	TH2 (Solid)	6.49E+01	3.62E+01	kg
	Total		7.95E+02	--	kg

Table F-2. Tank C-104 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
CN	Sludge	CWP1 (Solid)	6.90E+00	8.97E-01	kg
	Sludge	CWP2 (Solid)	4.85E+00	6.30E-01	kg
	Sludge	CWZr1 (Solid)	1.91E+00	2.48E-01	kg
	Sludge	NA	3.22E+00	4.18E-01	kg
	Sludge	OWW3 (Solid)	2.18E+00	2.83E-01	kg
	Sludge	TH2 (Solid)	1.69E+00	2.20E-01	kg
	Total		2.07E+01	--	kg
Cr *	Sludge	CWP1 (Solid)	4.83E+02	5.01E+01	kg
	Sludge	CWP2 (Solid)	3.39E+02	3.52E+01	kg
	Sludge	CWZr1 (Solid)	1.33E+02	1.38E+01	kg
	Sludge	NA	2.25E+02	2.33E+01	kg
	Sludge	OWW3 (Solid)	1.53E+02	1.59E+01	kg
	Sludge	TH2 (Solid)	1.19E+02	1.23E+01	kg
	Total		1.45E+03	--	kg
F	Sludge	CWP1 (Solid)	1.14E+04	3.79E+03	kg
	Sludge	CWP2 (Solid)	8.04E+03	2.67E+03	kg
	Sludge	CWZr1 (Solid)	3.16E+03	1.05E+03	kg
	Sludge	NA	5.33E+03	1.77E+03	kg
	Sludge	OWW3 (Solid)	3.61E+03	1.20E+03	kg
	Sludge	TH2 (Solid)	2.81E+03	9.33E+02	kg
	Total		3.44E+04	--	kg
Fe	Sludge	CWP1 (Solid)	9.12E+03	1.21E+03	kg
	Sludge	CWP2 (Solid)	6.41E+03	8.51E+02	kg
	Sludge	CWZr1 (Solid)	2.52E+03	3.35E+02	kg
	Sludge	NA	4.25E+03	5.64E+02	kg
	Sludge	OWW3 (Solid)	2.88E+03	3.82E+02	kg
	Sludge	TH2 (Solid)	2.24E+03	2.97E+02	kg
	Total		2.74E+04	--	kg
Hg	Sludge	CWP1 (Solid)	2.23E+01	1.99E+00	kg
	Sludge	CWP2 (Solid)	1.56E+01	1.39E+00	kg
	Sludge	CWZr1 (Solid)	6.15E+00	5.48E-01	kg
	Sludge	NA	1.04E+01	9.26E-01	kg
	Sludge	OWW3 (Solid)	7.03E+00	6.26E-01	kg
	Sludge	TH2 (Solid)	5.46E+00	4.86E-01	kg
	Total		6.69E+01	--	kg

Table F-2. Tank C-104 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
K	Sludge	CWP1 (Solid)	4.40E+02	1.05E+02	kg
	Sludge	CWP2 (Solid)	3.09E+02	7.35E+01	kg
	Sludge	CWZr1 (Solid)	1.22E+02	2.90E+01	kg
	Sludge	NA	2.05E+02	4.88E+01	kg
	Sludge	OWW3 (Solid)	1.39E+02	3.31E+01	kg
	Sludge	TH2 (Solid)	1.08E+02	2.57E+01	kg
	Total		1.32E+03	--	kg
La	Sludge	CWP1 (Solid)	1.61E+01	1.81E+00	kg
	Sludge	CWP2 (Solid)	1.13E+01	1.27E+00	kg
	Sludge	CWZr1 (Solid)	4.44E+00	4.98E-01	kg
	Sludge	NA	7.50E+00	8.40E-01	kg
	Sludge	OWW3 (Solid)	5.08E+00	5.69E-01	kg
	Sludge	TH2 (Solid)	3.95E+00	4.43E-01	kg
	Total		4.84E+01	--	kg
Mn	Sludge	TH2 (Solid)	5.69E+02	1.29E+02	kg
	Sludge	CWP1 (Solid)	2.32E+03	5.26E+02	kg
	Sludge	CWP2 (Solid)	1.63E+03	3.70E+02	kg
	Sludge	CWZr1 (Solid)	6.40E+02	1.45E+02	kg
	Sludge	NA	1.08E+03	2.45E+02	kg
	Sludge	OWW3 (Solid)	7.33E+02	1.66E+02	kg
	Total		6.97E+03	--	kg
Na	Sludge	CWP1 (Solid)	5.89E+04	5.28E+03	kg
	Sludge	CWP2 (Solid)	4.14E+04	3.71E+03	kg
	Sludge	CWZr1 (Solid)	1.63E+04	1.46E+03	kg
	Sludge	NA	2.75E+04	2.46E+03	kg
	Sludge	OWW3 (Solid)	1.86E+04	1.66E+03	kg
	Sludge	TH2 (Solid)	1.44E+04	1.29E+03	kg
	Total		1.77E+05	--	kg
Ni	Sludge	CWP1 (Solid)	8.71E+02	1.15E+02	kg
	Sludge	CWP2 (Solid)	6.12E+02	8.06E+01	kg
	Sludge	CWZr1 (Solid)	2.40E+02	3.16E+01	kg
	Sludge	NA	4.06E+02	5.34E+01	kg
	Sludge	OWW3 (Solid)	2.75E+02	3.62E+01	kg
	Sludge	TH2 (Solid)	2.14E+02	2.82E+01	kg
	Total		2.62E+03	--	kg

Table F-2. Tank C-104 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
NO_2 *	Sludge	CWP1 (Solid)	1.21E+04	3.41E+03	kg
	Sludge	CWP2 (Solid)	8.48E+03	2.39E+03	kg
	Sludge	CWZr1 (Solid)	3.33E+03	9.39E+02	kg
	Sludge	NA	5.63E+03	1.59E+03	kg
	Sludge	OWW3 (Solid)	3.81E+03	1.07E+03	kg
	Sludge	TH2 (Solid)	2.96E+03	8.35E+02	kg
	Total		3.63E+04	--	kg
NO_3	Sludge	CWP2 (Solid)	4.55E+03	1.42E+03	kg
	Sludge	CWZr1 (Solid)	1.79E+03	5.60E+02	kg
	Sludge	NA	3.02E+03	9.45E+02	kg
	Sludge	OWW3 (Solid)	2.04E+03	6.38E+02	kg
	Sludge	TH2 (Solid)	1.59E+03	4.97E+02	kg
	Sludge	CWP1 (Solid)	6.47E+03	2.02E+03	kg
	Total		1.95E+04	--	kg
Oxalate	Sludge	CWP1 (Solid)	1.86E+03	4.18E+02	kg
	Sludge	CWP2 (Solid)	1.30E+03	2.92E+02	kg
	Sludge	CWZr1 (Solid)	5.12E+02	1.15E+02	kg
	Sludge	NA	8.65E+02	1.94E+02	kg
	Sludge	OWW3 (Solid)	5.86E+02	1.32E+02	kg
	Sludge	TH2 (Solid)	4.55E+02	1.02E+02	kg
	Total		5.58E+03	--	kg
Pb	Sludge	TH2 (Solid)	6.79E+01	6.17E+00	kg
	Sludge	CWP1 (Solid)	2.77E+02	2.52E+01	kg
	Sludge	CWP2 (Solid)	1.94E+02	1.76E+01	kg
	Sludge	CWZr1 (Solid)	7.64E+01	6.95E+00	kg
	Sludge	NA	1.29E+02	1.17E+01	kg
	Sludge	OWW3 (Solid)	8.74E+01	7.95E+00	kg
	Total		8.32E+02	--	kg
PO_4	Sludge	CWP1 (Solid)	1.06E+03	1.33E+02	kg
	Sludge	CWP2 (Solid)	7.45E+02	9.33E+01	kg
	Sludge	CWZr1 (Solid)	2.93E+02	3.67E+01	kg
	Sludge	NA	4.94E+02	6.18E+01	kg
	Sludge	OWW3 (Solid)	3.35E+02	4.19E+01	kg
	Sludge	TH2 (Solid)	2.60E+02	3.25E+01	kg
	Total		3.19E+03	--	kg

Table F-2. Tank C-104 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
Si	Sludge	OWW3 (Solid)	1.07E+03	4.54E+02	kg
	Sludge	TH2 (Solid)	8.30E+02	3.52E+02	kg
	Sludge	CWP1 (Solid)	3.38E+03	1.43E+03	kg
	Sludge	CWP2 (Solid)	2.38E+03	1.01E+03	kg
	Sludge	CWZr1 (Solid)	9.34E+02	3.96E+02	kg
	Sludge	NA	1.58E+03	6.70E+02	kg
	Total		1.02E+04	--	kg
SO_4	Sludge	CWP1 (Solid)	1.13E+03	1.00E+02	kg
	Sludge	CWP2 (Solid)	7.94E+02	7.04E+01	kg
	Sludge	CWZr1 (Solid)	3.12E+02	2.77E+01	kg
	Sludge	NA	5.27E+02	4.67E+01	kg
	Sludge	OWW3 (Solid)	3.57E+02	3.17E+01	kg
	Sludge	TH2 (Solid)	2.77E+02	2.46E+01	kg
	Total		3.40E+03	--	kg
Sr	Sludge	CWP2 (Solid)	2.03E+01	1.92E+00	kg
	Sludge	CWP1 (Solid)	2.89E+01	2.73E+00	kg
	Sludge	CWZr1 (Solid)	7.98E+00	7.54E-01	kg
	Sludge	NA	1.35E+01	1.27E+00	kg
	Sludge	OWW3 (Solid)	9.14E+00	8.63E-01	kg
	Sludge	TH2 (Solid)	7.10E+00	6.70E-01	kg
	Total		8.69E+01	--	kg
TIC as CO_3	Sludge	CWP2 (Solid)	1.13E+04	2.53E+03	kg
	Sludge	CWZr1 (Solid)	4.43E+03	9.94E+02	kg
	Sludge	NA	7.48E+03	1.68E+03	kg
	Sludge	OWW3 (Solid)	5.07E+03	1.14E+03	kg
	Sludge	TH2 (Solid)	3.94E+03	8.84E+02	kg
	Sludge	CWP1 (Solid)	1.60E+04	3.59E+03	kg
	Total		4.82E+04	--	kg
TOC	Sludge	CWP1 (Solid)	4.68E+03	5.11E+02	kg
	Sludge	CWP2 (Solid)	3.29E+03	3.59E+02	kg
	Sludge	CWZr1 (Solid)	1.29E+03	1.41E+02	kg
	Sludge	NA	2.18E+03	2.38E+02	kg
	Sludge	OWW3 (Solid)	1.48E+03	1.62E+02	kg
	Sludge	TH2 (Solid)	1.15E+03	1.25E+02	kg
	Total		1.41E+04	--	kg

Table F-2. Tank C-104 Inventory. (15 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
U_{TOTAL}	Sludge	CWP1 (Solid)	1.17E+04	1.04E+03	kg
	Sludge	CWP2 (Solid)	8.19E+03	7.24E+02	kg
	Sludge	CWZr1 (Solid)	3.22E+03	2.85E+02	kg
	Sludge	NA	5.44E+03	4.81E+02	kg
	Sludge	OWW3 (Solid)	3.69E+03	3.26E+02	kg
	Sludge	TH2 (Solid)	2.86E+03	2.53E+02	kg
	Total		3.51E+04	--	kg
Zr	Sludge	NA	1.00E+04	4.47E+03	kg
	Sludge	OWW3 (Solid)	6.78E+03	3.03E+03	kg
	Sludge	TH2 (Solid)	5.27E+03	2.36E+03	kg
	Sludge	CWP1 (Solid)	2.15E+04	9.62E+03	kg
	Sludge	CWP2 (Solid)	1.51E+04	6.75E+03	kg
	Sludge	CWZr1 (Solid)	5.92E+03	2.65E+03	kg
	Total		6.45E+04	--	kg

Note: Reference download from http://twinsweb.pnl.gov/data dated 2/1/05.

CWP1 = cladding waste.
CWP2 = cladding waste.
CWZr1 = zirconium cladding waste.
OWW3 = organic wash waste.
NA = not available.
TBP = tributyl phosphate.
TH2 = thoria high-level waste.
TIC = total inorganic carbon.
TOC = total organic carbon.

* Indicator constituents as identified in Section 7.1.1.1.

Table F-3. Tank C-107 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{106}Ru	Sludge	1C (Solid)	4.45E-11	not reported	Ci
	Sludge	CWP2 (Solid)	7.42E-09	not reported	Ci
	Sludge	SRR (Solid)	2.08E-03	not reported	Ci
	Total		2.08E-03	--	Ci
^{113m}Cd	Sludge	1C (Solid)	5.23E-02	not reported	Ci
	Sludge	CWP2 (Solid)	1.41E-01	not reported	Ci
	Sludge	SRR (Solid)	3.57E+00	not reported	Ci
	Total		3.76E+00	--	Ci
^{125}Sb	Sludge	1C (Solid)	6.98E-04	not reported	Ci
	Sludge	CWP2 (Solid)	7.96E-04	not reported	Ci
	Sludge	SRR (Solid)	1.31E+02	not reported	Ci
	Total		1.31E+02	--	Ci
^{126}Sn	Sludge	1C (Solid)	4.34E-03	not reported	Ci
	Sludge	CWP2 (Solid)	1.61E-04	not reported	Ci
	Sludge	SRR (Solid)	2.16E-01	not reported	Ci
	Total		2.21E-01	--	Ci
^{129}I	Sludge	1C (Solid)	3.88E-01	1.48E-01	Ci
	Sludge	CWP2 (Solid)	6.81E-02	2.60E-02	Ci
	Sludge	SRR (Solid)	2.59E-01	9.88E-02	Ci
	Total		7.15E-01	--	Ci
^{134}Cs	Sludge	1C (Solid)	5.32E-07	not reported	Ci
	Sludge	CWP2 (Solid)	4.00E-05	not reported	Ci
	Sludge	SRR (Solid)	1.62E-01	not reported	Ci
	Total		1.62E-01	--	Ci
^{137}Cs	Sludge	SRR (Solid)	2.14E+04	2.81E+03	Ci
	Sludge	1C (Solid)	3.20E+04	4.20E+03	Ci
	Sludge	CWP2 (Solid)	5.61E+03	7.36E+02	Ci
	Total		5.89E+04	--	Ci
^{137m}Ba	Sludge	1C (Solid)	3.02E+04	not reported	Ci
	Sludge	CWP2 (Solid)	5.30E+03	not reported	Ci
	Sludge	SRR (Solid)	2.02E+04	not reported	Ci
	Total		5.56E+04	--	Ci
^{14}C	Sludge	1C (Solid)	2.07E-01	2.11E-01	Ci
	Sludge	CWP2 (Solid)	8.62E-02	not reported	Ci
	Sludge	SRR (Solid)	2.63E-01	not reported	Ci
	Total		5.56E-01	--	Ci

Table F-3. Tank C-107 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{151}Sm	Sludge	1C (Solid)	9.14E+01	not reported	Ci
	Sludge	CWP2 (Solid)	1.57E+00	not reported	Ci
	Sludge	SRR (Solid)	6.31E+05	not reported	Ci
	Total		6.31E+05	--	Ci
^{152}Eu	Sludge	1C (Solid)	2.93E-03	not reported	Ci
	Sludge	CWP2 (Solid)	3.54E-04	not reported	Ci
	Sludge	SRR (Solid)	1.37E+02	not reported	Ci
	Total		1.37E+02	--	Ci
^{154}Eu	Sludge	CWP2 (Solid)	2.49E-02	not reported	Ci
	Sludge	SRR (Solid)	1.25E+03	not reported	Ci
	Sludge	1C (Solid)	1.98E-01	not reported	Ci
	Total		1.25E+03	--	Ci
^{155}Eu	Sludge	CWP2 (Solid)	1.13E-02	not reported	Ci
	Sludge	SRR (Solid)	6.49E+02	not reported	Ci
	Sludge	1C (Solid)	8.53E-02	not reported	Ci
	Total		6.49E+02	--	Ci
^{226}Ra	Sludge	1C (Solid)	5.72E-06	not reported	Ci
	Sludge	CWP2 (Solid)	1.85E-07	not reported	Ci
	Sludge	SRR (Solid)	2.74E-06	not reported	Ci
	Total		8.64E-06	--	Ci
^{227}Ac	Sludge	1C (Solid)	4.89E-05	not reported	Ci
	Sludge	CWP2 (Solid)	2.80E-03	not reported	Ci
	Sludge	SRR (Solid)	1.38E-05	not reported	Ci
	Total		2.86E-03	--	Ci
^{228}Ra	Sludge	1C (Solid)	1.36E-02	not reported	Ci
	Sludge	CWP2 (Solid)	2.86E-03	not reported	Ci
	Sludge	SRR (Solid)	1.11E-02	not reported	Ci
	Total		2.75E-02	--	Ci
^{229}Th	Sludge	1C (Solid)	1.81E-08	not reported	Ci
	Sludge	CWP2 (Solid)	1.45E-02	not reported	Ci
	Sludge	SRR (Solid)	1.63E-08	not reported	Ci
	Total		1.45E-02	--	Ci
^{231}Pa	Sludge	1C (Solid)	3.65E-04	not reported	Ci
	Sludge	CWP2 (Solid)	1.46E-04	not reported	Ci
	Sludge	SRR (Solid)	2.11E-05	not reported	Ci
	Total		5.32E-04	--	Ci

Table F-3. Tank C-107 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{232}Th	Sludge	1C (Solid)	3.93E-02	5.51E-03	Ci
	Sludge	CWP2 (Solid)	6.89E-03	9.67E-04	Ci
	Sludge	SRR (Solid)	2.63E-02	3.69E-03	Ci
	Total		7.24E-02	--	Ci
^{232}U	Sludge	1C (Solid)	2.46E-05	not reported	Ci
	Sludge	CWP2 (Solid)	7.60E-02	not reported	Ci
	Sludge	SRR (Solid)	4.53E-05	not reported	Ci
	Total		7.61E-02	--	Ci
^{233}U	Sludge	1C (Solid)	2.05E-06	not reported	Ci
	Sludge	CWP2 (Solid)	4.72E+00	not reported	Ci
	Sludge	SRR (Solid)	1.42E-04	not reported	Ci
	Total		4.72E+00	--	Ci
^{234}U	Sludge	1C (Solid)	1.98E+00	not reported	Ci
	Sludge	CWP2 (Solid)	6.50E-01	not reported	Ci
	Sludge	SRR (Solid)	4.93E-01	not reported	Ci
	Total		3.12E+00	--	Ci
^{235}U	Sludge	1C (Solid)	8.82E-02	not reported	Ci
	Sludge	CWP2 (Solid)	2.54E-02	not reported	Ci
	Sludge	SRR (Solid)	2.08E-02	not reported	Ci
	Total		1.34E-01	--	Ci
^{236}U	Sludge	1C (Solid)	2.21E-02	not reported	Ci
	Sludge	CWP2 (Solid)	1.60E-02	not reported	Ci
	Sludge	SRR (Solid)	1.30E-02	not reported	Ci
	Total		5.11E-02	--	Ci
^{237}Np	Sludge	1C (Solid)	1.99E-03	not reported	Ci
	Sludge	CWP2 (Solid)	1.08E-04	not reported	Ci
	Sludge	SRR (Solid)	5.07E-02	not reported	Ci
	Total		5.28E-02	--	Ci
^{238}Pu	Sludge	SRR (Solid)	3.09E+01	not reported	Ci
	Sludge	1C (Solid)	8.73E+00	not reported	Ci
	Sludge	CWP2 (Solid)	4.61E+00	not reported	Ci
	Total		4.43E+01	--	Ci
^{238}U	Sludge	1C (Solid)	2.01E+00	not reported	Ci
	Sludge	CWP2 (Solid)	5.86E-01	not reported	Ci
	Sludge	SRR (Solid)	4.80E-01	not reported	Ci
	Total		3.08E+00	--	Ci

Table F-3. Tank C-107 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{239}Pu	Sludge	1C (Solid)	1.24E+03	not reported	Ci
	Sludge	CWP2 (Solid)	1.95E+02	not reported	Ci
	Sludge	SRR (Solid)	7.47E+02	not reported	Ci
	Total		2.18E+03	--	Ci
^{240}Pu	Sludge	1C (Solid)	1.35E+02	not reported	Ci
	Sludge	CWP2 (Solid)	4.62E+01	not reported	Ci
	Sludge	SRR (Solid)	1.73E+02	not reported	Ci
	Total		3.55E+02	--	Ci
^{241}Am	Sludge	1C (Solid)	3.63E+03	5.06E+02	Ci
	Sludge	CWP2 (Solid)	6.37E+02	8.89E+01	Ci
	Sludge	SRR (Solid)	2.43E+03	3.39E+02	Ci
	Total		6.69E+03	--	Ci
^{241}Pu	Sludge	1C (Solid)	2.27E+02	not reported	Ci
	Sludge	CWP2 (Solid)	2.89E+02	not reported	Ci
	Sludge	SRR (Solid)	1.27E+03	not reported	Ci
	Total		1.78E+03	--	Ci
^{242}Cm	Sludge	1C (Solid)	6.29E-01	not reported	Ci
	Sludge	CWP2 (Solid)	2.59E-02	not reported	Ci
	Sludge	SRR (Solid)	1.97E+00	not reported	Ci
	Total		2.62E+00	--	Ci
^{242}Pu	Sludge	1C (Solid)	1.88E-03	not reported	Ci
	Sludge	CWP2 (Solid)	2.34E-03	not reported	Ci
	Sludge	SRR (Solid)	1.21E-02	not reported	Ci
	Total		1.63E-02	--	Ci
^{243}Am	Sludge	1C (Solid)	3.69E-01	not reported	Ci
	Sludge	CWP2 (Solid)	1.68E-02	not reported	Ci
	Sludge	SRR (Solid)	1.49E+00	not reported	Ci
	Total		1.88E+00	--	Ci
^{243}Cm	Sludge	1C (Solid)	7.02E-03	not reported	Ci
	Sludge	SRR (Solid)	1.47E-01	not reported	Ci
	Sludge	CWP2 (Solid)	1.28E-03	not reported	Ci
	Total		1.55E-01	--	Ci
^{244}Cm	Sludge	1C (Solid)	1.58E-01	not reported	Ci
	Sludge	CWP2 (Solid)	3.79E-02	not reported	Ci
	Sludge	SRR (Solid)	3.42E+00	not reported	Ci
	Total		3.62E+00	--	Ci

Table F-3. Tank C-107 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{3}H	Sludge	CWP2 (Solid)	3.53E-01	3.54E-01	Ci
	Sludge	SRR (Solid)	2.45E+00	not reported	Ci
	Sludge	1C (Solid)	3.39E-01	2.38E-01	Ci
	Total		3.14E+00	--	Ci
^{59}Ni	Sludge	1C (Solid)	1.12E-02	not reported	Ci
	Sludge	CWP2 (Solid)	6.31E-01	not reported	Ci
	Sludge	SRR (Solid)	2.16E+00	not reported	Ci
	Total		2.81E+00	--	Ci
^{60}Co	Sludge	SRR (Solid)	1.67E+02	not reported	Ci
	Sludge	CWP2 (Solid)	6.34E-01	6.37E-01	Ci
	Sludge	1C (Solid)	7.15E-02	not reported	Ci
	Total		1.67E+02	--	Ci
^{63}Ni	Sludge	1C (Solid)	1.56E+00	not reported	Ci
	Sludge	CWP2 (Solid)	5.96E+01	not reported	Ci
	Sludge	SRR (Solid)	2.00E+02	not reported	Ci
	Total		2.61E+02	--	Ci
^{79}Se	Sludge	SRR (Solid)	5.07E-02	not reported	Ci
	Sludge	1C (Solid)	1.15E-03	not reported	Ci
	Sludge	CWP2 (Solid)	3.89E-05	not reported	Ci
	Total		5.19E-02	--	Ci
^{90}Sr	Sludge	1C (Solid)	3.40E+05	2.91E+05	Ci
	Sludge	CWP2 (Solid)	5.97E+04	5.11E+04	Ci
	Sludge	SRR (Solid)	1.68E+06	2.42E+05	Ci
	Total		2.08E+06	--	Ci
^{90}Y	Sludge	1C (Solid)	3.40E+05	not reported	Ci
	Sludge	CWP2 (Solid)	5.97E+04	not reported	Ci
	Sludge	SRR (Solid)	1.68E+06	not reported	Ci
	Total		2.08E+06	--	Ci
^{93m}Nb	Sludge	1C (Solid)	1.33E+00	not reported	Ci
	Sludge	CWP2 (Solid)	1.82E-03	not reported	Ci
	Sludge	SRR (Solid)	2.39E+00	not reported	Ci
	Total		3.72E+00	--	Ci
^{93}Zr	Sludge	1C (Solid)	1.47E+00	not reported	Ci
	Sludge	CWP2 (Solid)	2.24E-03	not reported	Ci
	Sludge	SRR (Solid)	3.02E+00	not reported	Ci
	Total		4.50E+00	--	Ci

Table F-3. Tank C-107 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{99}Tc *	Sludge	1C (Solid)	2.04E+01	2.02E+00	Ci
	Sludge	CWP2 (Solid)	3.59E+00	3.55E-01	Ci
	Sludge	SRR (Solid)	1.37E+01	1.35E+00	Ci
	Total		3.77E+01	--	Ci
Al	Sludge	1C (Solid)	1.89E+04	3.87E+03	kg
	Sludge	CWP2 (Solid)	1.64E+04	1.47E+03	kg
	Sludge	SRR (Solid)	2.29E+04	9.77E+03	kg
	Total		5.83E+04	--	kg
Bi	Sludge	1C (Solid)	9.80E+03	3.67E+03	kg
	Sludge	CWP2 (Solid)	4.83E+02	4.14E+02	kg
	Sludge	SRR (Solid)	5.27E+01	7.51E+00	kg
	Total		1.03E+04	--	kg
Ca	Sludge	1C (Solid)	4.80E+02	2.02E+02	kg
	Sludge	CWP2 (Solid)	8.40E+01	1.81E+01	kg
	Sludge	SRR (Solid)	6.73E+02	8.11E+01	kg
	Total		1.24E+03	--	kg
Cl	Sludge	1C (Solid)	5.72E+02	1.17E+02	kg
	Sludge	CWP2 (Solid)	5.88E+01	6.31E+00	kg
	Sludge	SRR (Solid)	2.34E+02	4.25E+01	kg
	Total		8.65E+02	--	kg
CN	Sludge	1C (Solid)	3.30E+00	3.31E+00	kg
	Sludge	CWP2 (Solid)	5.79E-01	5.81E-01	kg
	Sludge	SRR (Solid)	2.20E+00	2.21E+00	kg
	Total		6.08E+00	--	kg
Cr *	Sludge	CWP2 (Solid)	3.61E+01	6.84E+00	kg
	Sludge	SRR (Solid)	3.61E+02	5.74E+01	kg
	Sludge	1C (Solid)	5.29E+02	5.76E+01	kg
	Total		9.26E+02	--	kg
F	Sludge	SRR (Solid)	3.19E+02	7.51E+01	kg
	Sludge	1C (Solid)	5.77E+03	2.03E+03	kg
	Sludge	CWP2 (Solid)	2.49E+02	1.57E+02	kg
	Total		6.34E+03	--	kg
Fe	Sludge	1C (Solid)	4.17E+04	1.86E+04	kg
	Sludge	CWP2 (Solid)	2.83E+03	2.53E+02	kg
	Sludge	SRR (Solid)	5.79E+04	1.17E+04	kg
	Total		1.02E+05	--	kg

Table F-3. Tank C-107 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
Hg	Sludge	1C (Solid)	3.61E+01	8.53E+00	kg
	Sludge	CWP2 (Solid)	6.34E+00	1.50E+00	kg
	Sludge	SRR (Solid)	2.41E+01	5.70E+00	kg
	Total		6.66E+01	--	kg
K	Sludge	CWP2 (Solid)	7.90E+00	not reported	kg
	Sludge	SRR (Solid)	1.73E+02	not reported	kg
	Sludge	1C (Solid)	2.46E+02	4.49E+01	kg
	Total		4.27E+02	--	kg
La	Sludge	CWP2 (Solid)	1.71E+01	4.15E+00	kg
	Sludge	SRR (Solid)	1.53E+02	1.75E+01	kg
	Sludge	1C (Solid)	9.87E+01	5.27E+01	kg
	Total		2.69E+02	--	kg
Mn	Sludge	1C (Solid)	1.84E+03	1.06E+03	kg
	Sludge	CWP2 (Solid)	2.17E+02	1.94E+01	kg
	Sludge	SRR (Solid)	2.95E+03	5.82E+02	kg
	Total		5.01E+03	--	kg
Na	Sludge	1C (Solid)	5.85E+04	7.86E+03	kg
	Sludge	CWP2 (Solid)	7.88E+03	1.28E+03	kg
	Sludge	SRR (Solid)	2.83E+04	2.84E+03	kg
	Total		9.47E+04	--	kg
Ni	Sludge	CWP2 (Solid)	6.49E+02	6.64E+01	kg
	Sludge	SRR (Solid)	1.49E+03	1.53E+02	kg
	Sludge	1C (Solid)	9.37E+02	5.12E+02	kg
	Total		3.08E+03	--	kg
NO_2 *	Sludge	1C (Solid)	2.05E+04	3.01E+03	kg
	Sludge	CWP2 (Solid)	2.58E+03	5.24E+02	kg
	Sludge	SRR (Solid)	1.21E+04	3.07E+03	kg
	Total		3.51E+04	--	kg
NO_3	Sludge	1C (Solid)	3.43E+04	7.33E+03	kg
	Sludge	CWP2 (Solid)	3.21E+03	2.88E+02	kg
	Sludge	SRR (Solid)	1.00E+04	3.39E+03	kg
	Total		4.75E+04	--	kg
Oxalate	Sludge	1C (Solid)	2.01E+02	2.02E+02	kg
	Sludge	CWP2 (Solid)	2.96E+01	not reported	kg
	Sludge	SRR (Solid)	1.34E+02	1.35E+02	kg
	Total		3.65E+02	--	kg

Table F-3. Tank C-107 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
Pb	Sludge	1C (Solid)	3.45E+03	2.11E+03	kg
	Sludge	CWP2 (Solid)	1.66E+03	3.81E+02	kg
	Sludge	SRR (Solid)	4.96E+03	1.15E+03	kg
	Total		1.01E+04	--	kg
PO_4	Sludge	1C (Solid)	4.52E+04	1.13E+04	kg
	Sludge	CWP2 (Solid)	8.25E+03	7.89E+02	kg
	Sludge	SRR (Solid)	4.95E+03	1.22E+03	kg
	Total		5.84E+04	--	kg
Si	Sludge	1C (Solid)	9.78E+02	2.05E+02	kg
	Sludge	CWP2 (Solid)	1.22E+02	1.26E+01	kg
	Sludge	SRR (Solid)	7.58E+02	2.50E+02	kg
	Total		1.86E+03	--	kg
SO_4	Sludge	1C (Solid)	4.93E+03	6.82E+02	kg
	Sludge	CWP2 (Solid)	5.01E+02	4.49E+01	kg
	Sludge	SRR (Solid)	2.95E+03	3.38E+02	kg
	Total		8.38E+03	--	kg
Sr	Sludge	CWP2 (Solid)	2.42E+01	2.48E+00	kg
	Sludge	SRR (Solid)	6.84E+01	6.91E+00	kg
	Sludge	1C (Solid)	1.63E+02	2.48E+01	kg
	Total		2.56E+02	--	kg
TIC as CO_3	Sludge	1C (Solid)	6.16E+03	7.43E+02	kg
	Sludge	CWP2 (Solid)	1.08E+03	1.30E+02	kg
	Sludge	SRR (Solid)	4.12E+03	4.97E+02	kg
	Total		1.14E+04	--	kg
TOC	Sludge	1C (Solid)	3.97E+02	3.73E+01	kg
	Sludge	CWP2 (Solid)	6.97E+01	6.56E+00	kg
	Sludge	SRR (Solid)	2.66E+02	2.50E+01	kg
	Total		7.32E+02	--	kg
U_{TOTAL}	Sludge	1C (Solid)	6.03E+03	1.94E+03	kg
	Sludge	CWP2 (Solid)	1.75E+03	5.64E+02	kg
	Sludge	SRR (Solid)	1.44E+03	1.91E+02	kg
	Total		9.23E+03	--	kg

Table F-3. Tank C-107 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
Zr	Sludge	CWP2 (Solid)	1.72E+00	1.65E-01	kg
	Sludge	1C (Solid)	2.67E+01	1.15E+01	kg
	Sludge	SRR (Solid)	4.53E+01	2.01E+01	kg
	Total		7.37E+01	--	kg
Added Constituents (excluding water)					
Garnet	Total		5.80E+02 to 1.27E+03 (est)**		kg

Note: Reference download from http://twinsweb.pnl.gov/data dated 2/1/05.

1C = first cycle decontamination.
CWP2 = cladding waste.
SRR = strontium recovery supernate waste.
TIC = total inorganic carbon.
TOC = total organic carbon.

* Indicator constituents as identified in Section 7.1.1.1.

**Garnet used to cut hole in tank dome for insertion of new large central riser.

Table F-4. Tank C-108 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{106}Ru	Sludge	1C (Solid)	1.05E-11	not reported	Ci
	Sludge	TBP (Solid)	1.90E-14	not reported	Ci
	Sludge	TFeCN (Solid)	3.09E-12	not reported	Ci
	Total		1.36E-11	--	Ci
^{113m}Cd	Sludge	TBP (Solid)	1.28E-02	not reported	Ci
	Sludge	TFeCN (Solid)	2.56E-02	not reported	Ci
	Sludge	1C (Solid)	1.23E-02	not reported	Ci
	Total		5.06E-02	--	Ci
^{125}Sb	Sludge	TFeCN (Solid)	3.77E-04	not reported	Ci
	Sludge	1C (Solid)	1.64E-04	not reported	Ci
	Sludge	TBP (Solid)	2.07E-04	not reported	Ci
	Total		7.49E-04	--	Ci
^{126}Sn	Sludge	1C (Solid)	1.02E-03	not reported	Ci
	Sludge	TBP (Solid)	1.86E-03	not reported	Ci
	Sludge	TFeCN (Solid)	3.34E-03	not reported	Ci
	Total		6.23E-03	--	Ci
^{129}I	Sludge	1C (Solid)	1.09E-04	not reported	Ci
	Sludge	TBP (Solid)	2.20E-04	not reported	Ci
	Sludge	TFeCN (Solid)	6.47E-04	not reported	Ci
	Total		9.75E-04	--	Ci
^{134}Cs	Sludge	1C (Solid)	1.25E-07	not reported	Ci
	Sludge	TBP (Solid)	1.71E-06	not reported	Ci
	Sludge	TFeCN (Solid)	8.41E-05	not reported	Ci
	Total		8.59E-05	--	Ci
^{137}Cs	Sludge	1C (Solid)	3.42E+04	1.23E+04	Ci
	Sludge	TBP (Solid)	2.95E+04	1.06E+04	Ci
	Sludge	TFeCN (Solid)	1.40E+04	5.05E+03	Ci
	Total		7.77E+04	--	Ci
^{137m}Ba	Sludge	1C (Solid)	3.23E+04	not reported	Ci
	Sludge	TBP (Solid)	2.79E+04	not reported	Ci
	Sludge	TFeCN (Solid)	1.32E+04	not reported	Ci
	Total		7.33E+04	--	Ci
^{14}C	Sludge	1C (Solid)	4.87E-02	5.03E-02	Ci
	Sludge	TBP (Solid)	1.09E-02	not reported	Ci
	Sludge	TFeCN (Solid)	2.22E-02	not reported	Ci
	Total		8.18E-02	--	Ci

Table F-4. Tank C-108 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{151}Sm	Sludge	TBP (Solid)	1.79E+01	not reported	Ci
	Sludge	TFeCN (Solid)	3.51E+01	not reported	Ci
	Sludge	1C (Solid)	2.15E+01	not reported	Ci
	Total		7.45E+01	--	Ci
^{152}Eu	Sludge	1C (Solid)	6.90E-04	not reported	Ci
	Sludge	TBP (Solid)	5.72E-04	not reported	Ci
	Sludge	TFeCN (Solid)	1.09E-03	not reported	Ci
	Total		2.35E-03	--	Ci
^{154}Eu	Sludge	1C (Solid)	4.65E-02	not reported	Ci
	Sludge	TBP (Solid)	3.98E-02	not reported	Ci
	Sludge	TFeCN (Solid)	7.62E-02	not reported	Ci
	Total		1.63E-01	--	Ci
^{155}Eu	Sludge	1C (Solid)	2.01E-02	not reported	Ci
	Sludge	TBP (Solid)	1.91E-02	not reported	Ci
	Sludge	TFeCN (Solid)	3.66E-02	not reported	Ci
	Total		7.58E-02	--	Ci
^{226}Ra	Sludge	TFeCN (Solid)	4.25E-06	not reported	Ci
	Sludge	1C (Solid)	1.35E-06	not reported	Ci
	Sludge	TBP (Solid)	2.35E-06	not reported	Ci
	Total		7.95E-06	--	Ci
^{227}Ac	Sludge	1C (Solid)	1.15E-05	not reported	Ci
	Sludge	TBP (Solid)	1.04E-05	not reported	Ci
	Sludge	TFeCN (Solid)	2.03E-05	not reported	Ci
	Total		4.22E-05	--	Ci
^{228}Ra	Sludge	1C (Solid)	1.51E-11	not reported	Ci
	Sludge	TBP (Solid)	9.01E-12	not reported	Ci
	Sludge	TFeCN (Solid)	1.86E-11	not reported	Ci
	Total		4.27E-11	--	Ci
^{229}Th	Sludge	TBP (Solid)	5.24E-10	not reported	Ci
	Sludge	TFeCN (Solid)	1.90E-09	not reported	Ci
	Sludge	1C (Solid)	4.25E-09	not reported	Ci
	Total		6.68E-09	--	Ci
^{231}Pa	Sludge	1C (Solid)	8.60E-05	not reported	Ci
	Sludge	TBP (Solid)	9.79E-08	not reported	Ci
	Sludge	TFeCN (Solid)	2.21E-05	not reported	Ci
	Total		1.08E-04	--	Ci

Table F-4. Tank C-108 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{232}Th	Sludge	1C (Solid)	3.58E-11	not reported	Ci
	Sludge	TBP (Solid)	4.44E-12	not reported	Ci
	Sludge	TFeCN (Solid)	1.61E-11	not reported	Ci
	Total		5.63E-11	--	Ci
^{232}U	Sludge	1C (Solid)	2.79E-07	not reported	Ci
	Sludge	TBP (Solid)	2.35E-07	not reported	Ci
	Sludge	TFeCN (Solid)	1.12E-07	not reported	Ci
	Total		6.26E-07	--	Ci
^{233}U	Sludge	1C (Solid)	2.33E-08	not reported	Ci
	Sludge	TBP (Solid)	1.97E-08	not reported	Ci
	Sludge	TFeCN (Solid)	9.27E-09	not reported	Ci
	Total		5.22E-08	--	Ci
^{234}U	Sludge	1C (Solid)	2.24E-02	not reported	Ci
	Sludge	TBP (Solid)	1.94E-02	not reported	Ci
	Sludge	TFeCN (Solid)	9.18E-03	not reported	Ci
	Total		5.10E-02	--	Ci
^{235}U	Sludge	1C (Solid)	1.00E-03	not reported	Ci
	Sludge	TBP (Solid)	8.65E-04	not reported	Ci
	Sludge	TFeCN (Solid)	4.10E-04	not reported	Ci
	Total		2.28E-03	--	Ci
^{236}U	Sludge	1C (Solid)	2.51E-04	not reported	Ci
	Sludge	TBP (Solid)	2.22E-04	not reported	Ci
	Sludge	TFeCN (Solid)	1.03E-04	not reported	Ci
	Total		5.75E-04	--	Ci
^{237}Np	Sludge	1C (Solid)	4.68E-04	not reported	Ci
	Sludge	TBP (Solid)	1.36E-03	not reported	Ci
	Sludge	TFeCN (Solid)	2.39E-03	not reported	Ci
	Total		4.22E-03	--	Ci
^{238}Pu	Sludge	1C (Solid)	9.66E-03	not reported	Ci
	Sludge	TBP (Solid)	8.27E-03	not reported	Ci
	Sludge	TFeCN (Solid)	4.10E-03	not reported	Ci
	Total		2.20E-02	--	Ci
^{238}U	Sludge	1C (Solid)	2.29E-02	not reported	Ci
	Sludge	TBP (Solid)	1.97E-02	not reported	Ci
	Sludge	TFeCN (Solid)	9.36E-03	not reported	Ci
	Total		5.20E-02	--	Ci

Table F-4. Tank C-108 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{239}Pu	Sludge	1C (Solid)	1.37E+00	not reported	Ci
	Sludge	TBP (Solid)	1.19E+00	not reported	Ci
	Sludge	TFeCN (Solid)	5.60E-01	not reported	Ci
	Total		3.12E+00	--	Ci
^{240}Pu	Sludge	1C (Solid)	1.50E-01	not reported	Ci
	Sludge	TBP (Solid)	1.27E-01	not reported	Ci
	Sludge	TFeCN (Solid)	6.25E-02	not reported	Ci
	Total		3.39E-01	--	Ci
^{241}Am	Sludge	1C (Solid)	4.73E+00	4.82E+00	Ci
	Sludge	TBP (Solid)	4.08E+00	4.16E+00	Ci
	Sludge	TFeCN (Solid)	1.93E+00	1.97E+00	Ci
	Total		1.07E+01	--	Ci
^{241}Pu	Sludge	1C (Solid)	2.51E-01	not reported	Ci
	Sludge	TBP (Solid)	2.16E-01	not reported	Ci
	Sludge	TFeCN (Solid)	1.10E-01	not reported	Ci
	Total		5.77E-01	--	Ci
^{242}Cm	Sludge	TBP (Solid)	9.84E-04	not reported	Ci
	Sludge	TFeCN (Solid)	4.36E-04	not reported	Ci
	Sludge	1C (Solid)	8.32E-04	not reported	Ci
	Total		2.25E-03	--	Ci
^{242}Pu	Sludge	1C (Solid)	2.08E-06	not reported	Ci
	Sludge	TBP (Solid)	1.75E-06	not reported	Ci
	Sludge	TFeCN (Solid)	9.07E-07	not reported	Ci
	Total		4.73E-06	--	Ci
^{243}Am	Sludge	1C (Solid)	4.88E-04	not reported	Ci
	Sludge	TBP (Solid)	5.81E-04	not reported	Ci
	Sludge	TFeCN (Solid)	2.57E-04	not reported	Ci
	Total		1.33E-03	--	Ci
^{243}Cm	Sludge	1C (Solid)	9.29E-06	not reported	Ci
	Sludge	TBP (Solid)	1.10E-05	not reported	Ci
	Sludge	TFeCN (Solid)	4.89E-06	not reported	Ci
	Total		2.52E-05	--	Ci
^{244}Cm	Sludge	1C (Solid)	2.09E-04	not reported	Ci
	Sludge	TBP (Solid)	2.49E-04	not reported	Ci
	Sludge	TFeCN (Solid)	1.10E-04	not reported	Ci
	Total		5.68E-04	--	Ci

Table F-4. Tank C-108 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{3}H	Sludge	1C (Solid)	7.98E-02	5.77E-02	Ci
	Sludge	TBP (Solid)	2.38E-01	not reported	Ci
	Sludge	TFeCN (Solid)	8.13E-01	8.28E-01	Ci
	Total		1.13E+00	--	Ci
^{59}Ni	Sludge	1C (Solid)	2.65E-03	not reported	Ci
	Sludge	TBP (Solid)	2.86E-03	not reported	Ci
	Sludge	TFeCN (Solid)	1.11E+00	1.13E+00	Ci
	Total		1.12E+00	--	Ci
^{60}Co	Sludge	1C (Solid)	1.68E-02	not reported	Ci
	Sludge	TBP (Solid)	5.72E-03	not reported	Ci
	Sludge	TFeCN (Solid)	2.06E-02	not reported	Ci
	Total		4.32E-02	--	Ci
^{63}Ni	Sludge	1C (Solid)	3.67E-01	not reported	Ci
	Sludge	TBP (Solid)	2.44E-01	not reported	Ci
	Sludge	TFeCN (Solid)	9.92E+01	1.01E+02	Ci
	Total		9.98E+01	--	Ci
^{79}Se	Sludge	1C (Solid)	2.71E-04	not reported	Ci
	Sludge	TBP (Solid)	4.93E-04	not reported	Ci
	Sludge	TFeCN (Solid)	8.87E-04	not reported	Ci
	Total		1.65E-03	--	Ci
^{90}Sr	Sludge	1C (Solid)	3.52E+03	1.04E+03	Ci
	Sludge	TBP (Solid)	3.04E+03	8.97E+02	Ci
	Sludge	TFeCN (Solid)	1.44E+03	4.25E+02	Ci
	Total		8.00E+03	--	Ci
^{90}Y	Sludge	1C (Solid)	3.52E+03	not reported	Ci
	Sludge	TBP (Solid)	3.04E+03	not reported	Ci
	Sludge	TFeCN (Solid)	1.44E+03	not reported	Ci
	Total		8.00E+03	--	Ci
^{93m}Nb	Sludge	1C (Solid)	3.14E-01	not reported	Ci
	Sludge	TBP (Solid)	1.19E-04	not reported	Ci
	Sludge	TFeCN (Solid)	2.65E-02	not reported	Ci
	Total		3.40E-01	--	Ci
^{93}Zr	Sludge	1C (Solid)	3.47E-01	not reported	Ci
	Sludge	TBP (Solid)	1.32E-04	not reported	Ci
	Sludge	TFeCN (Solid)	2.94E-02	not reported	Ci
	Total		3.77E-01	--	Ci

Table F-4. Tank C-108 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{99}Tc *	Sludge	1C (Solid)	5.14E+00	1.96E+01	Ci
	Sludge	TBP (Solid)	1.72E-01	not reported	Ci
	Sludge	TFeCN (Solid)	2.94E-01	not reported	Ci
	Total		5.61E+00	--	Ci
Al	Sludge	1C (Solid)	8.48E+03	2.64E+03	kg
	Sludge	TBP (Solid)	7.32E+03	2.28E+03	kg
	Sludge	TFeCN (Solid)	3.47E+03	1.08E+03	kg
	Total		1.93E+04	--	kg
Bi	Sludge	1C (Solid)	4.02E+03	1.16E+03	kg
	Sludge	TBP (Solid)	8.80E+01	2.80E+01	kg
	Sludge	TFeCN (Solid)	5.44E+00	not reported	kg
	Total		4.12E+03	--	kg
Ca	Sludge	1C (Solid)	2.06E+03	7.98E+02	kg
	Sludge	TBP (Solid)	1.78E+03	6.90E+02	kg
	Sludge	TFeCN (Solid)	8.44E+02	3.27E+02	kg
	Total		4.69E+03	--	kg
Cl	Sludge	TBP (Solid)	1.03E+02	2.80E+01	kg
	Sludge	TFeCN (Solid)	4.86E+01	1.32E+01	kg
	Sludge	1C (Solid)	1.19E+02	3.24E+01	kg
	Total		2.70E+02	--	kg
CN	Sludge	1C (Solid)	3.23E+02	1.78E+02	kg
	Sludge	TBP (Solid)	2.79E+02	1.54E+02	kg
	Sludge	TFeCN (Solid)	1.32E+02	7.28E+01	kg
	Total		7.34E+02	--	kg
Cr *	Sludge	1C (Solid)	1.76E+02	7.67E+01	kg
	Sludge	TBP (Solid)	2.86E+01	1.60E+01	kg
	Sludge	TFeCN (Solid)	2.14E+01	1.20E+01	kg
	Total		2.26E+02	--	kg
F	Sludge	TFeCN (Solid)	2.83E+02	1.38E+02	kg
	Sludge	1C (Solid)	6.92E+02	3.37E+02	kg
	Sludge	TBP (Solid)	5.97E+02	2.90E+02	kg
	Total		1.57E+03	--	kg
Fe	Sludge	1C (Solid)	1.17E+03	3.66E+02	kg
	Sludge	TBP (Solid)	1.01E+03	3.16E+02	kg
	Sludge	TFeCN (Solid)	4.77E+02	1.49E+02	kg
	Total		2.65E+03	--	kg

Table F-4. Tank C-108 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
Hg	Sludge	1C (Solid)	8.00E-02	1.07E-01	kg
	Sludge	TBP (Solid)	1.18E+01	not reported	kg
	Sludge	TFeCN (Solid)	4.92E-01	2.08E-01	kg
	Total		1.23E+01	--	kg
K	Sludge	1C (Solid)	6.73E+01	5.25E+01	kg
	Sludge	TBP (Solid)	3.43E+01	1.89E+01	kg
	Sludge	TFeCN (Solid)	4.25E+01	2.34E+01	kg
	Total		1.44E+02	--	kg
La	Sludge	1C (Solid)	3.60E-01	3.67E-01	kg
	Sludge	TBP (Solid)	6.15E+00	6.27E+00	kg
	Sludge	TFeCN (Solid)	3.64E+00	5.01E+00	kg
	Total		1.02E+01	--	kg
Mn	Sludge	1C (Solid)	1.99E+01	1.82E+01	kg
	Sludge	TBP (Solid)	2.82E+01	1.12E+01	kg
	Sludge	TFeCN (Solid)	1.92E+01	7.61E+00	kg
	Total		6.73E+01	--	kg
Na	Sludge	1C (Solid)	1.53E+04	4.58E+03	kg
	Sludge	TBP (Solid)	1.32E+04	3.95E+03	kg
	Sludge	TFeCN (Solid)	6.27E+03	1.88E+03	kg
	Total		3.48E+04	--	kg
Ni	Sludge	1C (Solid)	1.37E+03	4.21E+02	kg
	Sludge	TFeCN (Solid)	5.60E+02	1.72E+02	kg
	Sludge	TBP (Solid)	1.18E+03	3.62E+02	kg
	Total		3.11E+03	--	kg
NO_2 *	Sludge	1C (Solid)	3.92E+03	1.01E+03	kg
	Sludge	TBP (Solid)	3.39E+03	8.76E+02	kg
	Sludge	TFeCN (Solid)	1.61E+03	4.16E+02	kg
	Total		8.92E+03	--	kg
NO_3	Sludge	1C (Solid)	7.07E+03	1.81E+03	kg
	Sludge	TBP (Solid)	6.10E+03	1.56E+03	kg
	Sludge	TFeCN (Solid)	2.89E+03	7.38E+02	kg
	Total		1.61E+04	--	kg
Oxalate	Sludge	1C (Solid)	2.97E+02	not reported	kg
	Sludge	TBP (Solid)	7.98E+01	not reported	kg
	Sludge	TFeCN (Solid)	3.78E+01	not reported	kg
	Total		4.14E+02	--	kg

Table F-4. Tank C-108 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
Pb	Sludge	1C (Solid)	4.15E+01	3.86E+01	kg
	Sludge	TBP (Solid)	8.17E+01	5.33E+01	kg
	Sludge	TFeCN (Solid)	1.25E+02	8.15E+01	kg
	Total		2.49E+02	--	kg
PO_4	Sludge	1C (Solid)	1.34E+04	5.20E+03	kg
	Sludge	TBP (Solid)	1.15E+04	4.46E+03	kg
	Sludge	TFeCN (Solid)	5.47E+03	2.12E+03	kg
	Total		3.04E+04	--	kg
Si	Sludge	1C (Solid)	1.30E+03	1.22E+03	kg
	Sludge	TBP (Solid)	9.50E+01	4.99E+01	kg
	Sludge	TFeCN (Solid)	2.06E+02	1.08E+02	kg
	Total		1.60E+03	--	kg
SO_4	Sludge	TBP (Solid)	9.41E+02	2.71E+02	kg
	Sludge	TFeCN (Solid)	4.46E+02	1.29E+02	kg
	Sludge	1C (Solid)	1.09E+03	3.14E+02	kg
	Total		2.48E+03	--	kg
Sr	Sludge	1C (Solid)	3.05E+01	9.32E+00	kg
	Sludge	TBP (Solid)	9.24E+01	3.52E+01	kg
	Sludge	TFeCN (Solid)	2.46E+01	9.37E+00	kg
	Total		1.47E+02	--	kg
TIC as CO_3	Sludge	1C (Solid)	1.70E+03	4.90E+02	kg
	Sludge	TBP (Solid)	1.47E+03	4.24E+02	kg
	Sludge	TFeCN (Solid)	6.97E+02	2.01E+02	kg
	Total		3.87E+03	--	kg
TOC	Sludge	1C (Solid)	1.54E+02	5.59E+01	kg
	Sludge	TBP (Solid)	1.33E+02	4.83E+01	kg
	Sludge	TFeCN (Solid)	6.30E+01	2.29E+01	kg
	Total		3.50E+02	--	kg
U_{TOTAL}	Sludge	1C (Solid)	6.85E+01	1.70E+01	kg
	Sludge	TBP (Solid)	5.92E+01	1.47E+01	kg
	Sludge	TFeCN (Solid)	2.80E+01	6.95E+00	kg
	Total		1.56E+02	--	kg

Table F-4. Tank C-108 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
Zr	Sludge	1C (Solid)	2.90E+01	2.84E+01	kg
	Sludge	TBP (Solid)	1.50E+00	7.62E-01	kg
	Sludge	TFeCN (Solid)	9.45E-01	4.80E-01	kg
	Total		3.15E+01	--	kg

Note: Reference download from http://twinsweb.pnl.gov/data dated 2/1/05.

1C = first cycle decontamination.
TBP = tributyl phosphate.
TFeCN = ferrocyanide scavenging.
TIC = total inorganic carbon.
TOC = total organic carbon.

* Indicator constituents as identified in Section 7.1.1.1.

Table F-5. Tank C-112 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{106}Ru	Sludge	TFeCN (Solid)	1.47E-11	not reported	Ci
	Sludge	1C (Solid)	4.77E-12	not reported	Ci
	Sludge	CWP1 (Solid)	3.56E-11	not reported	Ci
	Total		5.51E-11	--	Ci
^{113m}Cd	Sludge	1C (Solid)	5.60E-03	not reported	Ci
	Sludge	CWP1 (Solid)	1.28E-01	not reported	Ci
	Sludge	TFeCN (Solid)	1.21E-01	not reported	Ci
	Total		2.55E-01	--	Ci
^{125}Sb	Sludge	1C (Solid)	2.63E-02	5.71E-03	Ci
	Sludge	CWP1 (Solid)	2.95E-02	6.40E-03	Ci
	Sludge	TFeCN (Solid)	1.25E-01	2.71E-02	Ci
	Total		1.81E-01	--	Ci
^{126}Sn	Sludge	CWP1 (Solid)	1.90E-04	not reported	Ci
	Sludge	TFeCN (Solid)	1.58E-02	not reported	Ci
	Sludge	1C (Solid)	4.65E-04	not reported	Ci
	Total		1.65E-02	--	Ci
^{129}I	Sludge	1C (Solid)	4.94E-05	not reported	Ci
	Sludge	CWP1 (Solid)	2.42E-02	not reported	Ci
	Sludge	TFeCN (Solid)	3.07E-03	not reported	Ci
	Total		2.74E-02	--	Ci
^{134}Cs	Sludge	1C (Solid)	1.40E-02	1.41E-02	Ci
	Sludge	CWP1 (Solid)	1.58E-02	1.59E-02	Ci
	Sludge	TFeCN (Solid)	6.70E-02	6.76E-02	Ci
	Total		9.69E-02	--	Ci
^{137}Cs	Sludge	1C (Solid)	3.86E+04	2.00E+04	Ci
	Sludge	CWP1 (Solid)	4.33E+04	2.24E+04	Ci
	Sludge	TFeCN (Solid)	1.84E+05	9.54E+04	Ci
	Total		2.66E+05	--	Ci
^{137m}Ba	Sludge	1C (Solid)	3.64E+04	not reported	Ci
	Sludge	CWP1 (Solid)	4.09E+04	not reported	Ci
	Sludge	TFeCN (Solid)	1.74E+05	not reported	Ci
	Total		2.51E+05	--	Ci
^{14}C	Sludge	1C (Solid)	5.24E-01	2.17E-01	Ci
	Sludge	CWP1 (Solid)	5.88E-01	2.44E-01	Ci
	Sludge	TFeCN (Solid)	2.50E+00	1.04E+00	Ci
	Total		3.61E+00	--	Ci

Table F-5. Tank C-112 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{151}Sm	Sludge	1C (Solid)	9.79E+00	not reported	Ci
	Sludge	CWP1 (Solid)	1.91E+00	not reported	Ci
	Sludge	TFeCN (Solid)	1.66E+02	not reported	Ci
	Total		1.78E+02	--	Ci
^{152}Eu	Sludge	1C (Solid)	3.14E-04	not reported	Ci
	Sludge	CWP1 (Solid)	2.29E-04	not reported	Ci
	Sludge	TFeCN (Solid)	5.17E-03	not reported	Ci
	Total		5.72E-03	--	Ci
^{154}Eu	Sludge	1C (Solid)	2.51E+01	1.79E+01	Ci
	Sludge	CWP1 (Solid)	2.82E+01	2.01E+01	Ci
	Sludge	TFeCN (Solid)	1.20E+02	8.57E+01	Ci
	Total		1.73E+02	--	Ci
^{155}Eu	Sludge	TFeCN (Solid)	6.49E+01	1.29E+01	Ci
	Sludge	1C (Solid)	1.36E+01	2.71E+00	Ci
	Sludge	CWP1 (Solid)	1.53E+01	3.05E+00	Ci
	Total		9.38E+01	--	Ci
^{226}Ra	Sludge	1C (Solid)	6.13E-07	not reported	Ci
	Sludge	CWP1 (Solid)	6.08E-08	not reported	Ci
	Sludge	TFeCN (Solid)	2.02E-05	not reported	Ci
	Total		2.08E-05	--	Ci
^{227}Ac	Sludge	1C (Solid)	5.24E-06	not reported	Ci
	Sludge	CWP1 (Solid)	3.29E-07	not reported	Ci
	Sludge	TFeCN (Solid)	9.65E-05	not reported	Ci
	Total		1.02E-04	--	Ci
^{228}Ra	Sludge	1C (Solid)	6.89E-04	not reported	Ci
	Sludge	CWP1 (Solid)	5.33E-04	not reported	Ci
	Sludge	TFeCN (Solid)	2.84E-03	not reported	Ci
	Total		4.06E-03	--	Ci
^{229}Th	Sludge	1C (Solid)	1.94E-09	not reported	Ci
	Sludge	CWP1 (Solid)	1.02E-10	not reported	Ci
	Sludge	TFeCN (Solid)	9.01E-09	not reported	Ci
	Total		1.10E-08	--	Ci
^{231}Pa	Sludge	1C (Solid)	3.91E-05	not reported	Ci
	Sludge	CWP1 (Solid)	6.52E-07	not reported	Ci
	Sludge	TFeCN (Solid)	1.05E-04	not reported	Ci
	Total		1.45E-04	--	Ci

Table F-5. Tank C-112 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{232}Th	Sludge	TFeCN (Solid)	1.03E-02	not reported	Ci
	Sludge	1C (Solid)	2.15E-03	not reported	Ci
	Sludge	CWP1 (Solid)	2.42E-03	not reported	Ci
	Total		1.48E-02	--	Ci
^{232}U	Sludge	1C (Solid)	1.43E-05	not reported	Ci
	Sludge	CWP1 (Solid)	5.83E-05	not reported	Ci
	Sludge	TFeCN (Solid)	6.66E-05	not reported	Ci
	Total		1.39E-04	--	Ci
^{233}U	Sludge	1C (Solid)	1.19E-06	not reported	Ci
	Sludge	CWP1 (Solid)	2.84E-06	not reported	Ci
	Sludge	TFeCN (Solid)	5.52E-06	not reported	Ci
	Total		9.55E-06	--	Ci
^{234}U	Sludge	1C (Solid)	1.15E+00	not reported	Ci
	Sludge	CWP1 (Solid)	1.28E+00	not reported	Ci
	Sludge	TFeCN (Solid)	5.47E+00	not reported	Ci
	Total		7.89E+00	--	Ci
^{235}U	Sludge	1C (Solid)	5.12E-02	not reported	Ci
	Sludge	CWP1 (Solid)	5.45E-02	not reported	Ci
	Sludge	TFeCN (Solid)	2.44E-01	not reported	Ci
	Total		3.50E-01	--	Ci
^{236}U	Sludge	TFeCN (Solid)	6.14E-02	not reported	Ci
	Sludge	1C (Solid)	1.28E-02	not reported	Ci
	Sludge	CWP1 (Solid)	2.91E-02	not reported	Ci
	Total		1.03E-01	--	Ci
^{237}Np	Sludge	1C (Solid)	1.09E-01	2.00E-02	Ci
	Sludge	CWP1 (Solid)	1.22E-01	2.23E-02	Ci
	Sludge	TFeCN (Solid)	5.20E-01	9.52E-02	Ci
	Total		7.51E-01	--	Ci
^{238}Pu	Sludge	1C (Solid)	1.14E+00	1.65E-01	Ci
	Sludge	CWP1 (Solid)	1.28E+00	1.86E-01	Ci
	Sludge	TFeCN (Solid)	5.42E+00	7.87E-01	Ci
	Total		7.84E+00	--	Ci
^{238}U	Sludge	1C (Solid)	1.17E+00	not reported	Ci
	Sludge	CWP1 (Solid)	1.31E+00	not reported	Ci
	Sludge	TFeCN (Solid)	5.57E+00	not reported	Ci
	Total		8.05E+00	--	Ci

Table F-5. Tank C-112 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{239}Pu	Sludge	1C (Solid)	1.24E+01	not reported	Ci
	Sludge	CWP1 (Solid)	1.28E+01	not reported	Ci
	Sludge	TFeCN (Solid)	5.91E+01	not reported	Ci
	Total		8.43E+01	--	Ci
^{240}Pu	Sludge	CWP1 (Solid)	2.66E+00	not reported	Ci
	Sludge	TFeCN (Solid)	6.59E+00	not reported	Ci
	Sludge	1C (Solid)	1.35E+00	not reported	Ci
	Total		1.06E+01	--	Ci
^{241}Am	Sludge	1C (Solid)	6.83E+01	1.01E+01	Ci
	Sludge	CWP1 (Solid)	7.69E+01	1.14E+01	Ci
	Sludge	TFeCN (Solid)	3.26E+02	4.84E+01	Ci
	Total		4.71E+02	--	Ci
^{241}Pu	Sludge	1C (Solid)	2.27E+00	not reported	Ci
	Sludge	CWP1 (Solid)	9.98E+00	not reported	Ci
	Sludge	TFeCN (Solid)	1.16E+01	not reported	Ci
	Total		2.39E+01	--	Ci
^{242}Cm	Sludge	1C (Solid)	1.29E-02	4.65E-03	Ci
	Sludge	CWP1 (Solid)	1.45E-02	5.23E-03	Ci
	Sludge	TFeCN (Solid)	6.17E-02	2.22E-02	Ci
	Total		8.91E-02	--	Ci
^{242}Pu	Sludge	1C (Solid)	1.88E-05	not reported	Ci
	Sludge	TFeCN (Solid)	9.56E-05	not reported	Ci
	Sludge	CWP1 (Solid)	8.30E-05	not reported	Ci
	Total		1.97E-04	--	Ci
^{243}Am	Sludge	1C (Solid)	7.11E-03	not reported	Ci
	Sludge	CWP1 (Solid)	8.68E-04	not reported	Ci
	Sludge	TFeCN (Solid)	4.33E-02	not reported	Ci
	Total		5.13E-02	--	Ci
^{243}Cm	Sludge	1C (Solid)	3.74E-03	not reported	Ci
	Sludge	CWP1 (Solid)	4.20E-03	not reported	Ci
	Sludge	TFeCN (Solid)	1.79E-02	not reported	Ci
	Total		2.58E-02	--	Ci
^{244}Cm	Sludge	CWP1 (Solid)	8.54E-02	not reported	Ci
	Sludge	1C (Solid)	7.61E-02	not reported	Ci
	Sludge	TFeCN (Solid)	3.63E-01	not reported	Ci
	Total		5.25E-01	--	Ci

Table F-5. Tank C-112 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{3}H	Sludge	1C (Solid)	8.83E-01	1.28E-01	Ci
	Sludge	CWP1 (Solid)	9.92E-01	1.44E-01	Ci
	Sludge	TFeCN (Solid)	4.22E+00	6.14E-01	Ci
	Total		6.09E+00	--	Ci
^{59}Ni	Sludge	1C (Solid)	1.21E+00	1.94E-01	Ci
	Sludge	CWP1 (Solid)	1.36E+00	2.18E-01	Ci
	Sludge	TFeCN (Solid)	5.79E+00	9.27E-01	Ci
	Total		8.36E+00	--	Ci
^{60}Co	Sludge	1C (Solid)	4.23E-01	7.28E-02	Ci
	Sludge	CWP1 (Solid)	4.75E-01	8.17E-02	Ci
	Sludge	TFeCN (Solid)	2.02E+00	3.48E-01	Ci
	Total		2.92E+00	--	Ci
^{63}Ni	Sludge	1C (Solid)	1.08E+02	1.48E+01	Ci
	Sludge	CWP1 (Solid)	1.22E+02	1.67E+01	Ci
	Sludge	TFeCN (Solid)	5.16E+02	7.08E+01	Ci
	Total		7.46E+02	--	Ci
^{79}Se	Sludge	1C (Solid)	8.07E-02	1.11E-02	Ci
	Sludge	CWP1 (Solid)	9.06E-02	1.25E-02	Ci
	Sludge	TFeCN (Solid)	3.85E-01	5.32E-02	Ci
	Total		5.56E-01	--	Ci
^{90}Sr	Sludge	1C (Solid)	8.73E+04	3.57E+04	Ci
	Sludge	CWP1 (Solid)	9.80E+04	4.00E+04	Ci
	Sludge	TFeCN (Solid)	4.16E+05	1.70E+05	Ci
	Total		6.02E+05	--	Ci
^{90}Y	Sludge	TFeCN (Solid)	4.16E+05	not reported	Ci
	Sludge	1C (Solid)	8.73E+04	not reported	Ci
	Sludge	CWP1 (Solid)	9.80E+04	not reported	Ci
	Total		6.02E+05	--	Ci
^{93m}Nb	Sludge	1C (Solid)	1.43E-01	not reported	Ci
	Sludge	CWP1 (Solid)	2.37E-03	not reported	Ci
	Sludge	TFeCN (Solid)	1.26E-01	not reported	Ci
	Total		2.71E-01	--	Ci
^{93}Zr	Sludge	TFeCN (Solid)	1.39E-01	not reported	Ci
	Sludge	1C (Solid)	1.58E-01	not reported	Ci
	Sludge	CWP1 (Solid)	2.76E-03	not reported	Ci
	Total		3.00E-01	--	Ci

Table F-5. Tank C-112 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
^{99}Tc *	Sludge	1C (Solid)	8.86E+00	1.24E+00	Ci
	Sludge	CWP1 (Solid)	9.94E+00	1.39E+00	Ci
	Sludge	TFeCN (Solid)	4.23E+01	5.93E+00	Ci
	Total		6.11E+01	--	Ci
Al	Sludge	1C (Solid)	1.79E+03	4.56E+02	kg
	Sludge	CWP1 (Solid)	2.01E+03	5.12E+02	kg
	Sludge	TFeCN (Solid)	8.55E+03	2.18E+03	kg
	Total		1.24E+04	--	kg
Bi	Sludge	1C (Solid)	1.83E+03	4.63E+02	kg
	Sludge	CWP1 (Solid)	0.00E+00	not reported	kg
	Sludge	TFeCN (Solid)	2.58E+01	not reported	kg
	Total		1.86E+03	--	kg
Ca	Sludge	TFeCN (Solid)	8.09E+03	1.72E+03	kg
	Sludge	1C (Solid)	1.70E+03	3.60E+02	kg
	Sludge	CWP1 (Solid)	1.90E+03	4.03E+02	kg
	Total		1.17E+04	--	kg
Cl	Sludge	1C (Solid)	7.71E+01	1.14E+01	kg
	Sludge	CWP1 (Solid)	8.66E+01	1.28E+01	kg
	Sludge	TFeCN (Solid)	3.68E+02	5.43E+01	kg
	Total		5.32E+02	--	kg
CN	Sludge	1C (Solid)	1.06E+02	1.75E+01	kg
	Sludge	CWP1 (Solid)	1.19E+02	1.96E+01	kg
	Sludge	TFeCN (Solid)	5.06E+02	8.36E+01	kg
	Total		7.31E+02	--	kg
Cr *	Sludge	1C (Solid)	2.02E+01	3.20E+00	kg
	Sludge	CWP1 (Solid)	2.26E+01	3.58E+00	kg
	Sludge	TFeCN (Solid)	9.62E+01	1.52E+01	kg
	Total		1.39E+02	--	kg
F	Sludge	1C (Solid)	6.18E+01	1.19E+01	kg
	Sludge	CWP1 (Solid)	6.94E+01	1.33E+01	kg
	Sludge	TFeCN (Solid)	2.95E+02	5.66E+01	kg
	Total		4.26E+02	--	kg
Fe	Sludge	1C (Solid)	1.98E+03	3.44E+02	kg
	Sludge	CWP1 (Solid)	2.23E+03	3.87E+02	kg
	Sludge	TFeCN (Solid)	9.47E+03	1.64E+03	kg
	Total		1.37E+04	--	kg

Table F-5. Tank C-112 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
Hg	Sludge	TFeCN (Solid)	1.91E+00	3.69E-01	kg
	Sludge	1C (Solid)	4.01E-01	7.75E-02	kg
	Sludge	CWP1 (Solid)	4.51E-01	8.72E-02	kg
	Total		2.77E+00	--	kg
K	Sludge	1C (Solid)	4.35E+01	5.99E+00	kg
	Sludge	CWP1 (Solid)	4.88E+01	6.71E+00	kg
	Sludge	TFeCN (Solid)	2.07E+02	2.85E+01	kg
	Total		3.00E+02	--	kg
La	Sludge	1C (Solid)	6.54E+00	1.53E+00	kg
	Sludge	CWP1 (Solid)	7.35E+00	1.72E+00	kg
	Sludge	TFeCN (Solid)	3.12E+01	7.32E+00	kg
	Total		4.51E+01	--	kg
Mn	Sludge	CWP1 (Solid)	2.00E+01	3.50E+00	kg
	Sludge	TFeCN (Solid)	8.50E+01	1.49E+01	kg
	Sludge	1C (Solid)	1.78E+01	3.11E+00	kg
	Total		1.23E+02	--	kg
Na	Sludge	1C (Solid)	7.27E+03	1.03E+03	kg
	Sludge	CWP1 (Solid)	8.16E+03	1.16E+03	kg
	Sludge	TFeCN (Solid)	3.47E+04	4.93E+03	kg
	Total		5.01E+04	--	kg
Ni	Sludge	1C (Solid)	1.13E+03	2.35E+02	kg
	Sludge	CWP1 (Solid)	1.27E+03	2.64E+02	kg
	Sludge	TFeCN (Solid)	5.39E+03	1.12E+03	kg
	Total		7.78E+03	--	kg
NO_2 *	Sludge	1C (Solid)	4.03E+03	6.15E+02	kg
	Sludge	CWP1 (Solid)	4.53E+03	6.91E+02	kg
	Sludge	TFeCN (Solid)	1.92E+04	2.93E+03	kg
	Total		2.78E+04	--	kg
NO_3	Sludge	CWP1 (Solid)	6.05E+03	9.06E+02	kg
	Sludge	TFeCN (Solid)	2.57E+04	3.85E+03	kg
	Sludge	1C (Solid)	5.39E+03	8.07E+02	kg
	Total		3.72E+04	--	kg
Oxalate	Sludge	1C (Solid)	6.76E+02	not reported	kg
	Sludge	CWP1 (Solid)	1.23E+02	not reported	kg
	Sludge	TFeCN (Solid)	1.01E+03	not reported	kg
	Total		1.80E+03	--	kg

Table F-5. Tank C-112 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
Pb	Sludge	1C (Solid)	2.14E+02	4.24E+01	kg
	Sludge	CWP1 (Solid)	2.40E+02	4.76E+01	kg
	Sludge	TFeCN (Solid)	1.02E+03	2.02E+02	kg
	Total		1.48E+03	--	kg
PO_4	Sludge	1C (Solid)	5.66E+03	2.62E+03	kg
	Sludge	CWP1 (Solid)	6.36E+03	2.94E+03	kg
	Sludge	TFeCN (Solid)	2.70E+04	1.25E+04	kg
	Total		3.90E+04	--	kg
Si	Sludge	1C (Solid)	2.25E+02	7.11E+01	kg
	Sludge	CWP1 (Solid)	2.52E+02	7.96E+01	kg
	Sludge	TFeCN (Solid)	1.07E+03	3.38E+02	kg
	Total		1.55E+03	--	kg
SO_4	Sludge	1C (Solid)	1.02E+03	1.52E+02	kg
	Sludge	CWP1 (Solid)	1.14E+03	1.70E+02	kg
	Sludge	TFeCN (Solid)	4.85E+03	7.22E+02	kg
	Total		7.01E+03	--	kg
Sr	Sludge	1C (Solid)	2.80E+01	6.53E+00	kg
	Sludge	CWP1 (Solid)	3.15E+01	7.35E+00	kg
	Sludge	TFeCN (Solid)	1.34E+02	3.13E+01	kg
	Total		1.93E+02	--	kg
TIC as CO_3	Sludge	1C (Solid)	2.12E+03	3.63E+02	kg
	Sludge	CWP1 (Solid)	2.38E+03	4.07E+02	kg
	Sludge	TFeCN (Solid)	1.01E+04	1.73E+03	kg
	Total		1.46E+04	--	kg
TOC	Sludge	1C (Solid)	3.51E+02	6.68E+01	kg
	Sludge	CWP1 (Solid)	3.94E+02	7.50E+01	kg
	Sludge	TFeCN (Solid)	1.67E+03	3.18E+02	kg
	Total		2.42E+03	--	kg
U_{TOTAL}	Sludge	TFeCN (Solid)	1.67E+04	4.99E+03	kg
	Sludge	1C (Solid)	3.50E+03	1.05E+03	kg
	Sludge	CWP1 (Solid)	3.93E+03	1.18E+03	kg
	Total		2.41E+04	--	kg

Table F-5. Tank C-112 Inventory. (9 Sheets)

Analyte	Waste Phase	Waste Type	Inventory	Standard Deviation	Units
Zr	Sludge	CWP1 (Solid)	1.57E+00	4.32E-01	kg
	Sludge	TFeCN (Solid)	6.68E+00	1.84E+00	kg
	Sludge	1C (Solid)	1.40E+00	3.85E-01	kg
	Total		9.65E+00	--	kg

Note: Reference download from http://twinsweb.pnl.gov/data dated 2/1/05.

1C = first cycle decontamination.
CWP1 = cladding waste.
TFeCN = ferrocyanide scavenging.
TIC = total inorganic carbon.
TOC = total organic carbon.

* Indicator constituents as identified in Section 7.1.1.1.

APPENDIX G

WASHINGTON STATE DEPARTMENT OF ECOLOGY APPROVED CHANGE NOTICE(S)

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Table of Approved RPP-22393 Modification Notices

Number	Subject	Date Initiated	Date Approved by Ecology	Pg. Number
020706-1	Exhauster condensate	2/7/06	4/17/06	G-1
120806-1	AN-106 NO_2^- concentration change	12/8/06	12/14/06	G-4
2007-2	Groundwater monitoring data submittal	Not stated	5/31/07	G-6
2007-3	Tank heel removal equipment	8/2/07	11/8/07	G-8
2008-2	HRR reference	3/12/08	5/16/08	G-18
2008-4	No concrete pit upgrades	4/17/08	5/2/08	G-20
2008-5	Liquid removal from pits	5/7/08	6/11/08	G-32
2008-6	Revise LDM wording	7/8/08	7/31/08	G-34
2008-7	Delete DST supernate ^{99}Tc sample	7/8/08	7/31/08	G-37
2009-2	Addition of CR Vault sump solution to C-104	2/27/09	Initial 4/16/09 Final 4/30/09	G-42
2009-4	Revise C-104 and C-112 risk values in Appendices B and E	3/9/09	5/11/09	G-52
2009-5	Revise volume displacement measurement wording	7/15/09	8/27/09	G-56
2009-6	Add caustic for heel soak	11/4/09	4/7/10	G-58
2010-2	Leave CR Vault sump pumps in place	4/28/10	6/4/10	G-60
2010-3	Add tool to move equipment under C-104 pump, miscellaneous cleanup of out of date/inaccurate words	4/28/10	6/4/10	G-63
2010-4	Revise for MARS in C-107 and cutting of C-107 dome	4/28/10	11/5/10	G-78
2011-01	Change DST annulus leak detection from conductivity to Enraf or other	3/9/11	3/14/11	G-123
2011-02	Include Consent Decree reference and first and second technology	5/10/2011	9/20/11	G-125
2011-03	Change risk calculation for AN-106 nitrite concentration for C-107 retrieval.	8/2/11	8/24/11	G-140

2011-05	Added limit of technology reference for modified sluicing	9/27/11	10/11/11	G-141
2012-02	Provided a provision for equivalent triple rinse.	2/13/12	2/16/12	G-147
2012-03	Switched C-102 retrieved to AN-101.	4/16/12	5/3/212	G-152
2012-08	C-102 retrieval technologies specified.	9/5/12	10/31/12	G-167
2012-11	Updated C-102 groundwater risk estimates.	10/4/12	10/16/12	G-178
2013-05	Alternative leak detection method for C-102.	5/6/13	5/15/13	G-191
2013-06	Miscellaneous updates to align with other TWRWPs	5/8/13	10/15/13	G-194

Office of River Protection, State of Washington Department of Ecology
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(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

<table>
<tr><td colspan="3">1. Document Title and Number: RPP-22393, Rev. 2B, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tank Waste Retrieval Work Plan</td></tr>
<tr><td rowspan="2">2. Minor Field Change: (Section 12.4 HFFACO Action Plan)
☐ Yes: (CH2M HILL Hanford Signature Only – Attach signed form to Primary Document for record purposes)

x No: Proceed to Box 3</td><td>3. Document Issue Date:
9/20/05</td><td rowspan="2">5. Notice Number: 020706-1</td></tr>
<tr><td>3. Document Modification Notice Date:
02/07/06</td></tr>
<tr><td>6.
Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?)

☐ Yes x No</td><td>7.
Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan?

☐ Yes x No</td><td>8. (Check only one box)
☐ Significant Modification
(Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.)
Minor Modification
☐ Requires modification of the document
x Can be accomplished with Modification Notice.</td></tr>
<tr><td colspan="3">9. Description and Justification of Change: See attached redline/strikeout changes for pgs. 3-2 and 3-7.
1 – Deletion on pg 3-7 is made because it is incorrect. The C-103 exhauster condensate is going back to C-103. In addition, the sentence doesn't belong in this section. This section is for DST information.
2 – Added words on pg. 3-2 put condensate drainage wording where it belongs, and corrects it to say it will go to a tank being retrieved rather than the last sound tank. Clarification is also added to show wording refers to tank(s) being retrieved rather than the DST which is also actively ventilated.</td></tr>
<tr><td colspan="3">10. Impact of Change:
None.</td></tr>
<tr><td colspan="3">10. Additional Requirements and/or Provisions[1]:</td></tr>
<tr><td colspan="3"><u>Approvals</u></td></tr>
<tr><td>CH2M HILL Hanford Group, Inc.</td><td>Office of River Protection</td><td>State of Wash., Dept. of Ecology</td></tr>
<tr><td>☐ Provisional Approval[2]
Date</td><td>☐ Provisional Approval[2]
Date</td><td>☐ Provisional Approval[2]
Date</td></tr>
<tr><td>☒ Final Approval [signature]
Date 3/27/06</td><td>☑ Final Approval Roy J. Schepens
Date 4/3/06</td><td>☐ Final Approval [signature]
Date 4-17-06</td></tr>
</table>

Notes

1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision

2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 10, prior to final approval of this modification.

Various monitoring instruments will be used to collect data to support operation of the WRS and perform environmental monitoring. Cameras will be installed in each of the SSTs to provide the capability to visually monitor and aid in control of waste retrieval operations. Instrumentation will also be provided to monitor process control data (e.g., pressures and flow rates). This information will be used to support material balance calculations. The existing ENRAF[1] level gauges will be retracted during waste retrieval operations and will be used periodically to monitor waste levels.

Before initiating waste retrieval, a formal waste compatibility assessment will be performed in accordance with HNF-SD-WM-OCD-015, *Tank Farm Waste Transfer Compatibility Program*. Formal issuance of the compatibility assessment will not be completed until just before waste retrieval operations begin to ensure that current conditions are captured in the assessment.

During waste retrieval operations, the tank(s) being retrieved will be actively ventilated. The ventilation system will consist of skid-mounted high-efficiency particulate air filtered portable exhauster(s). The ventilation system(s) are ~~will be~~ designed to pass air through the tank, thereby reducing condensation and fog within the tank. The vent systems required by Washington State Department of Health (WDOH) ~~will typically~~ include a heater, prefilter, demister, two high-efficiency particulate air filters and test sections, exhaust fan, and stack. Project plans include the design and installation of ~~a new~~ ventilation system(s) to support waste retrieval operations for the C farm tanks as shown in Figure 3-2. Condensate drainage from the exhauster(s) will be routed back to an SST being retrieved. Any change to this drainage routing will covered by a Change Notice Form to this TWRWP. Details of the ~~new~~ ventilation systems are provided in AIR 05-407, *Categorical Tank Farm Facility Waste Retrieval and Closure: Phase II Waste Retrieval Operations*, and DE05NWP-002, *Notice of Construction (NOC) Application for Operations of Waste Retrieval Systems in the Single-Shell Tank (SST) Farms*.

ORP and CH2M HILL Hanford Group, Inc. (CH2M HILL), pursuant to federal requirements for protection of their workers, will develop and implement a personal exposure sampling and monitoring plan for SST waste retrievals. This plan will be developed and implemented by the operations Industrial Hygiene (IH) departments per the CH2M HILL Environmental Health Program with consideration of input from Ecology. Subsequent to issuance of the IH sampling and monitoring plan, changes to that portion of the plan pertaining to sampling exhauster emissions at the stack will be provided to Ecology for Ecology's information in as timely a manner as possible.

New equipment will be installed in the tanks to support waste retrieval. Existing equipment will be removed if and as required to make room for the new equipment. The new slurry pump will be installed in the center riser located in the center pit. Each pump may be mounted on a winch system that will allow the pump to be lowered as waste retrieval progresses. The pump suction will be installed just under the waste surface to start, so little or no water should be required for installation due to the sludge nature (i.e., not hard saltcake) of the waste and the small submergence of the pump suction. The system will be designed to allow the pump suction to be

[1] ENRAF is a trademark of Enraf, Inc., Enraf B.V., Delft, The Netherlands.

3.1.2 Double-Shell Receiver Tanks

The supernate pump and slurry distributor installed in DST AN-106 in support of tank C-103 waste retrieval (RPP-21895) may continue to be used to pump supernate back to the C farm and distribute the sludge as received from tanks C-107, C-108, and C-112. The pump installed in DST AN-101 under Project W-211 may be used to pump supernate in support of C farm retrieval. A new slurry distributor will be installed in DST AN-101 to distribute the sludge received from C farm tanks. A new supernate pump and a new slurry distributor are planned for DST AY-101 to support waste retrieval from C farm tanks.

Because the elevation of the AN farm is approximately 22 ft higher than the C farm and the elevation of the AY tank farm is approximately 32 ft higher than the C farm, the slurry distributor and the supernate pump incorporate anti-siphon devices to prevent unintentional flow from the DST to the SST. ~~Condensate drain lines from the ventilation system will be routed to the last sound tank in C tank farm scheduled for waste retrieval.~~

All waste transfers, including transfer of waste from the C farm tanks to the DSTs and the transfer of supernate from DSTs back to C farm tanks, will be performed using transfer lines that provide secondary containment. The waste retrieval project currently plans to use overground hose-in-hose transfer lines (HIHTLs) and the *Resource Conservation and Recovery Act of 1976* (RCRA)-compliant DST transfer system.

3.1.3 Waste Retrieval System Operating Description

The overall WRS operating strategy will consist of reducing the SST waste inventories. The process will be monitored using closed-circuit television to facilitate waste retrieval and minimize any liquids in the tanks. Supernate will be used as the primary retrieval liquid. Raw water will be used in limited quantities as necessary for waste conveyance and transfer line flushing.

During routine operations, waste retrieval will be initiated by starting the supernate pump in the DST source tank and using the pumped supernate to provide sluicing fluid to the selected sluice nozzle. Initial sluicing will be focused in the center portion of the tank to minimize the time required to get liquid to the slurry pump to allow it to be started. The in-tank camera will be used to provide visual input for directing the sluice nozzle. The slurry pump in tank C-102, C-104, C-107, C-108, or C-112 will be started as soon as liquid from the sluicer operation reaches the area of the pump inlet and there is enough liquid present to prime and operate the pump. During waste retrieval, the flow of liquid into the tanks through the sluice nozzles will be controlled to both limit accumulation of liquid in the tank and to maximize waste retrieval efficiency. The slurry removed will consist of both mobilized tank waste and DST supernate used for mobilization. Maintaining a balanced pumping rate into and out of the tanks is integral to minimizing the liquid volume in the tanks and reducing the potential for leakage.

If initial sluicing efforts show that tank C-102, C-104, C-107, C-108, or C-112 sludge is not readily mobilized, it may be necessary to add sufficient liquid to the tank(s) to cover the sludge and allow it to sit for a period of time to soften the solid waste before sluicing is resumed. It is

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<table>
<tr><td colspan="3">1. Document Title and Number: RPP-22393, Rev. 3, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tank Waste Retrieval Work Plan</td></tr>
<tr><td rowspan="2">2. Minor Field Change:
(Section 12.4 HFFACO Action Plan)
□ Yes: (CH2M HILL Hanford Signature Only – Attach signed form to Primary Document for record purposes)

x No: Proceed to Box 3</td><td>3. Document Issue Date:

4/27/06</td><td rowspan="2">5. Notice Number: 120806-1</td></tr>
<tr><td>4. Document Modification Notice Date:
12/08/06</td></tr>
<tr><td>6.
Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?)

□ Yes x No</td><td>7.
Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan?

□ Yes x No</td><td>8. (Check only one box)
□ Significant Modification
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Minor Modification
□ Requires modification of the document
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</table>

9. Description and Justification of Change:

Summary

The "241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tank Waste Retrieval Work Plan", RPP-22393, Rev 3, states, in Appendix D, Section D2.1, on page D-4, that:

> *Should the retrieval plan vary from that in Section 3.1.1, the Washington State Department of Ecology will be notified of the change via a change notice form.....A retrieval plan variation means: .....(2) making transfers from DSTs other than those listed in Section 3.1.1 into one of the Section 3.1.1 receiver DSTs, which will result in key indicator contaminant concentrations in the receiver DST liquid phase greater than those specified in RPP-21753* (C Farm Retrieval Flowsheet) *for the starting DST supernate concentration. A statement will be included on the change notice form that the estimated risk associated with the revised waste retrieval plan is bounded by the assumed worst case impact shown in Figures D-1, D-2, and D-3.....*

A process change is proposed for the C-108 retrieval that requires notification to Ecology pursuant to the above cited paragraph. That change is to use supernate from tank AY-102, which is not identified in RPP-22393 Section 3.1.1, in the receiver DST (AN-106) to sluice tank C-108, and, because of this change the concentration of NO_2^- in the AN-106 liquid will be above that listed in RPP-21753.

Explanation

Key indicator contaminants, as discussed in Appendix D of RPP-22393, Rev 3, are Tc^{99}, Cr, and NO_2^-.

AN-106, the DST receiver tank for C-108, has been pumped to close to a minimum liquid heel. Prior to retrieval of C-108, supernate will be transferred from AY-102 into AN-106 to provide sluicing liquid for C-108. Tank AY-102 is a DST not listed in Section 3.1.1 of RPP-22393. The AY-102 concentrations

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C-108. Tank AY-102 is a DST not listed in Section 3.1.1 of RPP-22393. The AY-102 concentrations listed in the BBI on 12/7/06 are 7.9×10^{-3} µCi/mL (7.9×10^{-6} Ci/L) for Tc^{99}, 4.9 µg/mL (0.0049 g/L) for Cr, and $2.8 \times 10^{+4}$ µg/mL (28 g/L) for NO_2^-. Thus, the key indicator contaminant concentrations in AN-106 at the start of C-108 retrieval are assumed to be 7.9×10^{-6} Ci/L Tc^{99}, 0.0049 g/L Cr, and 28 g/L NO_2^-

The AN-106 key indicator contaminant concentrations in RPP-21753 Rev 1A are 2.5×10^{-5} Ci/L (2.5×10^{-2} µCi/mL) for Tc^{99}, 1.08×10^{-3} M (0.056 g/L) for Cr, and 3.66×10^{-1} M (16.8 g/L) for NO_2^-.

The estimated AN-106 concentration of NO_2^- from AY-102 (28 g/L) is higher than given for AN-106 in RPP-21753 Rev 1A (16.8 g/L), thus necessitating this modification notice.

The assumed worst case concentrations used to calculate the estimated risk impact for a leak during retrieval of tank C-108 are given in the middle of pg D-4 of Appendix D of RPP-22393. They are 8.3×10^{-5} Ci/L for Tc^{99}, 2.3 g/L for Cr, and 43 g/L for NO_2^-. The AN-106 (AY-102) estimated concentrations are all below these numbers. Therefore, the estimated risk associated with the revised waste retrieval plan during C-108 retrieval is still bounded by the worst case impact shown in Figures D-1, D-2 and D-3.

The following table summarizes the above concentration values.

Key Contaminant	Used for RPP-22393 TWRWP Leak Risk Calculation	Given in RPP-21753 Flowsheet	In AY-102 per BBI and Assumed to be in AN-106
Tc^{99} (Ci/L)	8.3×10^{-5}	2.5×10^{-5}	7.9×10^{-6}
Cr (g/L)	2.3	0.056	0.0049
NO_2^- (g/L)	43	16.8	28

10. Impact of Change:
None.

10. Additional Requirements and/or Provisions[1]:

Approvals

CH2M HILL Hanford Group, Inc.	Office of River Protection	State of Wash., Dept. of Ecology
☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date
☒ Final Approval Date 12/13/06 John Kf for Moses Jaraysi	☒ Final Approval Date 12/13/06	☑ Final Approval Date 12-14-06

Notes
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<table>
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<tr><td rowspan="2">2. Minor Field Change: (Section 12.4 HFFACO Action Plan)
☐ Yes: (CH2M HILL Hanford Signature Only – Attach signed form to Primary Document for record purposes)

X No: Proceed to Box 3</td><td>3. Document Issue Date:

12/14/06</td><td rowspan="2">5. Notice Number: 2007-2</td></tr>
<tr><td>4. Document Modification Notice Date:</td></tr>
<tr><td>6.
Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?)

☐ Yes X No</td><td>7.
Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan?

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☐ Significant Modification
(Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.)
Minor Modification
☐ Requires modification of the document
X Can be accomplished with Modification Notice.</td></tr>
<tr><td colspan="3">9. Description and Justification of Change:

Summary
The "241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tank Waste Retrieval Work Plan", RPP-22393, Rev. 3A, states, in Section 4.1.2:

"The quarterly groundwater monitoring that is currently performed is adequate for the purpose of supplementary data collection during waste retrieval. Ecology will continue to be provided quarterly groundwater monitoring sample results in the PNNL quarterly and annual groundwater monitoring reports. This quarterly information will be formally provided to Ecology by ORP as soon as it becomes available."

It is proposed to delete the last sentence of the above.

Explanation

The deletion is proposed because Ecology is, and has been, on distribution for this report by PNNL. For ORP to formally transmit a report to Ecology that Ecology already has (Ecology receives the report when ORP receives it) works an undue and unnecessary administrative burden on ORP that provides no benefit to Ecology.</td></tr>
<tr><td colspan="3">10. Impact of Change:

Relieve ORP of unnecessary administrative burden.</td></tr>
</table>

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11. Additional Requirements and/or Provisions[1]: The Tank Waste Retrieval Work Plans will continue to provide the list of groundwater monitoring well numbers used for Leak Detection, Monitoring, and Mitigation.

Approvals

CH2M HILL Hanford Group, Inc.	Office of River Protection	State of Wash., Dept. of Ecology
☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date
☒ Final Approval Date 5/24/07	☐ Final Approval Date 5/24/07	☒ Final Approval Date 5/31/07

Notes

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1. Document Title and Number: RPP-22393, Rev. 3B, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tank Waste Retrieval Work Plan		
2. Minor Field Change: (Section 12.4 HFFACO Action Plan) ☐ Yes: (CH2M HILL Hanford Signature Only – Attach signed form to Primary Document for record purposes) x No: Proceed to Box 3	**3.** Document Issue Date: 06/07/07 **4.** Document Modification Notice Date: 8/2/07	**5.** Notice Number: 2007-3
6. Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?) ☐ Yes x No	**7.** Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan? ☐ Yes x No	**8.** (Check only one box) ☐ Significant Modification (Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.) Minor Modification X Requires modification of the document ☐ Can be accomplished with Modification Notice.

9. Description and Justification of Change:

Description

See the proposed redline/strikeout changes on the attached pgs 3-3, 3-5, 3-6, 3-8, 3-11, 3-18, 3-19 and 3-20 of RPP-22393 Rev 3C draft. These changes add a description of tank heel removal equipment and two new diversion boxes. Please note that all pages of section 3 will be replaced for Rev 3C due to carry-over of a lot of wording from one page to the next, but the only document changes are on the attached listed pages.

Explanation

Waste removal in C-108 has proceeded to the point where the originally installed equipment is no longer effective in removing the waste, and the current waste volume is greater than the HFFACO agreed upon limit of 360 ft^3 for 100-series single-shell waste tanks. Additional equipment is necessary to be added to, and operated in, C-108 in order to remove more of the waste heel. Similar equipment may be needed for other tanks covered by this work plan. A description of this equipment and its operation is thus required.

Heel removal technology equipment is subject to the regulatory requirements in Section 5 of RPP-22393 where applicable.

Wording also needs to be added to describe two additional diversion boxes which are being added to C-Farm. These boxes are added to provide a safer and more flexible system where retrieval operations can be easily switched between tanks instead of disconnecting and repositioning HIHTLs.

The new diversion boxes will be in compliance with regulatory requirements of WAC 173-303. Each diversion box which receives hose-in-hose drainage has a leak detector and is inspected using

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instrumentation once every 24 hours during operation via operator rounds. The diversion box can send potential liquid leaks back to the sending SST via drainback or a sump pump. The IQRPE will prepare an independent inspection plan for the tank retrieval project with independent oversight and review of fabrication, installation, and system leak tests considering both primary and secondary containment. The IQRPE plan uses verification points, witness points or hold points to document this review. Per request from Ecology, P&IDs for C-104 retrieval activities will be provided to Ecology when detailed design is complete.		
10. Impact of Change: This change is expected to enable more of the waste heel in a tank to be removed than may be practical with modified sluicing alone.		
11. Additional Requirements and/or Provisions[1]:		
Approvals		
CH2M HILL Hanford Group, Inc.	Office of River Protection	State of Wash., Dept. of Ecology
☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date
☒ Final Approval Date 11/6/07	☑ Final Approval Date 11/7/07	☐ Final Approval Date 11-8-07

TB (mw) 11/07/07

Notes

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lowered as low as possible in each tank to facilitate maximum waste removal. This will allow approximately 10 ft of height adjustment.

The pump installation will be performed by lowering the pump into the tank with a crane. The pump will be installed with the suction just into the waste surface a few inches. No water addition should be necessary for the pump installation because the pump suction will be located just under the waste surface. If the pump suction is too shallow when retrieval is started, the sluice nozzle discharges can be aimed at the pump inlet to enable to the pump to be inserted a little deeper.

A booster pump, if used, will be located within the central riser pit. The WRS for tanks C-107, C-108, and C-112 may require modifications to the saltwell pits to accommodate installation of a slurry pump in the center of the tanks.

The pump adjustment features described previously should allow the pump to be installed with little or no water additions. However, if tank conditions require water additions to successfully install the pumps (e.g., debris under the pump installation riser), water additions would be controlled in accordance with OSD-T-151-00013, *Operating Specifications for Single-Shell Waste Storage Tanks*, Section 4.1). This water would be added through one or both of the sluicers by lancing or by backflushing through the pump. Lancing refers to lowering a water lance into the waste and adding water to fluidize hard material under the addition point. The initial installation height of the pump will be determined using the in-tank video system.

The sluice nozzles in tanks C-102 and C-104 will be installed within the existing pump and sluice pits. The configuration of tanks C-107, C-108, and C-112 is different in that there are no concrete pits and only a single central corrugated metal saltwell pump pit. The WRSs for tanks C-107, C-108, and C-112 will require design and construction of riser extensions to support the installation of the two sluice nozzles and slurry pump. The in-tank imaging system will be installed in an available riser in the tank. Table 3-1 provides the planned riser usage for the tanks C-102, C-104, C-107, C-108, and C-112 WRSs. This riser usage may change.

An in-tank vehicle may be used to aid in removal of waste from a tank. This in-tank vehicle will have high pressure water spray nozzles and a movable blade. The high pressure water can be supplied at a nominal 3000 psig and a nominal 10 gpm. The blade will have a polymer 'squeegee' on the bottom when installed in the tank. The hydraulically powered vehicle will move about on polymer tracks. The in-tank vehicle will be designed to access the tank via a 12 in. diameter riser. The in-tank vehicle support system will include an above ground water supply skid and hydraulic power pack.

Table 3-1. Planned Riser Usage for Tanks C-102, C-104, C-107, C-108, and C-112 Waste Retrieval System.

Riser Number	Tank C-102[2]	Tank C-104[2]	Tank C-107[2]	Tank C-108[2]	Tank C-112[2]
2	ENRAF*[1] level gauge	Exhauster connection	Sluicer	Sluicer	Sluicer
3	Sluicer	Sluicer	Exhauster connection	Vacuum relief/camera port	Exhauster connection
5	--	--	--	--	ENRAF level gauge
6	Sluicer	Sluicer	Vacuum relief, camera port	Exhauster connection	Vacuum relief, camera port
7	Vacuum relief, camera port	Vacuum relief	Sluicer	Sluicer	Sluicer
8	--	ENRAF level gauge	ENRAF level gauge	ENRAF level gauge	--
13	Slurry pump	Slurry pump	Slurry pump	Slurry pump	Slurry pump
14	--	Camera port	--	--	--
Condenser hatchway	Exhauster connection	--	--	--	--

*[1]ENRAF is a trademark of Enraf, Inc., Enraf B.V., Delft, The Netherlands.

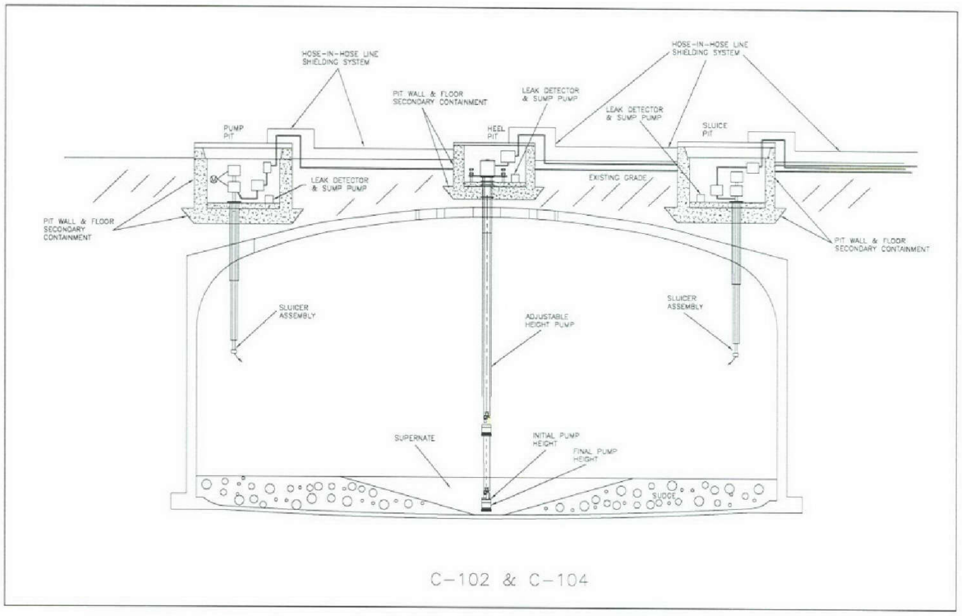
[2]Riser usage may change following detailed design and/or during operations. Should an in-tank vehicle be added to the tank to aid in waste heel removal the riser used will be selected during detailed design for the heel removal. For C-108 waste heel removal the riser used for the in-tank vehicle will be Riser 3 or 6.

A sketch of the WRS installation planned for tanks C-102 and C-104 is provided in Figure 3-3. A sketch of the WRS installation planned for tanks C-107, C-108, and C-112 is provided in Figure 3-4. A potential equipment layout in the tank farm is provided in Figure 3-2.

The portable valve box serves to control the routing and flow of liquid to the sluice nozzles and to control water additions to the waste retrieval process. The valve box provides secondary containment and the collection/detection of any leakage in a sump. The portable valve box has a leak detector that is connected to the pump shutdown system in the control trailer. In the event that a leak is detected in the portable valve box, the transfer pumps in the SST being retrieved and in the receiver DST would be shut down. The portable valve box has a sump and a sump pump that can be configured to transfer any leakage to the SST being retrieved.

Two portable diversion boxes will be added to the C-Farm retrieval system, both will be used for the tanks in this work plan. The transfer lines to and from up to three tanks will be routed through a valving arrangement in each box to permit switching retrieval operations between the tanks. The diversion boxes provide secondary containment and the collection/detection of any leakage in a sump. The diversion boxes each have a leak detector that is connected to the pump shutdown system in the control trailer. In the event that a leak is detected in a diversion box, the transfer pumps in the SST being retrieved and in the receiver DST would be shut down. The diversion boxes each have a sump and a sump pump that can be configured to transfer leakage to the SST being retrieved.

Figure 3-3. Tanks C-102 and C-104 Waste Retrieval System In-Tank Components.



soften the waste would be if the surface had become so hard it resisted breakup by solution from the sluicing nozzles. Extensive dryout of the waste (not likely at the estimated water levels and the 70 to 100 °F waste temperatures) could cause some agglomeration of the material. The waste could also be held together with salt crystals from supernate that had evaporated. Should either of these occur and the waste not breakup effectively when hit with solution from the sluicing nozzles, adding liquid to the waste surface may be tried to soften it for retrieval. Liquid breaks down the bonds in dried out waste or dissolves most salt crystals. The supernate used will not be saturated at the start of retrieval in a tank and thus will be expected to dissolve such salts or break the crystal structure down sufficiently to permit retrieval.

The volume of free liquid added to soften any waste would be minimized by keeping the free liquid height above the waste to as small as practical. Any free liquid added beyond this would provide little benefit. The time period needed to soften the waste is unknown, but would not be expected to be more than a few hours to a few days.

Pumping during sluicing will maintain minimum liquid volume in the tanks. This will be performed by initially directing the nozzle flow towards the center of the tanks. As the sluice liquid contacts the tank waste, the sludge will be mobilized and retrieved via the slurry pumps. Typically, one sluicer will be operated at a time operating at a flow rate of approximately 60 to 120 gal/min.

When needed, the in-tank vehicle will be lowered through a riser to the tank bottom. It will be moved about the tank with the blade employed as needed to push waste towards the pump inlet. The high pressure water nozzles will be used as needed to break up and mobilize the waste. The vehicle tracks may also break up some of the waste agglomerations.

During all field activities, standard operating procedures and safety precautions will be implemented to protect worker health and safety, the public, and the environment. In accordance with standard operating procedures, health physics and industrial health technicians will monitor conditions within the tank farm in accordance with approved monitoring plans.

Liquid will not be added to an SST for the sole purpose of obtaining a level measurement. However, heel submergence remains the best and easiest measurement readily available for estimating the heel volume, and level data will be obtained on an opportunistic basis when performing flushes or during retrieval activities in the latter stages or at the end of the waste retrieval process.

When the level of residual solids gets low in the tank, the volume of solids removed per unit volume of sluicing fluid removed from the tank will be tracked. The units used will be selected by engineering personnel. Waste retrieval operations will continue until less than 360 ft^3 of residual waste remains in the tank, and/or the limits of technology have been reached for this retrieval method. The limit of technology will occur when there are little or no waste solids being removed per unit volume of sluicing fluid used.

The following information will be used to evaluate termination of retrieval and will be shared with Ecology before a decision to terminate field retrieval activities:

- System performance and efficiency data

Table 3-2. Tank C-102, C-104, C-107, C-108, and C-112 Waste Retrieval Summary Data. [a]

Tank	Initial Tank Waste Volume prior to Retrieval (kgal)	Retrieval Flush Volume (kgal) [b]	DST Supernate Recycle (kgal)	Estimated Operating Duration (days) [c]
C-102	316	105	10,270	115
C-104	259	105	8,420	100
C-107	247	105	8,070	98
C-108	66	105	2,180	50
C-112	104	105	3,410	60

DST = double-shell tank.

[a] RPP-21753, 2005, *C Farm 100-Series Tanks, Retrieval Process Flowsheet Description*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

[b] Flushing volume allocation from RPP-21753.

[c] Durations estimated based on the general operating assumptions of 3 shifts operating 7 days/week with 60% operating efficiency. Sluicing durations assume 3 vol% solids loading in slurry and an average transfer rate of 75 gal/min.

The volume of water added to a tank via the high pressure water nozzles of the in-tank vehicle will be dependent upon how efficiently the in-tank vehicle can mobilize waste and direct it to the retrieval pump. Experience with high pressure water usage for a different in-tank vehicle deployed in S-112 showed roughly 1.5 to 2 gal of high pressure water per gal of waste removed. The water pressure used with the in-tank vehicle planned for deployment in C-Farm will be lower than that used in S-112, and the waste agglomerations will be different than the solidified salt in S-112, so the water usage ratios may not be comparable. Assuming 1 to 3 gal of high pressure water per gal waste removed, every 5 kgal of waste heel removed from a tank would add 5 to 15 kgal of water to the DST system. The roughly estimated 7 kgal of waste remaining in C-108 as of mid 2007 would add 7 to 21 kgal of water to the DST system at 1 to 3 gal of high pressure water per gal waste removed.

At the cessation of retrieval operations, the tank walls and heel will be flushed with water. When performing the tank flushes, the flush water may be used to push some of the residual waste to a convenient sampling location. For each flush, the volume of water added will be metered and recorded. The flush liquid will be pumped to a minimum heel following each flush addition. It is assumed that performing the final tank flushes will remove residual solids to the extent practical on the walls and dilute soluble radionuclides and chemicals in the tank liquid. The ENRAF level gauge readings taken during the flushing will provide backup data for final tank residual waste measurement.

Assuming a 2,700-gal. liquid heel in a tank with no solids present before rinsing (solids are expected), rinsing with 33,333 gal. of fresh water, pumping down to 2,700 gal. and repeating twice more, the concentration of soluble constituents in the final 2,700 gal. in the tank would be approximately 5×10^{-4} of the original heel concentrations. If the pump heel is below 2,700 gal. or there are solids present in the heel, the dilution would be more. Performing the final tank

Table 3-3. Tanks C-102, C-104, C-107, C-108, and C-112 Waste Retrieval System Functions and Requirements. (2 Sheets)

Function	Requirement	Basis*	Key Elements
Nuclear safety	The WRS shall be designed and operated to protect workers, the public, the environment, and equipment from exposure to radioactive tank waste and emissions during the retrieval campaign.	WAC 246-247 10 CFR 830 RPP-13033 HNF-SD-WM-TSR-006 HNF-IP-1266	Ensure protection of workers and the public from routine operations and potential accident conditions.
Occupational safety and health	The WRS shall be designed for safe installation, operation and maintenance.	WAC 173-303-283(3)(i) 29 CFR 1910 10 CFR 835 29 CFR 1926	OSHA standards. Occupational Radiation Protection.
WRS secondary containment and leak detection	For ex-tank equipment and piping, the WRS shall incorporate secondary containment and leak-detection design features.	40 CFR 265 WAC 173-303 DOE O 435.1 RPP-13033 HNF-SD-WM-TSR-006	Provide for safe and compliant transfer of waste to the receiver DST.

DST = double-shell tank.
Ecology = Washington State Department of Ecology.
HFFACO = *Hanford Federal Facility Agreement and Consent Order*.
OSHA = Occupational Safety and Health Administration.
WRS = waste retrieval system.
* Basis documents reference information is provided in Section 9.0 of this document.

3.7 ANTICIPATED IMPACTS OF TANK WASTE RETRIEVAL ON FUTURE PIPELINE/ANCILLARY EQUIPMENT RETRIEVAL

The existing buried waste transfer lines routed to tanks C-102, C-104, C-107, C-108, and C-112 have been isolated to prevent the inadvertent transfer of waste or intrusion of water into the tanks. Following waste retrieval activities for these tanks, the new transfer lines and auxiliary equipment will be flushed as needed and the equipment reused or disposed of as discussed in Section 3.9.

Any line flushes for the new transfer lines should direct the flush solution to the receiver DSTs. However, because of the physical location of C tank farm at a lower elevation than the DSTs, there will be some line drainback. The holdup for each transfer line is in the 150- to 200-gal. range. This solution would go to the tank just retrieved, unless a valve change could be made to direct the solution to another SST covered by this tank waste retrieval work plan which had not yet completed retrieval.

Flushing of any valve or diversion boxes should not be necessary following retrieval since any such flushing, which is expected to be transferred back to the SST being retrieved, would be expected to be performed before completion of retrieval. Should the situation arise where a valve or diversion box needs to be flushed following retrieval, it is estimated that the flush volume would be in the 100- to 200-gal. range. This solution would go to the tank just retrieved, unless a valve change could be made to direct the solution to another SST covered by this tank waste retrieval work plan which had not yet completed retrieval.

When retrieval activities are completed, the exhauster(s) used will be disconnected for use elsewhere. This will require draining the exhauster seal pot back to the receiver tank for the drain line. Such drainage will be in the 0- to 20-gal. range.

It is currently planned to leave all in-tank equipment (e.g., the transfer pump) in the tank following retrieval. However, in the unlikely event it is necessary to remove such equipment, it may have to be washed down upon removal to remove excess contamination or to reduce exposure for personnel protection. The volume of water expected for such purposes would likely be in the 50- to 200-gal. range.

Existing risers, pits, and/or caissons associated with the tanks will be isolated following the retrieval activities. These isolation methods are designed to minimize water intrusion to the tank.

In accordance with RPP-13774, disposition of the ex-tank ancillary equipment, including pipelines, will be performed in accordance with a separate component closure activity plan. Flushing of old lines or pits would not be done unless required or permitted by the component closure activity plan. Should such flushing be required or necessary, it would not take place until closure activities were underway, so the impact of any line flush volumes would be accounted for in the closure plan approved tank fill process. See Section 7.1.3.2 for assumptions regarding characterization of residual waste in piping system components.

Following retrieval, it may be necessary to add small (0- to 50-gal.) volumes of water periodically to flush the ENRAF plummet before tank closure. No other activities are envisioned that will purposely add liquids back to a tank once waste retrieval is complete. Should it become necessary to add liquid to a retrieved tank for any reason other than those stated above, Ecology will be notified per existing notification channels.

3.8 INFORMATION FOR NEW ABOVEGROUND TANK SYSTEMS

While there are no new aboveground waste tanks or waste treatment systems, the ancillary and containment equipment are considered part of a tank system per WAC-173-303-040, "Definitions." The new aboveground waste tank system equipment is described in Section 3.1.1. The WRS components that contact the waste are the equipment installed in the SST risers that introduce the retrieval sluicing liquid and retrieve the waste, temporary aboveground HIHTLs, and piping in thea portable valve and diversion boxes. Aboveground ~~pits~~ boxes, leak detectors, etc. may also come in contact with the waste should there be transfer line leakage.

3.9 DISPOSITION OF WASTE RETRIEVAL SYSTEM FOLLOWING WASTE RETRIEVAL

3.9.1 Disposition of New Waste Retrieval System Components

Following completion of waste retrieval, the in-tank equipment will be left in place for disposition during component closure actions. The abovegrade equipment (e.g., transfer lines, portable valve and diversion boxes) will be reused to the extent possible for future waste retrieval activities in the C tank farm. Transfer lines and the portable valve and diversion boxes will be flushed to reach acceptable exposure rates for disconnecting and relocating the equipment. Any abovegrade equipment that needs to be removed and is not suitable for reuse will be packaged and disposed of onsite in accordance with the approved waste acceptance criteria for the Hanford Site burial grounds and TFC-OPS-WM-C-10, *Contaminated Equipment Management Practices*. The HIHTLs will be managed in accordance with RPP-12711, *Temporary Waste Transfer Line Management Program Plan*.

3.9.2 Disposition of Existing Ancillary Equipment

Ancillary equipment associated with tanks C-102, C-104, C-107, C-108, and C-112 is limited to waste transfer lines and equipment installed in pits and abovegrade risers. The current status of the ancillary equipment associated with tanks C-102, C-104, C-107, C-108, and C-112 is described in Section 2.6. Any contaminated equipment located within risers that needs to be removed following waste retrieval will be packaged and disposed of onsite in accordance with the approved waste acceptance criteria for the Hanford Site burial grounds and TFC-OPS-WM-C-10.

In accordance with the SST system closure plan (RPP-13774), disposition of the ex-tank ancillary equipment, including pipelines, will be performed in accordance with a separate component closure activity plan. Closure plans will be incorporated into the SST permit.

3.10 AIR MONITORING PLAN

ORP and CH2M HILL, pursuant to federal requirements for protection of their workers, will develop and implement IH monitoring plans for exhauster stack emissions for the retrieval of tanks C-102, C-104, C-107, C-108, and C-112. The plans will be developed and implemented pursuant to the requirements of TFC-PLN-43, *Tank Farm Contractor Health And Safety Plan*. The constituents of potential concern (COPCs) for which exhauster stack sampling and analysis will be conducted will be identified in the IH monitoring plans for each tank retrieval. The COPCs identified in the IH monitoring plans will be all or a subset, as determined to be appropriate by CH2M HILL IH, of those constituents listed in RPP-20949, *Data Quality Objectives For The Evaluation Of Tank Chemical Emissions For Industrial Hygiene Technical Basis*, Table 4-1, developed with input from Ecology. Once the initial subset of COPCs is

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

1. Document Title and Number: RPP-22393, Rev. 3C, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tank Waste Retrieval Work Plan		
2. Minor Field Change: (Section 12.4 HFFACO Action Plan) ☐ Yes: (CH2M HILL Hanford Signature Only – Attach signed form to Primary Document for record purposes) X No: Proceed to Box 3	**3.** Document Issue Date: 11/20/07 **4.** Document Modification Notice Date: 3/12/08	**5.** Notice Number: 2008-2
6. Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?) ☐ Yes X No	**7.** Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan? ☐ Yes X No	**8.** (Check only one box) ☐ Significant Modification (Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.) Minor Modification X Requires modification of the document ☐ Can be accomplished with Modification Notice.

9. Description and Justification of Change:

Description

In paragraph 5, section 4.2.1.3 change:

> HRR data will be evaluated on a periodic basis as described in RPP-24576, *HRR LDM Data Processing, Assessment, and Reporting Procedure for C-Farm*. RPP-24576 provides the details as to how the data are reviewed and on what frequency. Following is a summary of some of the information provided in this document. This summary is for information purposes only, and where a difference exists between RPP-24576 and this summary, the wording in RPP-24576 takes precedence.

to:

> HRR data will be evaluated on a periodic basis as described in RPP-32477, *High Resolution Resistivity Leak Detection Data Processing and Evaluation Methods and Requirements*. RPP-32477 provides the details as to how the data are reviewed and on what frequency. Following is a summary of some of the information provided in this document. This summary is for information purposes only, and where a difference exists between RPP-32477 and this summary, the wording in RPP-32477 takes precedence.

and make the appropriate changes to the References section.

Explanation

RPP-24576 was released in March 2005 and is obsolete. It has been replaced with RPP-32477 which describes the current and improved method of HRR data processing and review. This change is required to maintain RPP-22393 current with the HRR data processing method used, and is also required as part of the administrative implementation of HRR when used for leak detection during SST waste retrievals.

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10. Impact of Change: No impact.		
11. Additional Requirements and/or Provisions[1]: Words added by Ecology: Ecology will do a detailed review following the completion of the RFI report review. Ecology will review the procedures and provide comments and a recommended TWRWP modification if Ecology determines a change is necessary. Following approval of C-110, revisions to this TWRWP will reflect HRR implementation.		
Approvals		
CH2M HILL Hanford Group, Inc.	Office of River Protection	State of Wash., Dept. of Ecology
□ Provisional Approval[2] Date	□ Provisional Approval[2] Date	□ Provisional Approval[2] Date
☒ Final Approval Date 5/15/08	☒ Final Approval Date 5/15/08	□ Final Approval Date 5/16/08

Notes
1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision
2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 10, prior to final approval of this modification.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

1. Document Title and Number: RPP-22393, Rev. 3C, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tank Waste Retrieval Work Plan

2. Minor Field Change: (Section 12.4 HFFACO Action Plan) ☐ Yes: (CH2M HILL Hanford Signature Only – Attach signed form to Primary Document for record purposes) X No: Proceed to Box 3	**3.** Document Issue Date: 11/20/07 **4.** Document Modification Notice Date: 4/17/08	**5.** Notice Number: 2008-4
6. Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?) ☐ Yes X No	**7.** Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan? ☐ Yes X No	**8.** (Check only one box) ☐ Significant Modification (Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.) Minor Modification X Requires modification of the document X Can be accomplished with Modification Notice.

9. Description and Justification of Change:

Description

In Table 5-1, pg 5-5, under *Compliance Method* for *265-192, Design and Installation of New Tank Systems or Components,* add the following note:

> ***Note:*** *The 241-C-102 and 241-C-104 concrete pits are not fully compliant with 40 CFR 265.193 and WAC 173-303-640 secondary containment standards and cannot be certified by an IQRPE pursuant to 40 CFR 265.192 or WAC 173-303-640. The alternative design and operating practices, together with location characteristics are as effective as secondary containment because the concrete pits have installed leak detection systems that will terminate a waste transfer upon detection of a leak, have a method for removal of any waste or liquid that enters the pit, and have sufficient volume such that they will contain, without overflowing the pit, any leaked waste resulting from transfer line hold-up drainage and pump operation from the time of detection to time of automatic or operator induced shutdown. ~~the current pits are protective of human health and the environment~~. The pits will not be upgraded to meet the secondary containment standards and will not be inspected by, or certified by, an IQRPE. An IQRPE will certify the leak detection operability criteria have been met before retrieval begins.*

per RAD per telecon

Explanation

This change is made to clarify that the existing pit structures for these two existing unfit for use tanks will contain new tank retrieval system components subject to the 40 CFR 265-192 [WAC 173-303-640(3)] requirement for an IQRPE assessment, but the pits themselves will not be included in the IQRPE assessment for secondary containment. RPP-10435, *Single Shell Tank System Integrity Assessment Report,* Appendix B evaluated existing pits and states *"A review of the design requirements and performance history of the pits evaluated in this assessment indicate that the pits are sound and*

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compatible with the waste transfers.....". These pits will contain pumps and/or associated piping components and function as secondary containment for a small portion of the new installation retrieval systems for these tanks. The pits will not be upgraded to meet secondary containment standards, but will have leak detectors interlocked to the retrieval system, and either sump pumps or direct drain-back provisions for any liquid holdup in the pits. Given that the leak detectors and sump pumps, or drain back provisions, would prevent a leak from overflowing out of the pits and that the pits will only be used to support waste transfers for retrieval of these tanks, this configuration is protective of human health and the environment.

Additional Considerations:

- Dose to workers: The dose rates are not known in all pits, but where that information is available, rates range from 6 mR/hour to 39 R/hour (beta/gamma). Many of the pits would be considered High Radiation Areas (limit is 100 mR/hour.) Exposing workers to any dose to upgrade pits that are already protective of human health and the environment is not prudent and would not be in accordance with the obligation of the Department of Energy, under Title 10 CFR Part 835, "Occupational Radiation Protection".
- Retrieval delays: Because there is not adequate space on top of the 75 ft. diameter tank to support three cranes and three work crews, the pits cannot be upgraded simultaneously but would have to be upgraded sequentially. Additionally, ALARA principles would not allow three adjacent high radiation/high contamination jobs to be performed simultaneously. Based on these considerations and past pit upgrade experience, it could take as long as two years to upgrade the three pits, delaying retrieval by that period of time. A more detailed estimate would have to be developed to determine if that schedule could be shorten, but the implication is that there would be a significant delay to the retrieval schedule.
- Generation of radioactive waste: It is estimated that at least one and up to three radioactive waste disposal boxes will be generated, per pit, as a result of work required to support pit upgrades.

10. Impact of Change:

No impact.

11. Additional Requirements and/or Provisions[1]:

Approvals

CH2M HILL Hanford Group, Inc. [signature] Moses Jaraysi	Office of River Protection [signature]	State of Wash., Dept. of Ecology Cheryl Whalen by John B. Price
☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date
☒ Final Approval Date 5/2/08	☒ Final Approval Date 5/2/08	☒ Final Approval Date 5-2-2008

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

'or use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In tion, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision ?rovisional approval allows DOE and it's contractors to take specific actions identified in section 10, prior to final approval of this ification.

Interagency Accountability Team (IAT)
Documentation of Agreements Reached (IAT 2008-01)
May 2, 2008

Problem Statement: An affirmative decision is required on this request by May 8, 2008 in order to avoid retrieval schedule impacts for 241-C-104.

Status of Review: The parties have been discussing this action beginning in January, 2008. Originally, the request was going to be made through a variance request. Ecology determined that a variance request was not appropriate and that the proper process would be a change notice to the TWRWP in accordance with Section 9.3 of the TPA. DOE submitted a change notice for Tank Waste retrieval Work Plan RPP-22393, Rev. 3C on April 28, 2008. The change noticed identified that the language of the TWRWP would be changed to state that the concrete pits associated with 241-C-102 and 241-C-104 were protective of human health and the environment and would not be upgraded (to meet secondary containment standards) for the purposes of retrieving the tank waste. Ecology's project manager requested that the approval be elevated to the IAT for timely resolution. DOE and CHG managers agreed with that request.

IAT Final Decision:

The TWRWP language was modified and approved as indicated below

> ***Note:*** *The 241-C-102 and 241-C-104 concrete pits are not fully compliant with 40 CFR 265.193 and WAC 173-303-640 secondary containment standards and cannot be certified by an IQRPE pursuant to 40 CFR 265.192 or WAC 173-303-640. The alternative design and operating practices, together with location characteristics are as effective as secondary containment because the concrete pits have installed leak detection systems that will terminate a waste transfer upon detection of a leak, have a method for removal of any waste or liquid that enters the pit, and have sufficient volume such that they will contain, without overflowing the pit, any leaked waste resulting from transfer line hold-up drainage and pump operation from the time of detection to time of automatic or operator induced shutdown. ~~the current pits are protective of human health and the environment.~~ The pits will not be upgraded to meet the secondary containment standards and will not be inspected by, or certified by, an IQRPE. An IQRPE will certify the leak detection operability criteria have been met before retrieval begins.*

JJC
DLW
RAD per tele
SLD
CAW

Additional Direction to Staff:

In the future TWRWPs should consider the need to upgrade pits for retrieval

Suzanne Dahl, Ecology

Ryan Dodd, CH2M HILL

Laura Cusack, CH2M HILL

Delmar Noyes, DOE-ORP

Problem:
The following note is proposed for addition to RPP-22393 (the underline is for emphasis here only, the note will not have the underline):

Note: *The 241-C-102 and 241-C-104 concrete pits are not fully compliant with 40 CFR 265.193 and WAC 173-303-640 secondary containment standards and cannot be certified by an IQRPE pursuant to 40 CFR 265.192 or WAC 173-303-640. As the concrete pits have installed leak detection systems that will terminate a waste transfer upon detection of a leak, have a method for removal of any waste or liquid that enters the pit, and have sufficient volume such that they will contain, without overflowing the pit, any leaked waste resulting from transfer line hold-up drainage and pump operation from the time of detection to time of automatic or operator induced shutdown, the current pits are protective of human health and the environment. As the pits are protective of human health and the environment, they will not be upgraded to meet the secondary containment standards and will not be inspected by, or certified by, an IQRPE.*

Ecology, in an e-mail dated 4/2/08 requested an engineering analysis be provided to support the underlined words. This calculation provides that analysis.

Calculation:
Figure 1 is a simplified sketch of the system for C-104. The design for C-102 has not been initiated yet, but the two tanks are close to each other, have the same pit dimensions, and the distances to an AN Farm receiver tank will be about the same. The conclusions of this calculation are applicable to both the C-104 and C-102 concrete pits.

The pits in question are the pump pit, heel pit and sluice pit. The pits are shown with the original cover blocks in place on the drawings, but when used during retrieval each pit will be covered with a steel plate. Table 1 lists the approximate pit dimensions, excluding the lip where the cover block sits, and the drawings used to obtain the dimensions. The cover blocks are 24 in. thick and sit on a 4 in. lip plus an additional 3 in. wide sloped section.

Table 1 C-102 and C-104 Concrete Pit Information

Pit	Approximate basic pit dimensions (ft-in.) (L×W×H to bottom of steel plate)	Reference Drawing
Pump Pit	14'6" × 11' × 8'5"	H-2-41343
Sluice pit	9' × 8'6" × 9'8"	H-2-41344
Heel Pit	9' × 6' × 4'9"	H-2-41345

Table 2 was prepared using these drawings and basic pit dimensions. Column 2 is the volume of the basic pit, Column 3 is the approximate volume taken up by the cover block lip, Column 4 is an allowance to account for any risers and equipment in the pit, and Column 5 is the approximate net pit volume calculated from Column 2 + Column 3 – Column 4.

The leak detectors in the pits will actuate and shut down the system pumps when the liquid covers the contact points in the leak detector elements. Per RPP-CALC-34582, *241-C-104 HIHTL Leak Rate Calculation*, Rev 0, this actuation point is at 1 inch. Table 3 gives the volume of each basic pit at a depth of 1.0 inches.

Table 2 C-102 and C-104 Concrete Pit Approximate Volumes

Pit	Volume to bottom of cover plate excl. cover block lip (gal)	Volume of cover block lip (gal)	Allow for volume of equipment in pit (gal)	Approx. volume in pit to bottom of cover plate (gal)
Pump Pit	10,040	363	-30	~9,650
Sluice pit	5,530	253	-20	~5,760
Heel Pit	1,920	219	-20	~2,120

Table 3 C-102 and C-104 Approximate Volume of Liquid in Pit at 1 inch Depth

Pit	Volume @ 1 Inch Depth (gal)
Pump Pit	99.4
Sluice pit	47.7
Heel Pit	33.7

Column 2 of Table 4 provides the lengths and volumes of HIHTLs used. The lengths were obtained from RPP-CALC-34582. The inner hose is 2 in. ID by 2.75 in. OD, which calculates to 0.163 gal/ft. The outer hose is 4 in. ID which calculates to 0.344 gal/ft. for the annular space.

Table 4 C-104 Hose-in-Hose, Valve Pit, and Diversion Box Information

HIHTL	Length (ft)	Volume of Inner Hose (gal)	Volume of Outer Hose (gal)
Hose #1	86.3	14.1	29.7
Hose #2	61.3	10.0	21.1
Hose #3	40.3	6.6	13.9
Hose #4	124	20.2	42.7
Hose #5	119	19.4	40.9
Hose #6+8+10+12	1,304.3	212.6	448.8
Hose #7+9+11+13	1,304.3	212.6	448.8
Allowance for volume in pipe in Valve Pit	-	4	-
Allowance for volume in pipe in Diversion Box	-	6	-

The worst case scenario would be if there was a leak and drainback to the heel pit, since this pit has the smallest volume of the three. The leak scenario assumes there is a leak in the heel pit and the pumps are shut down when the depth reaches 1.0 inch in the heel pit. If the all the liquid in the line from the heel pit to AN-101 drained back to the heel pit the volume in the pit would be:

Vol in Heel Pit after drainback = 33.7 + 10.0 + 20.2 + 212.6 + 4 + 6 = 286.5 gal

Where: 33.7 = heel pit with 1 in. of liquid
10.0 = inner volume of Hose #2
20.2 = inner volume of Hose #4
212.6 = inner volume of combined Hoses #6 + 8 + 10 + 12
4 = allowance for volume of pipe in Valve Pit
6 = allowance for volume of pipe in Diversion Box

To this 286.5 gal must be added the volume of any outer hose accumulation before the leak detector was activated which may drain back to the heel pit also. Per RPP-CALC-34582 Hose #2 will drain to the diversion box, but conservatively assuming it drained back to the heel pit instead, the volume in the heel pit would be:

Vol in Heel Pit after drainback + Hose #2 outer = 286.5 + 21.1 = 307.6 gal

Therefore, the heel pit could contain approximately 310 gal following drainback. This is well below the approximate 2,120 gal volume of the heel pit so waste solution draining into the pit will be contained within the pit. The pits also contain spaces around the installed equipment through which accumulated liquid can drain back into the tank. No credit is taken for this drainage in this calculation.

Drainage from the outer hoses between the diversion box and the valve pit would drain to either one. (Both the diversion box and the valve pit are compliant with the secondary containment requirements of WAC 173-303-640.) Drainage from the outer hoses between the valve pit and AN-106 would drain to the valve pit. Even if this liquid somehow ended up being misrouted back to the heel pit the additional volume would not overflow the heel pit.

References:

RPP-CALC-34582, *241-C-104 HIHTL Leak Rate Calculation*, Rev 0, CH2M Hill Hanford Group Inc., March, 2008

H-2-41343, Structural concrete Plan and Sections – Pump Pit (241-CR), as updated

H-2-41344, Structural concrete Plan and Sections – Sluicing Pit (241-CR), as updated

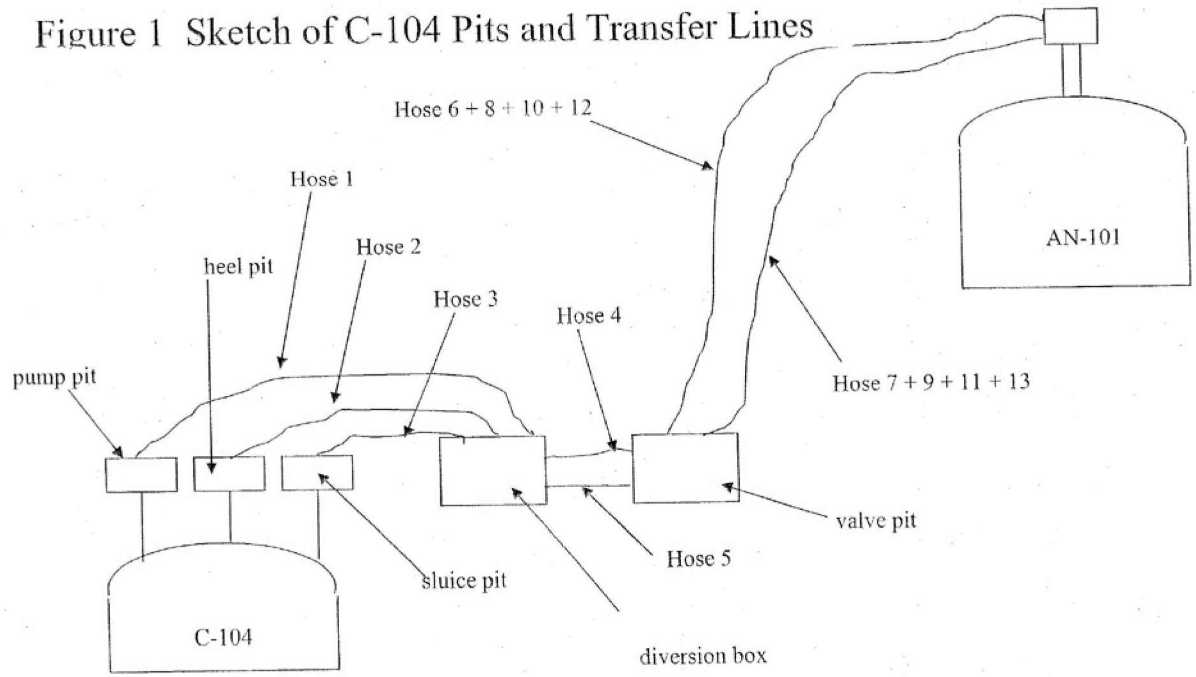
H-2-41345, Structural concrete Plan and Sections – Heel Pit (241-CR), as updated

H-14-107326, 241-C Sluice Retrieval C-104 to AN-101 Installation, sheet 1 as updated

H-14-107326, 241-C Sluice Retrieval C-104 to AN-101 Installation, sheet 2 as updated

H-14-107326, 241-C Sluice Retrieval C-104 to AN-101 Installation, sheet 3 as updated

Figure 1 Sketch of C-104 Pits and Transfer Lines



Explanation of Pit Upgrade Information in TWRWP Modification Notice 2008-4

Section 9, "Description and Justification of Change", of Tank Waste Retrieval Work Plan Modification Notice 2008-4 states that upgrading the three pits at C-102 and the three pits at C-104 will have the following impacts:

- A schedule increase of approximately 2 years for each tank
- Generate 1 to 3 radioactive waste boxes per pit
- Result in personnel exposure of 10-15 person-rem per pit

Information and data supporting these statements is provided below.

Schedule Increase of approximately 2 Years

Upgrading each pit requires completing the following 23 separate tasks:

1. Remove all trash and failed equipment from pit so that it is completely empty
2. Erect a temporary enclosure around pit
3. Unplug the drain in each pit (required so that water used to decontaminate the pit can drain into the tank) or, if not possible, install sump pump and tubing to remove residual liquid
4. Install a temporary drain plug (required so water can be pumped into the pit for shielding while cleaning pit)
5. Add a foot depth of water to pit for shielding
6. Use high pressure spray washer to wash down walls above the foot of water
7. Use high pressure spray washer to remove contamination on walls and pit floor below the water surface
8. Remove drain plug
9. Use high pressure spray washer to manually suspend crud and contamination on bottom of pit and pump that which can't drain into the tank so that the pit bottom is as clean as practical
10. Wash down walls and floor again
11. Add riser extensions or drain extensions, if necessary, to support the following step:
12. Add 6 inches of grout to the bottom of pit to fill in pits or cracks and cover up contamination to permit personnel entry to pit.
13. Enter pit and inspect walls for pits and cracks
14. Enter pit and repair pits and cracks
15. Enter pit and do final preparation/smoothing and crack repairs
16. Add primer coat to walls and floor
17. Add first coat of polyurea
18. Add second coat of polyurea
19. Add third coat of polyurea
20. Add final coat of Amercoat or similar paint
21. Enter pit and conduct final inspection before addition of equipment
22. Enter pit and conduct second inspection after addition of equipment to ensure coating wasn't damaged

Four basic phases were identified for each job: 1) plan the work; 2) perform the work; 3) cleanup; 4) and a general 'other'. Personnel required for each job were identified as: operators, HPTs, IHTs, construction laborers/pipefitters, supervisors, and a general 'other'. The number of personnel and the duration of each phase for each task were then estimated for each pit. This resulted in an estimated 33 weeks to upgrade the heel pit, 43 weeks to upgrade the sluice pit, and 54 weeks to upgrade the pump pit. The total of 130 weeks is 2.5 years. This was rounded down to 2 years as it was felt there would be some schedule improvement with experience.

The three pits need to be upgraded sequentially. There is not room on top of the 75 ft. diameter tank to support three cranes and three large work crews working next to each other, nor would three adjacent high radiation/high contamination jobs be performed simultaneously even if there were sufficient room.

Several key assumptions were made in identifying the above work scope. First is that the floor drains can be unplugged in each pit. To perform pit cleaning free flowing drains are needed to remove the water and contaminated material. The second key assumption is that pit dose rates can be reduced to levels allowing personnel to enter the pits for extended periods of time. If pit dose rates cannot be reduced to levels allowing personnel entry, the pit upgrades cannot be accomplished. The third key assumption is that dose rates from the tank waste will not be too high to allow personnel entry. The pump pit for each tank is located directly on top of the tank dome. It is not known what the dose rate from the tank waste, through the dome and pit bottom, will be in the bottom of the pump pit.

Volume of Radioactive Waste Generated

Time was not available to permit calculation of the number of radioactive waste boxes needed for all the equipment in each pit. However, pit videos show considerable equipment in each pit. Therefore, it was estimated that at least one and up to three radioactive waste boxes will be required for each pit. (Much of this equipment would not be required to be removed if the pits were not upgraded.)

Personnel Exposure

Personnel exposure was estimated for each of the four general work phases and for each of the four categories of personnel required to complete the 23 identified tasks. Personnel exposure was calculated by multiplying the number of personnel by the job length, the estimated fraction of time the person would be exposed during the job, and the assumed dose rate. (Note: this is not a formal exposure estimate made by radiological engineering personnel using detailed work plans and known radiation levels. This estimate is order of magnitude only. At this time, specific job dose rates and job durations cannot be accurately determined. Therefore, the exposure estimates were based on reasonable judgment.) No dose rates >50 mR/hr were assumed, which would be low for personnel entry to an old pit. Using this methodology, the total dose rates were still unacceptably high, ranging from 100 person-rem for the heel pit to 122 person-rem for the pump pit. No work would be attempted with personnel exposure estimates at these levels. Therefore, the assumption was made that exposure associated with these tasks could be reduced by 90% by work planning and implementation of standard ALARA principles. The heel pit exposure estimate was thus revised down to12 person-rem. The assumption was then made that the estimated personnel exposure would be 10-15 person-rem per pit.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

1. Document Title and Number: RPP-22393, Rev. 3C, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tank Waste Retrieval Work Plan

2. Minor Field Change: (Section 12.4 HFFACO Action Plan)	**3.** Document Issue Date:	**5.** Notice Number: 2008-5
☐ Yes: (CH2M HILL Hanford Signature Only – Attach signed form to Primary Document for record purposes)	11/20/07	
x No: Proceed to Box 3	**4.** Document Modification Notice Date: 5/7/08	

6.	**7.**	**8.** (Check only one box)
Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?)	Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan?	☐ Significant Modification (Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.)
		Minor Modification
		x Requires modification of the document
☐ Yes x No	☐ Yes x No	x Can be accomplished with Modification Notice.

9. Description and Justification of Change:

Description

In Section 2.2.1, of RPP-22393,Rev. 3C, revise the second paragraph to add the shaded text as follows:

> Tanks C-102 and C-104 both have three reinforced concrete process pits that were installed after initial tank construction to facilitate waste retrieval. These pits are constructed of reinforced concrete and extend abovegrade. The pits provide secondary containment for the primary transfer piping within, and have removable cover blocks or plates that allow entry into the pits. The pit floors were constructed with drains that direct any liquid back into the tank through a tank riser located in the pit. ~~Where~~ the drains are plugged, any liquid (intrusion, tank waste, or other) will be pumped back to the associated SST. The condenser hatchway (not shown in Figure 2-3) located above the outside edge of the tank provided an indirect access path into the tank for ventilation.

For the purpose of retrieval of these 2 tanks, if

pit

Pit pumping into the associated SST will occur so that the pit liquids may be removed before retrieval completion.

Explanation

The change clarifies how liquid in the pit will be removed if the pit drain is grouted closed or otherwise plugged.

10. Impact of Change:

No impact.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

11. Additional Requirements and/or Provisions[1]:		
Approvals		
CH2M HILL Hanford Group, Inc.	Office of River Protection	State of Wash., Dept. of Ecology
☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date
☒ Final Approval Date 5/20/08	☒ Final Approval Date 6/3/08	☐ Final Approval Date 6-11-08

Notes

1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision
2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 9, prior to final approval of this modification.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

1. Document Title and Number: RPP-22393, Rev. 3E, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tank Waste Retrieval Work Plan		
2. Minor Field Change: (Section 12.4 HFFACO Action Plan) □ Yes: (CH2M HILL Hanford Signature Only – Attach signed form to Primary Document for record purposes) X No: Proceed to Box 3	**3.** Document Issue Date: 6/26/08 **4.** Document Modification Notice Date: 7/3/08	**5.** Notice Number: 2008-6
6. Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?) □ Yes x No	**7.** Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan? □ Yes x No	**8.** (Check only one box) □ Significant Modification (Check if the answer to question in either section 6 or 7 is "yes". Significant modifications require revision of the primary document.) Minor Modification X Requires modification of the document X Can be accomplished with Modification Notice.

9. Description and Justification of Change:
Description: Delete the current Section 4 from RPP-22393 Rev 3E and replace it with the attached new Section 4 wording. Revise the Table of Contents and the Reference section for consistency with the Section 4 changes.
Justification: Section 4 is on leak detection. The attached Section 4 rewrite is rewritten to be consistent with the Section 4 wording in RPP-33116, *241-C-110 Tank Waste Retrieval Work Plan*, Rev 2, which was approved by Ecology on 7/3/08. The only differences between the RPP-33116 and RPP-22393 Section 4 wording is specific tank related information. This wording change ensures that the same leak detection wording is present and applied in both documents.

10. Impact of Change:

No impact.

11. Additional Requirements and/or Provisions[1]:
3rd paragraph in section 4.1.3 on C-107 leak detection monitoring should be deleted. Paragraph #2 states monitoring correct

E SIGN

Approvals

CH2M HILL Hanford Group, Inc.	Office of River Protection	State of Wash., Dept. of Ecology
□ Provisional Approval[2] Date	□ Provisional Approval[2] Date	□ Provisional Approval[2] Date
X Final Approval Date 7/8/08	X Final Approval Date 7/17/08	□ Final Approval Date 7-31-08 see changes

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

□ Provisional Approval[2] Date	□ Provisional Approval[2] Date	□ Provisional Approval[2] Date
□ Final Approval Date	□ Final Approval Date	□ Final Approval Date

Notes
1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision
2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 10, prior to final approval of this modification.

The pages attached to Modification Notice 2008-6 are omitted here for the sake of brevity. The pages attached to Modification Notice 2008-6 when submitted to Ecology for approval are the same as pages 4-1 through 4-25 in the main body of RPP-22393 Rev 4, with two exceptions. One exception is the requested deletion written in Block 11 of the mod notice by Ecology. The second exception is the deletion requested by Ecology of what was the third sentence in the second paragraph in Section 4.2. Both of these deletions have been made in the released version of RPP-22393, Rev 4, Section 4. The original pages of Modification Notice 2008-6 as marked up by Ecology are on file with the TPA and Permitting group of the tank farm contractor, and with Ecology.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

<table>
<tr><td colspan="3">1. Document Title and Number: RPP-22393, Rev. 3E, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tank Waste Retrieval Work Plan</td></tr>
<tr><td rowspan="2">2. Minor Field Change:
(Section 12.4 HFFACO Action Plan)
□ Yes: (CH2M HILL Hanford Signature Only – Attach signed form to Primary Document for record purposes)

x No: Proceed to Box 3</td><td>3. Document Issue Date:

6/26/08</td><td rowspan="2">5. Notice Number: 2008-7</td></tr>
<tr><td>4. Document Modification Notice Date: 7/3/08</td></tr>
<tr><td>6.
Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?)

□ Yes x No</td><td>7.
Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan?

□ Yes x No</td><td>8. (Check only one box)
□ Significant Modification
(Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.)
Minor Modification
x Requires modification of the document
x Can be accomplished with Modification Notice.</td></tr>
</table>

9. Description and Justification of Change:

Description: Delete the following wording in Section 3.2:

> A chemical analysis of the technetium-99 in the supernate of the receiving DST shall be obtained for DST samples taken during the retrieval process. This value will be reported in the retrieval data report, and compared with (1) the currently estimated BBI concentration, and (2) estimated flowsheet changes in the supernate technetium-99 concentration.

and add the following wording in its place:

> Should the SST be shown to leak during the retrieval process, a liquid sample will be taken if needed to verify the ^{99}Tc concentration in the DST supernate used for sluicing.
>
> Should a DST sample be required during the C-102, C-104, C-107 or C-112 retrieval process for corrosion control or other reasons, a ^{99}Tc analysis will be requested on the sample. A DST sample has already been obtained during the C-108 retrieval process.

Justification: See attached white paper on deletion of the ^{99}Tc sample requirement. This white paper was originally provided to Ecology with the RCR file for the RPP-33116 Rev 1 TWRWP (C-110). However, the wording in this white paper covers deletion of the ^{99}Tc sample requirement for both the C-110 (RPP-33116) and the C-102, C-104, C-107, C-108, and C-112 (RPP-22393) TWRWPs. The C-110 TWRWP with the requirement for a ^{99}Tc sample deleted was approved by Ecology on 7/3/08. The basic justification for deleting the sample requirement from RPP-22393 is that there is no benefit to taking a DST supernate sample prior to the need. If an SST leak occurs during retrieval a DST supernate sample can be obtained following the leak. Not obtaining a sample until it is needed will have no impact on the subsequent ability to analyze the DST sample for ^{99}Tc, and not obtaining an unnecessary sample will save personnel exposure, solid waste volume and resources.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

10. Impact of Change: The impact of this change is that money spent, personnel exposure, and solid waste volumes will be reduced, with no offsetting problems.		
11. Additional Requirements and/or Provisions[1]:		
Approvals		
CH2M HILL Hanford Group, Inc.	Office of River Protection	State of Wash., Dept. of Ecology
□ Provisional Approval[2] Date	□ Provisional Approval[2] Date	□ Provisional Approval[2] Date
☒ Final Approval Date 7/3/08	□ Final Approval Date 7/17/08	☒ Final Approval Date 7-31-08

Notes

1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision

2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 10, prior to final approval of this modification.

White Paper on DST Sampling for ^{99}Tc during Modified Sluicing SST Waste Retrievals Revision 2

Summary of Issue

The current tank waste retrieval work plans (TWRWPs) for C-103/C-109 and C-102/C-104/C-107/C-108/C-112 require a DST supernate sample be obtained and analyzed for ^{99}Tc during SST waste retrieval processes using modified sluicing. The C-110 TWRWP does not include this requirement, instead it states a DST supernate sample will be obtained and analyzed for ^{99}Tc if needed should the SST leak during retrieval, or, if a DST supernate sample is needed for some other reason during the waste retrieval process (such as for corrosion control), a ^{99}Tc analysis will be requested on the sample. Obtaining DST samples prior to a specific need is unnecessary and results in the expenditure of resources, unnecessary personnel radiation exposure and the generation of extra radioactive waste. A DST supernate sample can be obtained if necessary should an SST be shown to leak during waste retrieval. The C-Farm modified sluicing TWRWPs for C-103/C-109 and C-102/C-104/C-107/C-108/C-112 are planned to be modified to state a DST supernate sample will be obtained and analyzed for ^{99}Tc if needed should the SST leak during retrieval, or, if a DST supernate sample is needed for some other reason during the waste retrieval process (such as for corrosion control), a ^{99}Tc analysis will be requested on the sample.

Background

The C-103/C-109 TWRWP (RPP-21895, *241-C-103 and 241-C-109 Tanks Waste Retrieval Work Plan*) and the C-102/C-104/C-107/C-108/C-112 TWRWP (RPP-22393, *241-C-102, 241-C-104, 241-C-107, 241-C-108, and 241-C-112 Tanks Waste Retrieval Work Plan*) both state words similar to the following as a requirement when performing modified sluicing in an SST using DST supernate solution as the sluicing liquid:

> *A chemical analysis of the technetium-99 in the supernate of the receiving DST shall be obtained for DST samples taken during the retrieval process. This value will be reported in the retrieval data report, and compared with (1) the currently estimated BBI concentration, and (2) estimated flowsheet changes in the supernate technetium-99 concentration.*

This requirement has been requested by Ecology so that, if the SST leaks during retrieval, an estimate of the risk involved can be made by multiplying the DST ^{99}Tc concentration by an estimated SST leak volume. This sampling has been agreed to by DOE-ORP only because DST supernate samples have been required in the past for corrosion control and the ^{99}Tc analyses were 'piggy backed' onto the corrosion control samples.

Discussion

Ecology desires the ^{99}Tc concentration in the DST supernate so that, should an SST leak occur during retrieval, the quantity of ^{99}Tc which enters the soil can be estimated. Two items are needed to estimate the quantity of ^{99}Tc which enters the soil, the leak volume and the ^{99}Tc concentration in that leaked solution. Should an SST leak, the leak volume will not be a measured quantity, only an estimate. The accuracy of this volume estimate is dependent upon the data available at the time. The concentration of ^{99}Tc in the DST supernate at the time of the SST leak will be known in to a similar or better accuracy than the accuracy of any leak volume estimate. The DST supernate concentration is known from the latest BBI data for the tank, and can be adjusted as needed based upon transfers into the tank, if any, following the BBI date. The BBI data is based primarily upon past samples of the supernate and transfers in and out of the tank since the last sample was taken. The BBI may also consider other factors that can narrow the expected ^{99}Tc content, such as the ratio to other easily analyzed soluble or insoluble radionuclides in the tank. These ratios may be based upon reactor fission yield and the source(s) of the waste in the tank.

Despite having an estimate of the ^{99}Tc concentration in the DST supernate based upon BBI data, a validation of this estimate can still be obtained if needed by taking a sample of the DST supernate should an SST leak. This sample would confirm or update the BBI ^{99}Tc value used for the initial ^{99}Tc release estimate following the leak.

The specific reasons for not needing a DST supernate sample for ^{99}Tc prior to an SST leak are:

1. Past BBI data has showed a close estimate of the ^{99}Tc concentration in AN-106. The 5 samples taken from various depths in AN-106 in May 2006 during C-103 retrieval showed an average concentration within a few percent of the calculated BBI value[1]. This demonstrates that the DST ^{99}Tc concentration can be reasonably be predicted based upon previous sample data and waste transfers.

2. Another set of 5 samples were taken from AN-106 in May of 2007 when the modified sluicing of C-108 was about 88% complete.[2] Since May of 2007, C-109 retrieval was initiated and is about 84% complete. The ^{99}Tc concentration in AN-106 following the completion of all C-108, C-109 and C-110 retrieval has been conservatively estimated and is almost exactly the same, 0.0475 μCi/mL vs. 0.0477 μCi/mL, as that used in the risk calculations for C-110 provided in RPP-33116 Rev 0A. The slightly higher value will be maintained for the risk calculations in RPP-33116 Rev 1.

3. A separate sample for ^{99}Tc will incur extra radiation exposure to personnel, generation of additional radioactive waste requiring disposal, and expenditure of resources. Sampling will also result in downtime and delays to other work while the sample is being taken. This sample would provide no offsetting benefits to these factors because, should the SST leak during retrieval, the DST supernate could be sampled at that time if needed to verify the DST ^{99}Tc concentration.

4. For past SST waste retrievals, DST supernate samples have been agreed to because DST samples were also required for corrosion control, so the ^{99}Tc sample analysis was 'piggy-backed' onto the corrosion samples. Future retrievals may not require corrosion control samples, hence, the ^{99}Tc would be a stand-alone singular purpose sample not supported by any current DQO.

Proposed Resolution

It is proposed that the wording be put in the C-110 TWRWP (and similar wording in RPP-21895 and RPP-22393) to say:

a. Should tank C-110 be shown to leak during the retrieval process, a liquid sample will be taken if needed to verify the ^{99}Tc concentration in the DST supernate used for sluicing.

b. Should a DST sample be required during the C-110 retrieval process for corrosion control or other reasons, a ^{99}Tc analysis will be requested on the sample.

Summary

Taking these samples prior to a need is unnecessary and results in unnecessary expenditure of resources, unnecessary personnel exposure, and unnecessary generation of radioactive waste. The proposed resolution will provide the desired information.

[1] The 4-30-06 samples of AN-106 showed a ^{99}Tc concentration of 0.0279 µCi/mL. The concentration calculated from the BBI for the same time was 0.0288 µCi/mL. The flowsheet for C-Farm retrieval, RPP-21753, estimated that the DST concentration would be 0.0302 µCi/mL before starting C-103 retrieval and be 0.0267 µCi/mL following C-103 retrieval. The 4/30/06 AN-106 ^{99}Tc sample information was provided to Ecology with the C-103 RDR, RPP-RPT-33060, *Retrieval Data Report for Single-Shell Tank 241-C-103*, Rev 0. The DST sample result was the average of five samples taken at five different depths (0.0279. 0.0273, 0.0284, 0.0285 and 0.0283 µCi/mL, as reported in RPP-RPT-29777, *Final Report for Tank 241-AN-106 Grab Samples in Support of Corrosion Mitigation and Compatibility Programs*, Rev 0. The consistency between sample results at different depths and the close comparison of the flowsheet value to the sampled value demonstrates that the DST supernate concentration can be adequately estimated during SST modified sluicing waste retrievals.

[2] The 5-22-07 samples of AN-106 showed a ^{99}Tc concentration of 0.0175 µCi/mL. This concentration was the average of five samples taken at five different depths (0.0159, 0.0174, 0.0197, 0.0177 and 0.0167 µCi/mL, as reported in RPP-RPT-34287, *Final Report for Tank 241-AN-106 Grab Samples for Corrosion Mitigation and Compatibility Support, May 2007*, Rev 0. Per RPP-22521, *Tanks C-101, C-105, C-110, and C-111 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan*, Rev 3, conservatively assuming all of C-108, C-109 and C-110 are added to AN-106 and no water is used in the retrieval processes the AN-106 ^{99}Tc concentration will be 0.0475 µCi/mL at the end of C-110 retrieval.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

1. Document Title and Number: RPP-22393, Rev. 4, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tank Waste Retrieval Work Plan

2. Minor Field Change: (Section 12.4 HFFACO Action Plan) □ Yes: (CH2M HILL Hanford Signature Only – Attach signed form to Primary Document for record purposes) x No: Proceed to Box 3	**3.** Document Issue Date: 8/7/08 **4.** Document Modification Notice Date: 2/27/09	**5.** Notice Number: 2009-2
6. Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?) □ Yes x No	**7.** Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan? □ Yes x No	**8.** (Check only one box) □ Significant Modification (Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.) Minor Modification x Requires modification of the document x Can be accomplished with Modification Notice.

9. Description and Justification of Change:

Description

In Section 3.2 of RPP-22393,Rev. 4, revise the last paragraph, pg. 3-11, to add the shaded text as follows:

> A process flowsheet has been prepared for the C farm 100-series tanks (RPP-21753, *C Farm 100-Series Tanks, Retrieval Process Flowsheet Description*). The calculations performed in support of the flowsheet assume that the retrieved solids are about 3 vol% in the slurry transferred to the receiving DST. The waste retrieval process flowsheet estimate of the total liquid volume transferred during the sluicing of each tank is provided in Table 3-2. In addition, the flowsheet allocates a nominal 105,000 gal. of water for tank and equipment flushing during each tank's waste retrieval operations. Following the initiation of C-104 active retrieval operations, solutions currently contained in the CR vault sumps for Cells 1, 2, 3, and 11, and line flush water may be transferred using a hose-in-sleeve line into C-104 for subsequent transfer out to the receiving DST.

In Section 3.8 of RPP-22393,Rev. 4, add the following second paragraph:

> Transfer system equipment provided for transferring CR Vault sump solutions to C-104 will meet the requirements of WAC 173-303-640 (3)~~(a)(f)~~.

Explanation

It is estimated these sumps contain a nominal 100 gallons, 1,500 gallons, 1,800 gallons, and 7,300 gallons, respectively. The solutions are believed to be rainwater accumulation containing radionuclide

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

and chemical contamination from past spills into these sumps. Routing this liquid direct to C-104 is preferable to installing additional transfer lines and connections to tie into lines to AN farm, or running new lines to AN farm. Not only will this permit earlier removal of the liquid, but there will be much less contaminated equipment to dispose of when the operations are complete.

10. Impact of Change:

No impact.

11. Additional Requirements and/or Provisions[1]: Please provide information described in attachments with TWRWP changes. Please initial & return for final approval. (See attached)

Liquids can not be transferred until USDOE reciews final approval. 4/16/09

Approvals

Washington River Protection *Solutions*, Inc.	Office of River Protection	State of Wash., Dept. of Ecology
☑ Provisional Approval[2] Date 3/30/09	☑ Provisional Approval[2] Date	☑ Provisional Approval[2] Date 4-16-09
☑ Final Approval Date Mark Lindholm per telecon CTK 3-30-09	☑ Final Approval Date Stacy Charboneau 3/31/09	☑ Final Approval Date 4-20-09

Notes

1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision

2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section ~~10~~ #11, prior to final approval of this modification.

use #11 not 10 4/16/09

FINAL APPROVAL
4/21/09
WRPS

FINAL APPROVAL
DOE-ORP
4/22/09
per

** These final approvals to the WDOE items behind this is per the WDOE email to ORP sent on 4-16-09, 4:01pm.

The next two pages are a list of requests/questions from Ecology referred to in Block 11 of the mod notice and a figure Ecology requested to be formally provided. The four pages after that are the requests/questions with responses and the figure with an attachment designation at the top showing it is associated with Request A-1. The last (7th) page is a figure requested in Request B-2.

Attachment to Modification Notice Number: 2009-2
RPP-22393, Rev. 4, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tank Waste Retrieval Work Plan
Ecology requests the following information be supplied to the Modification Notice through an attachment.

The purpose of this additional information is to provide documentation that will indicate planning ensures environmental protectiveness, procedures are in place to detect and mitigate leaks, completed and IQRPE-reviewed design, and use of appropriate operational procedures during waste transfer.

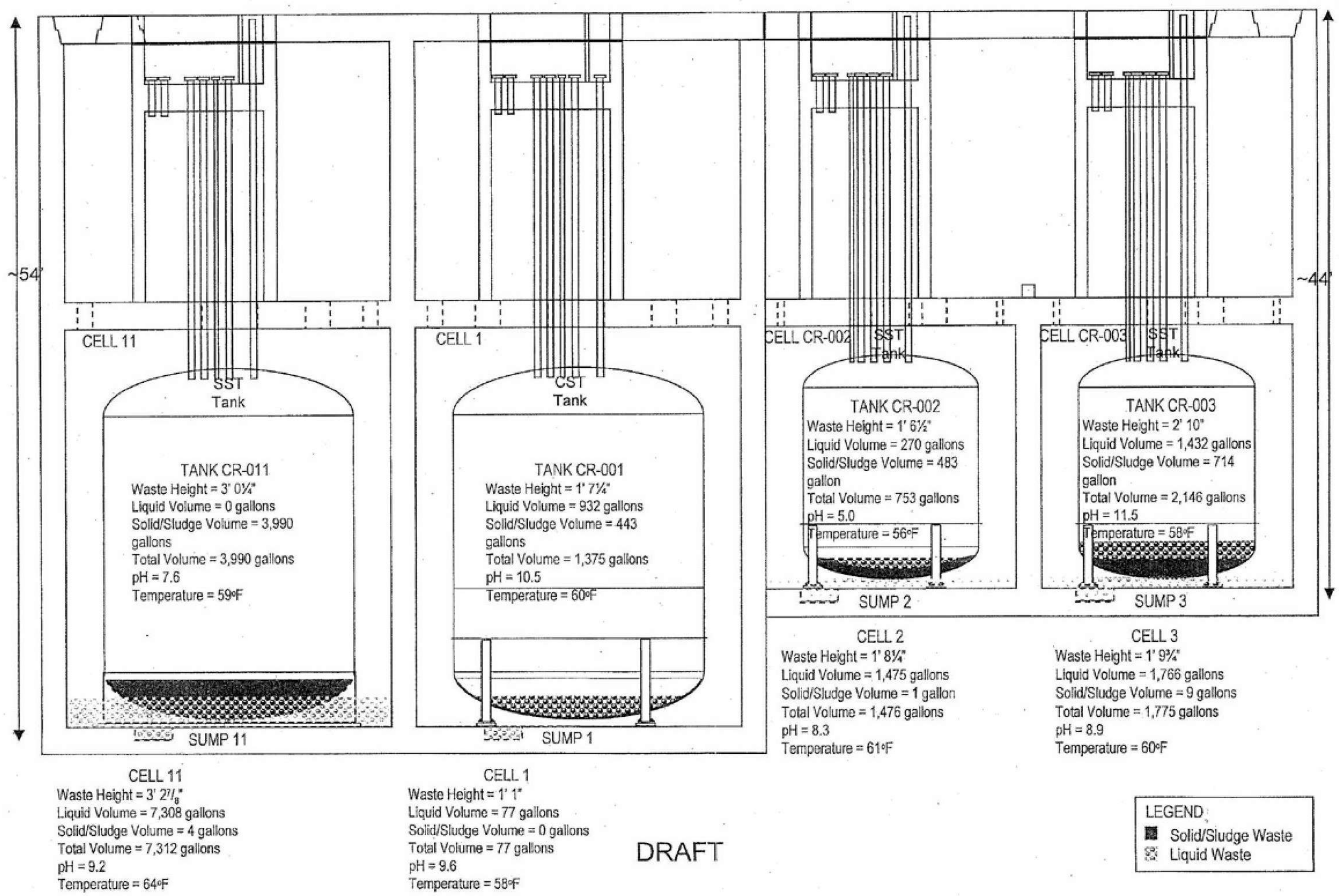
A. Provide identification of CR Vault cells and associated facilities and equipment— configuration and waste characteristics
   1. Include the attached diagram (244-CR VAULT MEASUREMENTS DEC. 2004 (RPP-RPT-24257) that shows vault components and lists tank and cell liquid and solid/sludge volumes.
   2. Provide results of sump sampling and analysis from each cell to Ecology prior to start of waste transfer out of CR vault.
   3. List all pipelines and equipment associated with the proposed waste transfer action.
   4. List existing information on condition of transfer pipelines and transfer equipment.

B. Planned Waste Removal and Transfer Technology
   1. Describe removal system/technology and capability (pumps, cameras, flow measurement equipment, etc.).
   2. Provide a diagram of the transfer system (include flow path, elevation changes, and layout).
   3. List waste transfer start date(s) to C-104 for each sump.
   4. State anticipated performance of technology with the goal to remove all waste as possible from the cell sumps.
   5. State that the waste from the CR vault cell sumps is being transferred to AN-101 via C-104 and must be pumped out as soon as practical from C-104. Vault cell sump waste can be transferred to C-104 after C-104 retrieval operations have removed at least 12,000 gal of waste.
   6. Describe the disposition of the system and equipment at the completion of waste transfer.

C. Description of planned leak detection and monitoring technology(s) for transfer system
   1. Identify leak detection and monitoring during transfer, including drain back pathways.
   2. Identify existing level measurement instrumentation in sumps and receiver SST.
   3. Identify future sump and vault tanks level monitoring activities.
   4. Describe mitigation strategy including a response plan to a detected leak during waste transfer (identify responses to various leak rates) including notifications and provisions for obtaining approval of any remedial actions.

D. Regulatory and other requirements in support of waste transfer operations
   (If the transfer is using an HIHTL, then it must conform to the WAC Regulations (173-303-640) and the HIHTL Management Plan.)
   1. State in the associated TWRWP that waste compatibility assessment of adding CR vault waste into C-104 and AN-101 will be performed if necessary and waste transfer is compatible with AN-101.
   2. Provide Ecology with latest revision of the C-104 to AN-101 Waste Compatibility Assessment prior to the CR Vault sump waste transfer.
   3. State in the associated TWRWP that the procedures in place for waste transfer from C-104 to AN-101 will be in place and used for CR Vault waste transfer.
   4. Include in the associated TWRWP, that an IQPRE report of all equipment to be used for transfer (provide information to demonstrate compliance with WAC 173-303-640 (3) for any new, including above ground, systems) will be completed before waste transfer.

244-CR VAULT MEASUREMENTS DEC. 2004 (RPP-RPT-24257)



Attachment to Modification Notice Number: 2009-2
RPP-22393, Rev. 4, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tank Waste Retrieval Work Plan
Ecology requests the following information be supplied to the Modification Notice through an attachment.
Responses to Ecology requests are provided in bold blue font.

The purpose of this additional information is to provide documentation that will indicate planning ensures environmental protectiveness, procedures are in place to detect and mitigate leaks, completed and IQRPE-reviewed design, and use of appropriate operational procedures during waste transfer.

A. Provide identification of CR Vault cells and associated facilities and equipment— configuration and waste characteristics

1. Include the attached diagram (244-CR VAULT MEASUREMENTS DEC. 2004 (RPP-RPT-24257) that shows vault components and lists tank and cell liquid and solid/sludge volumes.

Response: Figure ES-1 from RPP-RPT-24257 Rev 0 is attached.

2. Provide results of sump sampling and analysis from each cell to Ecology prior to start of waste transfer out of CR vault.

Response: An action item has been added as a prestart condition to the CR Vault sump pumping schedule to provide this information to Ecology.

3. List all pipelines and equipment associated with the proposed waste transfer action.

Response: There will be a nominal one inch hose in sleeve line that runs from above ground by the CR vault to C-104. This line will be connected and disconnected in turn to the discharge of the four pumps inserted into each of the four sumps. There is planned to be a camera inserted into the vault(s) to observe the pumping. Power is planned to come from a local generator. Pump control will be with a local on/off switch .

4. List existing information on condition of transfer pipelines and transfer equipment.

Response: The transfer line and the pumps are new.

B. Planned Waste Removal and Transfer Technology

1. Describe removal system/technology and capability (pumps, cameras, flow measurement equipment, etc.).

Response: The pumps have a nominal 10-20 gpm transfer rate depending upon the transfer head. The camera used will be a standard color video camera of the type normally used inside waste tanks and pits. There is no flow measurement equipment.

2. Provide a diagram of the transfer system (include flow path, elevation changes, and layout).

Response: Attached is a sketch of the transfer system.

3. List waste transfer start date(s) to C-104 for each sump.

Response: The transfers will be done in the August to mid September time frame. The currently scheduled start dates are: CR-011 sump – August 4, 2009, CR-002 sump – August 13, 2009, CR-003 sump – August 19, 2009, and CR-001 sump – August 26, 2009. However, the added requirement in B-5 below to not transfer into C-104 until 12 kgal have been pumped out of C-104 ties start of CR Vault sump pumping to after the start of C-104 retrieval. C-104 retrieval is scheduled for startup August 18, 2009, which will delay the above dates accordingly.

4. State anticipated performance of technology with the goal to remove all waste as possible from the cell sumps.

Response: The pump free liquid heel is expected be in the range of 21 to 26 gal for each sump.

5. State that the waste from the CR vault cell sumps is being transferred to AN-101 via C-104 and must be pumped out as soon as practical from C-104. Vault cell sump waste can be transferred to C-104 after C-104 retrieval operations have removed at least 12,000 gal of waste.

Response: The liquid in the CR vault cell sumps is being transferred to AN-101 via C-104 and must be pumped out as soon as practical from C-104. Vault cell sump waste can be transferred to C-104 after C-104 retrieval operations have removed at least 12,000 gal of waste.

6. Describe the disposition of the system and equipment at the completion of waste transfer.

Response: The transfer line ~~and pumps~~*will be removed and disposed of as mixed wastes at the end of the transfer.

C. Description of planned leak detection and monitoring technology(s) for transfer system

1. Identify leak detection and monitoring during transfer, including drain back pathways.

Response: Transfer line leak detection will be accomplished by visual observation of the transfer line for leaks during the active transfers.

2. Identify existing level measurement instrumentation in sumps and receiver SST.

Response: A zip cord is used periodically for level measurement instrumentation in the sumps. The C-104 Enraf will be removed during the CR Vault sump transfers and reinstalled when the CR Vault sump transfers are complete. The C-104 Enraf plummet will be retracted if the CR Vault sumps are pumped into C-104 during active retrieval operations.

3. Identify future sump and vault tanks level monitoring activities.

Response: In the future the sump levels will be measured with zip cords, or an Enraf if these gauges are installed on the sumps. It is currently planned to install Enraf level gauges on tanks CR-001, CR-002 and CR-011 during the next fiscal year. CR-003 currently has level indication capability.

4. Describe mitigation strategy including a response plan to a detected leak during waste transfer (identify responses to various leak rates) including notifications and provisions for obtaining approval of any remedial actions.

Response: The mitigation strategy is to shut the transfer pump off when a leak is detected, and to contain the leak as practical until cleaned up. The response is the same regardless of the leak rate. Notification to regulatory organizations will be performed in compliance with TFC-OPS-OPER-CD-01, *Event Notification*, and TFC-ESHQ-ENV_FS-C-01, *Environmental Notification*.

D. Regulatory and other requirements in support of waste transfer operations

(If the transfer is using an HIHTL, then it must conform to the WAC Regulations (173-303-640) and the HIHTL Management Plan.)

1. State in the associated TWRWP that waste compatibility assessment of adding CR vault waste into C-104 and AN-101 will be performed if necessary and waste transfer is compatible with AN-101.

Response: Words will be added to RPP-22393 stating that transfer of CR vault sump waste to AN-101 via C-104 will be documented in a compatibility assessment, if such documentation is necessary.

2. Provide Ecology with latest revision of the C-104 to AN-101 Waste Compatibility Assessment prior to the CR Vault sump waste transfer.

Response: An action item has been added as a prestart condition to the CR Vault sump pumping schedule to provide this information to Ecology.

3. State in the associated TWRWP that the procedures in place for waste transfer from C-104 to AN-101 will be in place and used for CR Vault waste transfer.

Response: The CR Vault sump transfer will have its own procedure. The transfer from C-104 to AN-101 is a separate procedure. CR Vault sump solution sent to AN-101 is transferred out to AN-101 using the C-104 to AN-101 transfer procedure This procedure has to be in place prior to startup of C-104 retrieval so there is no need to add any additional words to the TWRWP on procedures.

*Per Change Notice 2010-2 on pg G-60, the words "and pumps" are deleted.

4. Include in the associated TWRWP, that an IQPRE report of all equipment to be used for transfer (provide information to demonstrate compliance with WAC 173-303-640 (3) for any new, including above ground, systems) will be completed before waste transfer.

Response: An action item has been added as a prestart condition to the CR Vault sump pumping schedule to provide this information to Ecology.

Attachment for request A-1

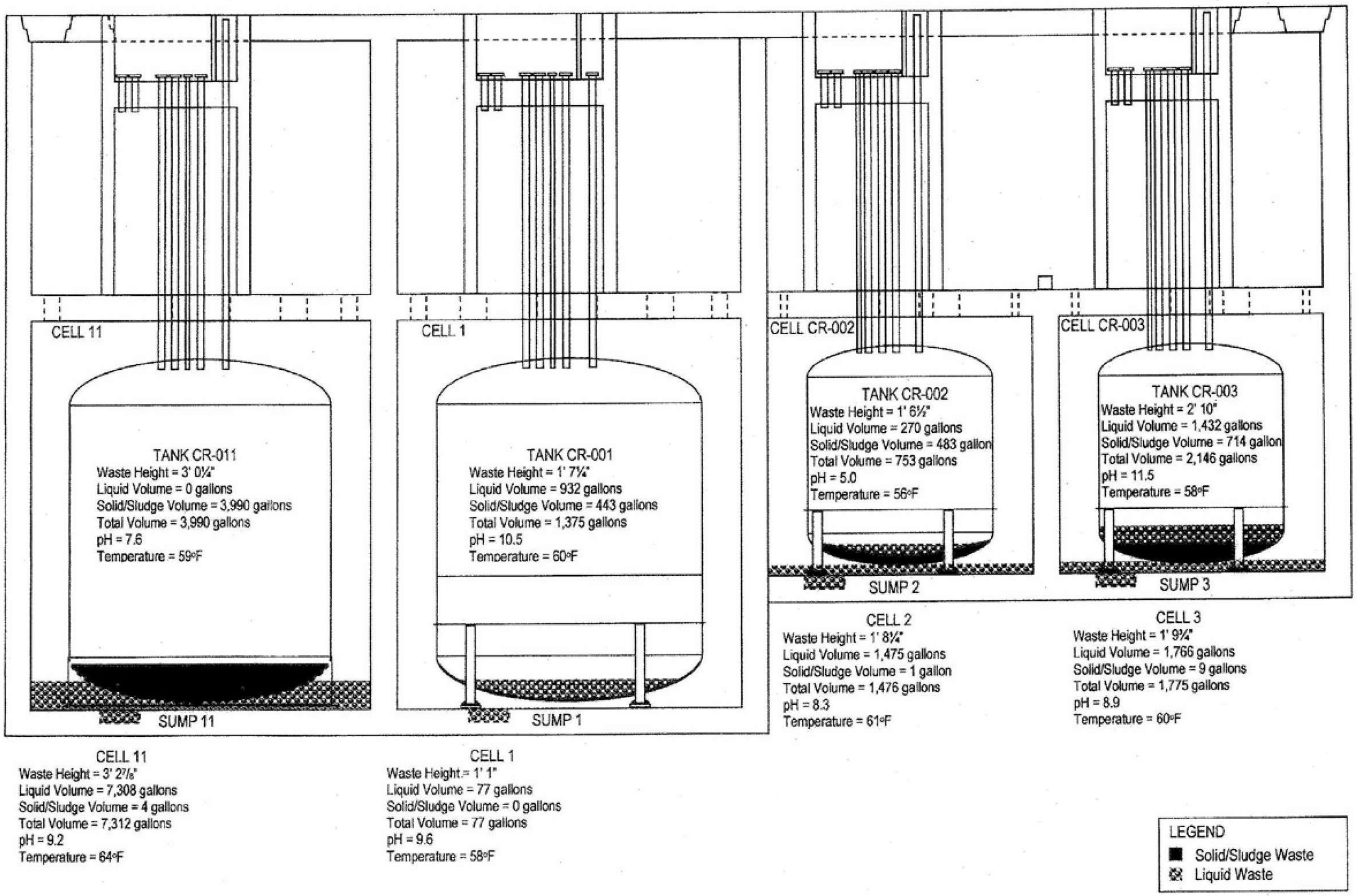
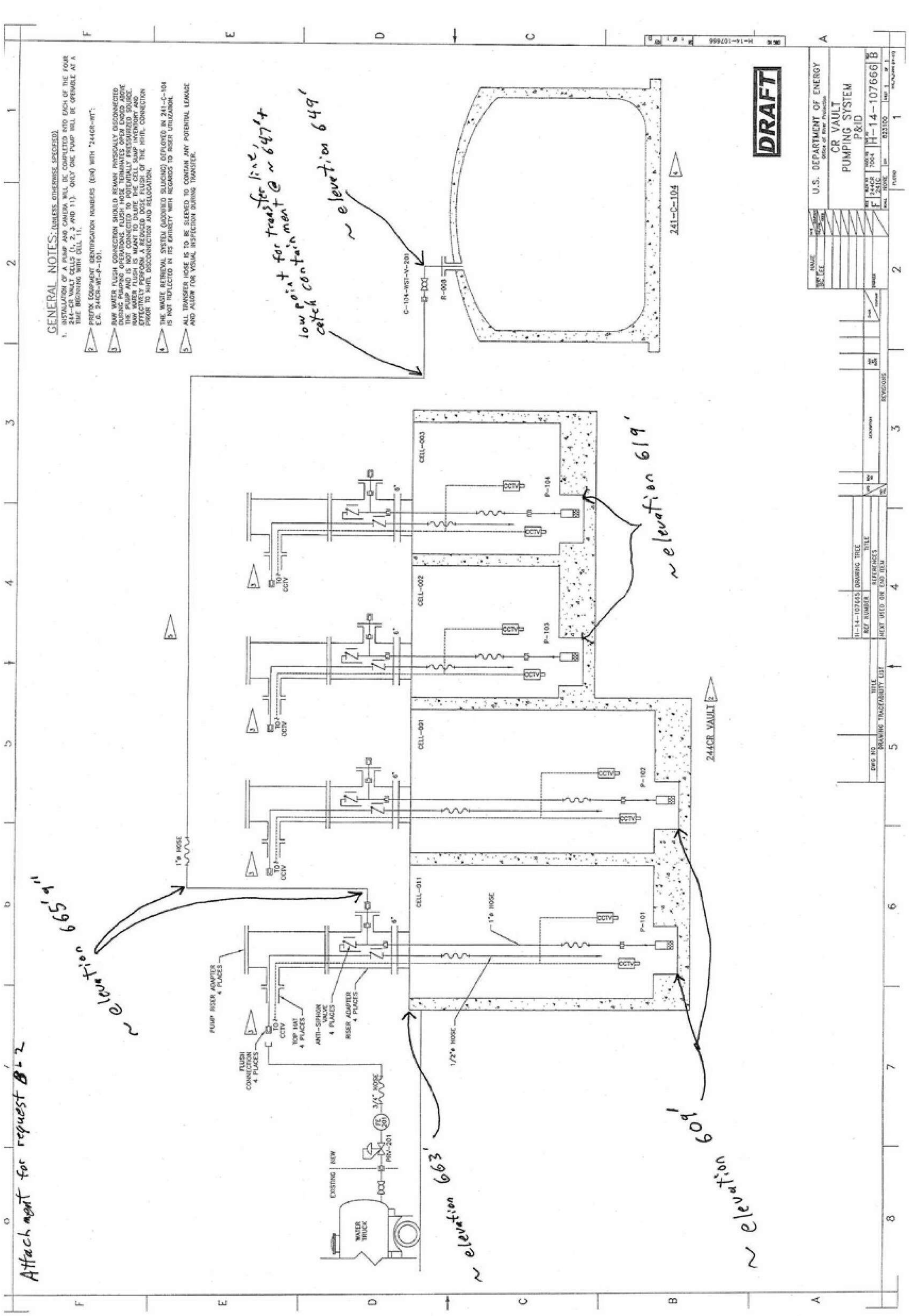


Figure ES-1. 244-CR Vault Waste pH, Temperature, and Volume Estimates.


Attach mgnt for request B-2
~ elevation 665'4"
~ elevation 663'
~ elevation 609'
~elevation 619'
low point for transfer line, catch containment @ ~647'±
~ elevation 649'
GENERAL NOTES:
WATER TRUCK
EXISTING | NEW
PRV-201
FE 201
3/4" HOSE
FLUSH CONNECTION 4 PLACES
TOP HAT 4 PLACES
ANTI-SIPHON VALVE 4 PLACES
RISER ADAPTER 4 PLACES
PUMP RISER ADAPTER 4 PLACES
CCTV
1/2" HOSE
1" HOSE
CELL-011
CELL-001
CELL-002
CELL-003
P-101
P-102
P-103
P-104
244CR VAULT
C-104-WST-V-201
R-003
241-C-104
DRAFT
U.S. DEPARTMENT OF ENERGY
CR VAULT
PUMPING SYSTEM
P&ID
H-14-107666
H-14-107665
DRAWING TREE
DRAWING TRACEABILITY LIST
REVISIONS

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

1. Document Title and Number: RPP-22393, Rev. 4, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tanks Waste Retrieval Work Plan

2. Minor Field Change: (Section 12.4 HFFACO Action Plan) □ Yes: (WRPS Signature Only – Attach signed form to Primary Document for record purposes) X No: Proceed to Box 3	**3.** Document Issue Date: 8/7/08 **4.** Document Modification Notice Date: 3/09/09	**5.** Notice Number: 2009-4
6. Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?) □ Yes X No	**7.** Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan? □ Yes X No	**8.** (Check only one box) □ Significant Modification (Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.) Minor Modification X Requires modification of the document X Can be accomplished with Modification Notice.

9. Description and Justification of Change:

Description: Delete pg 3-1 and Appendices B and E in RPP-22393 Rev 4 and replace with new pg 3-1 and Appendices B and E (attached are redline-strikeout copies of changes), and make appropriate changes to the references.

Justification: The only change in the main body of the TWRWP (on pg. 3-1) is to show AN-101 instead of AN-106 as the source tank for the C-112 sluicing supernate. The changes to the two appendices update the risk and hazard quotient plots and the associated numbers in the text.

The concentrations of key indicator constituents in potential SST leaks during retrieval of C-104 and C-112 are changed from those assumed for the previous leak risk calculations in 2005. This mod notice form is required due to a change in the composition of the supernate in the DST, AN-101, which will be used to sluice these tanks, and because the supernate source tank for C-112 is changed from that in Rev 4 of the TWRWP. The TWRWP currently shows AN-101 being used to sluice C-104 and AN-106 to sluice C-112. Per wording in Appendices B and E, if the DST supernate concentrations increase above those assumed in the Appendices, or if the source tank for the supernate changes, a mod notice is required to reflect the change. In addition, the previous versions of Appendices B and E provided both an assumed nominal leak concentration and a worst case assumed leak concentration for each tank. The revised calculations delete the unnecessary nominal concentrations and provide a single conservative concentration for each constituent.

Table 1 shows the previous nominal and worst case retrieval leak concentrations assumed in 2005 and the revised 2009 single assumed retrieval leak concentrations for C-104 and C-112. Note that the worst case ^{99}Tc retrieval leak concentration increases by ~46%, the worst case Cr retrieval leak concentration drops by ~77%, and the worst case NO_2 retrieval leak concentration increases by ~86%.

Office of River Protection, State of Washington Department of Ecology
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Table 1 Previous and Updated Retrieval Leak Concentrations

	^{99}Tc (Ci/L)	Chromium (kg/L)	Nitrite (kg/L)
C-104 2005 nominal leak conc.	4.02E-05	4.85E-04	2.54E-02
C-104 2005 worst case leak conc.	8.30E-05	2.3E-03	4.3E-02
C-104 2009 single leak conc.	1.21E-04	5.28E-04	8.01E-02
C-112 2005 nominal leak conc.	3.68E-05	1.27E-04	2.33E-02
C-112 2005 worst case leak conc.	8.30E-05	2.3E-03	4.3E-02
C-112 2009 single leak conc.	1.21E-04	5.28E-04	8.01E-02

The risk and hazard quotient plot Figures B-1, B-2, B-3, E-1, E-2, and E-3 are replaced as well as necessary numbers and words in the supporting documentation, as can be seen on the attached redline-strikeout copies of the revised appendices. The only change on pg. 3-1 in the main body of the TWRWP is to show AN-101 instead of AN-106 as the source tank for the C-112 sluicing supernate.

10. Impact of Change:

No impact.

11. Additional Requirements and/or Provisions[1]:

Approvals

Washington River Protection Solutions, LLC.	Office of River Protection	State of Wash., Dept. of Ecology
□ Provisional Approval[2] Date	□ Provisional Approval[2] Date	□ Provisional Approval[2] Date
□ Final Approval Date 4/20/09	□ Final Approval Date 5/6/09	□ Final Approval Date 5-11-09

Notes

1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision
2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 10, prior to final approval of this modification.

3.0 PLANNED WASTE RETRIEVAL TECHNOLOGY

This section provides a description of the planned waste retrieval technology for retrieving the waste from tanks C-102, C-104, C-107, C-108, and C-112.

3.1 SYSTEM DESCRIPTION

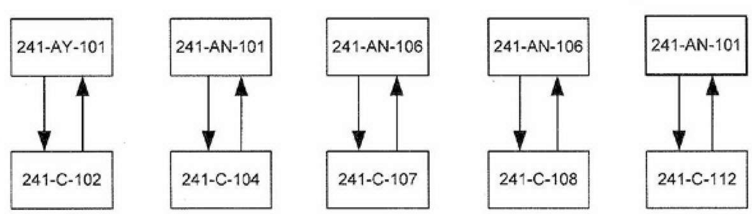
This section provides a description of the WRS and how it will be operated. Continued design development and incorporation of lessons learned may lead to changes in the design and/or operating strategy.

3.1.1 Physical System Description

The WRS will consist of a modified sludge sluicing system to mobilize and retrieve waste from tanks C-102, C-104, C-107, C-108, and C-112. The sluicing system will consist of two (or more) sluice nozzles and a slurry pump in each tank. The sluice nozzles or hydraulic sluicers will be controlled from a control trailer located near the tanks. The sluice nozzles will be installed in existing tank risers located around the perimeter of the tank. The sluice nozzles will have the capability to direct liquid at various locations in the tanks. The flow rate through the sluice nozzles will be adjusted based on the pump-out rate so that the rate of liquid introduction will approximately equal the rate of solution removal with the objective of minimizing the liquid waste volume in the retrieval tank. The waste retrieved from tanks C-102, C-104, C-107, C-108, and C-112 will be transferred to a DST. To minimize the overall volume of waste requiring storage in the DST system, the waste retrieval project plans to use DST supernate as the primary sluice liquid (see Section 3.1.2 for operating description). The WRS will also have the capability to use raw water for sluicing with minor modifications.

The waste retrieval plan as of mid March 2005 for using DSTs for waste receipt and as source tanks for supernate recycle is shown in Figure 3-1. The DSTs were selected based on their location, available space, and existing or planned equipment upgrades. Additional detail on the planned use of supernate during waste retrieval is discussed in Section 3.2.

Figure 3-1. Waste Retrieval Liquid Supply and Double-Shell Tank Receiver Tank Designation.



The remaining pages attached to Modification Notice 2009-4 are omitted here for the sake of brevity. The remaining pages attached to Modification Notice 2009-4 when submitted to Ecology for approval are the same as Appendices B and E in RPP-22393 Rev 4A, except the appendices attached to 2009-4 were in redline/strikeout. The original pages of Modification Notice 2009-04 and the attachments are on file with the TPA and Permitting group of the tank farm contractor, and with Ecology.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

<table>
<tr><td colspan="3">1. Document Title and Number: RPP-22393, Rev. 4A, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tanks Waste Retrieval Work Plan</td></tr>
<tr><td rowspan="2">2. Minor Field Change:
(Section 12.4 HFFACO Action Plan)
□ Yes: (WRPS Signature Only – Attach signed form to Primary Document for record purposes)
X No: Proceed to Box 3</td><td>3. Document Issue Date:
7/15/09</td><td rowspan="2">5. Notice Number: 2009-5</td></tr>
<tr><td>4. Document Modification Notice Date: 7/15/09</td></tr>
<tr><td>6.
Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?)
□ Yes X No</td><td>7.
Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan?
□ Yes X No</td><td>8. (Check only one box)
□ Significant Modification
(Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.)
Minor Modification
X Requires modification of the document
X Can be accomplished with Modification Notice.</td></tr>
</table>

9. Description and Justification of Change:

Description: Delete following words in section 3.1.3:

Liquid will not be added to an SST for the sole purpose of obtaining a level measurement. However, heel submergence remains the best and easiest measurement readily available for estimating the heel volume, and level data will be obtained on an opportunistic basis when performing flushes or during retrieval activities in the latter stages or at the end of the waste retrieval process.

Add the following words in section 3.2:

When adding liquid to the SST for the sole purpose of obtaining a waste level measurement, the following conditions apply:

1. *The HRR leak detection system for the tank described in Section 4.2.1 must be continuously operable for at least 48 hours prior to the liquid addition.*
2. *The benchmark level described in Section 4.6.1 will not be exceeded during the liquid addition.*
3. *Excess liquid will be removed from the tank as soon as practical once a usable waste level measurement is obtained.*
4. *The liquid to be used for volume displacement measurement should only be supernate. Use of raw water for volume displacement instead of or in addition to supernate shall be discussed with Ecology prior to use.*

Justification: This change is made to provide significantly increase operational flexibility and enable

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

obtaining of tank waste volume estimates based upon actual measurement rather than an assumed starting volume estimate. The change implements the exact same wording as has been verbally agreed to by Ecology for the C-111 TWRWP (RPP-37739) which is currently undergoing Ecology review.		
10. Impact of Change: No impact.		
11. Additional Requirements and/or Provisions[1]:		
Approvals		
Washington River Protection Solutions, LLC.	Office of River Protection	State of Wash., Dept. of Ecology
□ Provisional Approval[2] Date	□ Provisional Approval[2] Date	□ Provisional Approval[2] Date
☑ Final Approval 7/27/09 Date	☑ Final Approval 8/17/09 Date	☑ Final Approval Date 8-27-09

Notes

1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision
2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 11, prior to final approval of this modification.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

<table>
<tr><td colspan="3">1. Document Title and Number: RPP-22393, Rev. 4B, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tank Waste Retrieval Work Plan</td></tr>
<tr><td rowspan="2">2. Minor Field Change:
(Section 12.4 HFFACO Action Plan)
☐ Yes: (WRPS Hanford Signature Only – Attach signed form to Primary Document for record purposes)

X No: Proceed to Box 3</td><td>3. Document Issue Date:

9/25/09</td><td rowspan="2">5. Notice Number: 2009-6</td></tr>
<tr><td>4. Document Modification Notice Date: 11/04/09</td></tr>
<tr><td>6.
Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?)

☐ Yes X No</td><td>7.
Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan?

☐ Yes X No</td><td>8. (Check only one box)
☐ Significant Modification
(Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.)
Minor Modification
X Requires modification of the document Can be accomplished with Modification Notice.</td></tr>
<tr><td colspan="3">9. Description and Justification of Change:
Description: Add following to Section 3.2
Prior to the heel waster flush, a caustic solution may also be added to the tank heel. The caustic would be used to improve retrieval of waste from the tank by breaking down certain hydrated aluminum hydroxide solids to enable their removal.
Justification: A concentrated caustic soak may be used for tank heels to break down much of the larger residual waste solid chunks to improve tank waste retrieval.</td></tr>
<tr><td colspan="3">10. Impact of Change: TWRWP changes are approved and to improve current retrieval technology performance, the application of caustic additions is approved.

The Proposed Consent Decree and Tri-Party Agreement Modifications for the Hanford Tank Waste Treatment, Part 1, and Appendix C (public comment period October 1, 2009, to December 11, 2009) establish that two or three technologies may be required for the purpose of completing tank retrievals for the Consent Decree. The technologies, and the criteria that would be used to identify the technologies, have not been defined or agreed to by either the State or the USDOE. This change notice is not associated with the process or approval of the Proposed Consent Decree retrieval technologies, and does not constitute an agreement on the use of caustic as a second technology.

It is expected that the sodium hydroxide addition will not affect WTP waste feed operations.</td></tr>
<tr><td colspan="3">11. Additional Requirements and/or Provisions[1]:
If the decision to add caustic is made, Ecology is to be informed of:
1. the approximate amount of caustic to be added,
2. the approximate soaking time to support maximum waste removal,
3. the frequency of caustic additions,
Ecology must be informed if the caustic added amounts and/or soak times are exceeded.</td></tr>
<tr><td colspan="3"></td></tr>
</table>

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

Approvals		
Washington River Protection *Solutions*, Inc.	Office of River Protection	State of Wash., Dept. of Ecology
□ Provisional Approval² Date	□ Provisional Approval² Date	□ Provisional Approval² Date
☑ Final Approval Date 4/15/10	☑ Final Approval Date 4/27/10	☑ Final Approval Date 4-7-10

Notes
1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision
2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 10, prior to final approval of this modification.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

1. Document Title and Number: RPP-22393, Rev. 4B, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tanks Waste Retrieval Work Plan

2. Minor Field Change: (Section 12.4 HFFACO Action Plan) □ Yes: (WRPS Signature Only – Attach signed form to Primary Document for record purposes) X No: Proceed to Box 3	**3.** Document Issue Date: 9/25/09 **4.** Document Modification Notice Date: 4/28/10	**5.** Notice Number: 2010-2
6. Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?) □ Yes x No	**7.** Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan? □ Yes x No	**8.** (Check only one box) □ Significant Modification (Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.) Minor Modification X Requires modification of the document X Can be accomplished with Modification Notice.

9. Description and Justification of Change:

Description: Modify the response to Ecology question B 6 in the attachment to mod notice 2009-2 (located on pg. G-48 of Appendix G) as follows:

6. Describe the disposition of the system and equipment at the completion of waste transfer.

Response: The transfer line ~~and pumps~~ will be removed and disposed of as mixed wastes at the end of the transfer. The pumps will remain in the vault sumps.

Justification: The pumps will be left in the CR Vault sumps in case needed to pump out waste if there is future intrusion.

10. Impact of Change:

No impact.

11. Additional Requirements and/or Provisions[1]; CR Vault pumping system P+ID (H-14-107166) shows pump in each of the 4 Vault cells (1,2,3 & 11)

Approvals

Washington River Protection Solutions, LLC.	Office of River Protection	State of Wash., Dept. of Ecology
□ Provisional Approval[2] Date	□ Provisional Approval[2] Date	□ Provisional Approval[2] Date
X Final Approval [signature] Date 5/10/10	X Final Approval [signature] Date 6/8/10	X Final Approval [signature] Date 6-9-10

Notes

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

<table>
<tr><td colspan="3">1. Document Title and Number: RPP-22393, Rev. 4B, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tanks Waste Retrieval Work Plan</td></tr>
<tr><td rowspan="2">2. Minor Field Change:
(Section 12.4 HFFACO Action Plan)
□ Yes: (WRPS Signature Only – Attach signed form to Primary Document for record purposes)
x No: Proceed to Box 3</td><td>3. Document Issue Date:
9/25/09</td><td rowspan="2">5. Notice Number: 2010-3</td></tr>
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(Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.)
Minor Modification
x Requires modification of the document
x Can be accomplished with Modification Notice.</td></tr>
<tr><td colspan="3">9. Description and Justification of Change:</td></tr>
</table>

Change Description: A change is needed to add a description of the tool that will go into C-104 to try and move the debris keeping the pump from going to the bottom of the tank. This opportunity is being taken to clean up a number of out-of-date or inaccurate words in the TWRWP. The changes covered by this modification notice are shown in redline/strikeout on the attached redline/strikeout pgs. 2-5, 2-6, 2-8, 3-1, 3-2, 3-3, 3-5, 3-7, 3-13, 3-21, 3-22, 5-1, 5-9, and 5-10.

Justifications:

- Pgs 2-5 and 2-6 change 'conductivity probe leak detector' to 'leak detector probe' since may use a thermal probe as an alternate to conductivity probe. The words 'using the caisson' in the next to last paragraph are added for clarification.
- Pg 2-8 Table 2-2, Column 4, change 02-A pit to 04-A pit (2 rows) and 02-B pit to 04-B pit, this fixes typos.
- Pg 3-1, the deletion is made since sluicers may be used in risers not around the perimeter, this sentence should not have been in the document. The addition below it is made because with some tanks only a valving change is needed to provide water, no minor mod is required.
- Pgs 3-2, 3-21, 3-22, 5-1, 5-9 and 5-10 delete the past tank farm contractor name and add the general term 'tank operations contractor'.
- Pg 3-~~2~~3, the top deletion is made because the wording is too detailed, unnecessary, and out of date. The addition at the bottom adds the description of the tool that will be added to C-104.
- Pg 3-5 grammatical changes made to reflect there is more than one valve box in C-farm.
- Pg 3-7 deletions and additions made because tanks going to AN-106 are listed on pg 3-1 and the

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AN-101 pump wording updated to be more general to reflect new pump to be used.

- Pg 3-13 two paragraphs related to heel concentrations following flushing are deleted as the wording is out of date and misleading, and was removed from the more recent C-110 and C-111 TWRWPs when they were written and approved.

10. Impact of Change:

No impact.

11. Additional Requirements and/or Provisions[1]:

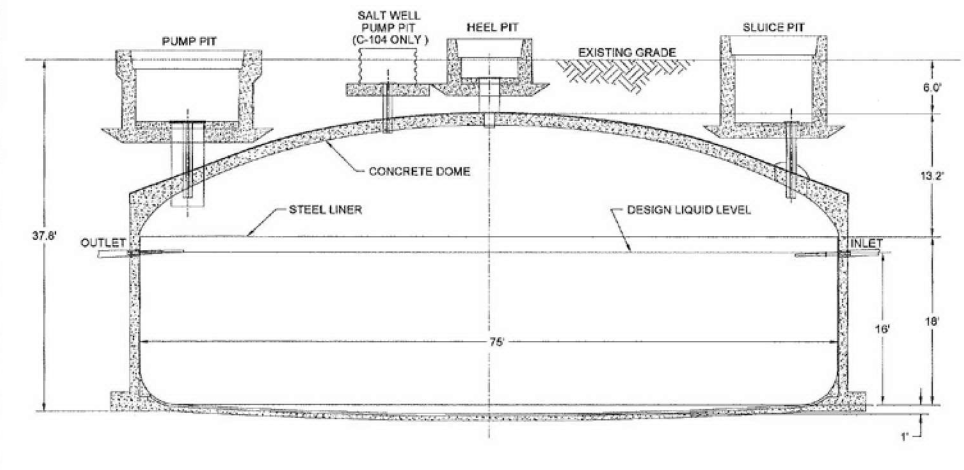
Approvals

Washington River Protection Solutions, LLC.	Office of River Protection	State of Wash., Dept. of Ecology
☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date
☒ Final Approval Date 6/10/10	☒ Final Approval Date 9/30/10	☐ Final Approval Date

Notes

1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision
2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 11, prior to final approval of this modification.

Figure 2-3. Tanks C-102 and C-104 Cross-Section View.*



C-102/-104 Cross-Section View
530,000-gal. Capacity

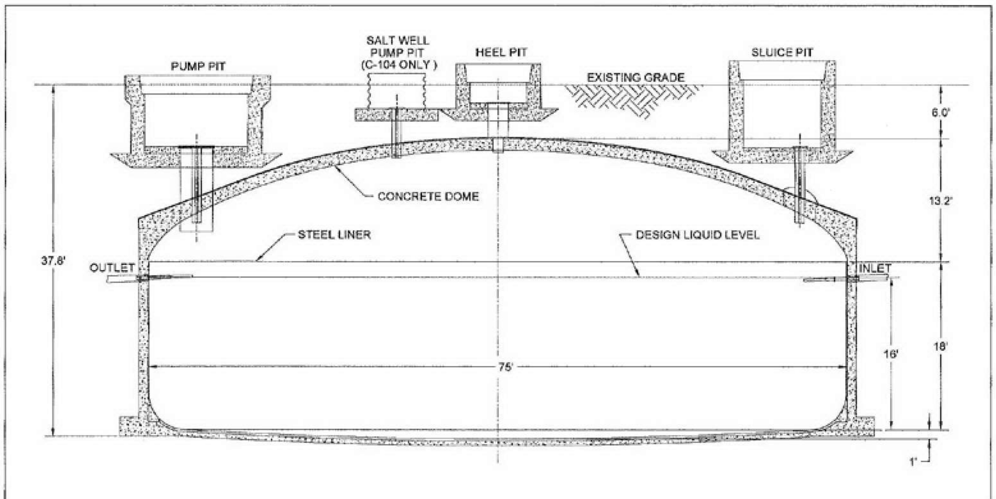
* Adapted from RPP-13774, 2004, *Single-Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

Tanks C-102 and C-104 both have three reinforced concrete process pits that were installed after initial tank construction to facilitate waste retrieval. These pits are constructed of reinforced concrete and extend abovegrade. The pits provide secondary containment for the primary transfer piping within, and have removable cover blocks or plates that allow entry into the pits. The pit floors were constructed with drains that direct any liquid back into the tank through a tank riser located in the pit. For the purpose of retrieval of these two tanks, if the pit drains are plugged, any liquid (intrusion, tank waste, or other) will be pumped back to the associated SST. Pit pumping into the associated SST will occur so that the pit liquids may be removed before retrieval completion. The condenser hatchway (not shown in Figure 2-3) located above the outside edge of the tank provided an indirect access path into the tank for ventilation.

In addition, tank C-104 has a caisson made from a corrugated pipe embedded in a concrete base. The concrete base was sloped to a drain that connected to the tank riser so any leakage within the caisson would drain back into the tank. The caisson extends abovegrade and is closed off on the top with a coverplate. This caisson and the associated 12-in. riser were added to the tank to support saltwell pumping.

Each pit or caisson used for waste retrieval will have a ~~conductivity probe~~ leak detector probe.

Figure 2-3. Tanks C-102 and C-104 Cross-Section View.*



C-102/-104 Cross-Section View
530,000-gal. Capacity

* Adapted from RPP-13774, 2004, *Single-Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

Tanks C-102 and C-104 both have three reinforced concrete process pits that were installed after initial tank construction to facilitate waste retrieval. These pits are constructed of reinforced concrete and extend abovegrade. The pits provide secondary containment for the primary transfer piping within, and have removable cover blocks or plates that allow entry into the pits. The pit floors were constructed with drains that direct any liquid back into the tank through a tank riser located in the pit. For the purpose of retrieval of these two tanks, if the pit drains are plugged, any liquid (intrusion, tank waste, or other) will be pumped back to the associated SST. Pit pumping into the associated SST will occur so that the pit liquids may be removed before retrieval completion. The condenser hatchway (not shown in Figure 2-3) located above the outside edge of the tank provided an indirect access path into the tank for ventilation.

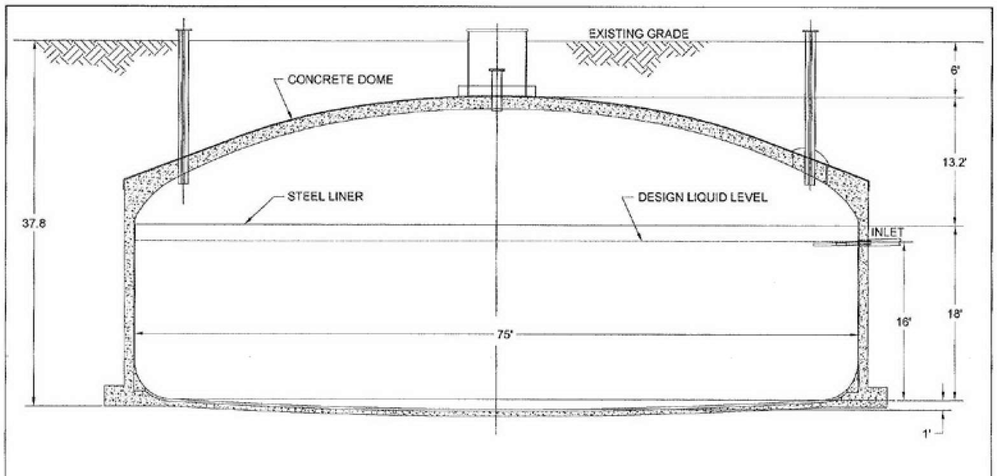
In addition, tank C-104 has a caisson made from a corrugated pipe embedded in a concrete base. The concrete base was sloped to a drain that connected to the tank riser so any leakage within the caisson would drain back into the tank. The caisson extends abovegrade and is closed off on the top with a coverplate. This caisson and the associated 12-in. riser were added to the tank to support saltwell pumping.

Each pit or caisson used for waste retrieval will have a ~~conductivity probe~~ leak detector probe.

2.2.2 Tanks C-107, C-108, and C-112 Configuration

The configuration of tanks C-107, C-108, and C-112 is depicted in the cross-section view in Figure 2-4.

Figure 2-4. Tanks C-107, C-108, and C-112 Cross-Section View.*



Note: The cascade line configuration in these three tanks varies. Tank C-107 has only an outlet line. Tank C-108 has both an inlet and an outlet, and tank C-112 has only an inlet.

* Adapted from RPP-10435, 2002, *Single-Shell Tank System Integrity Assessment Report*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

Tanks C-107, C-108, and C-112 do not have any concrete pits, but do have a caisson that was installed over the center riser after initial tank construction to facilitate waste retrieval. The caissons are constructed of a section of corrugated pipe embedded in a concrete base. The concrete base was sloped to a drain that connected to the tank riser so any leakage within the caisson would drain back into the tank. The caisson extends abovegrade and is closed off on the top with a coverplate.

Drawing H-2-38597, *Salt Well Pump Pit Assembly for Std. 12" Riser*, shows the original installation of the corrugated caisson. The caisson was installed in a groove in the concrete bottom of the pit and sealed with grout. A drain, flush with the bottom of the pit, previously routed drainage to the 12-in. riser. Drawing H-14-106599, *241-C Sluice Retrieval Mechanical Equipment Installation*, shows the equipment installation to be used during SST retrieval using the caisson. A ~~conductivity probe~~ leak detector probe will be used in the pit. A sump pump is used to pump leakage into the tank.

Each pit or caisson used for waste retrieval will have a ~~conductivity probe~~ leak detector probe.

Table 2-2. Tanks C-102 and C-104 Riser and Fill/Cascade Line Descriptions.

Riser Number	Diameter (in.)	Use Description	
		Tank C-102	Tank C-104
R1	4	Unused temperature probe	Liquid level well, belowgrade
R2	12	Level gauge (ENRAF) [a]	Breather filter and benchmark
R3	12	Observation port/breather filter in weather covered pit (02-C pit)	Observation port in weather covered pit (04-C pit)
R4	4	Recirculating dip leg in weather covered pit (02-C pit)	Recirculating dip leg in weather covered pit (04-C pit)
R5	4	Recirculating dip leg in weather covered pit (02-A pit)	Recirculating dip leg in weather covered pit (04-A pit)
R6	12	Sluicing access riser in weather covered pit	Sluicing access riser in weather covered pit
R7	12	Temperature probe in riser through pit wall, flange weather covered pit (02-A pit)	Temperature probe in riser through pit wall (0~~2~~4-A pit)
R8	4	blind flange (obstruction)	Level gauge (ENRAF)
R9	36	sludge pump access riser in weather covered pit (02-A pit)	Sludge pump access riser in weather covered pit (0~~2~~4-A pit)
R13	12	Saltwell screen in weather covered pit (02-B pit)	Heel jet in 0~~2~~4-B pit
R14	4	NA	Blind flange
R15	12	NA	Empty
A [b]	3	Cascade overflow line to tank C-103	Cascade overflow line to tank C-105
B [b]	3	Cascade inlet line from tank C-101	NA
C1 [b]	3	Spare inlet, capped	Fill line V150
C2 [b]	3	Spare inlet, capped	Fill line V149, sealed in diversion box 241-C-153
C3 [b]	3	Spare inlet, capped	Fill line V148, sealed in diversion box 241-C-153
C4 [b]	3	Spare inlet, capped	Spare, capped

Note: Reference documents from TWINS, Web Site - http://twinsweb.pnl.gov/twins.htm and H-14-010613, 2003, *Waste Storage Tank (WST) Riser Data*, Sheet 2, Rev. 6, CH2M HILL Hanford Group, Inc., Richland, Washington (with ECNs).

ECN = engineering change notice.
NA = not applicable.
TWINS = Tank Waste Information Network System.

[a] Enraf is the supplier of the identified level gauges; ENRAF is a trademark of Enraf, Inc., Enraf B.V., Delft, The Netherlands.

[b] Cascade and/or fill line, not a riser.

3.0 PLANNED WASTE RETRIEVAL TECHNOLOGY

This section provides a description of the planned waste retrieval technology for retrieving the waste from tanks C-102, C-104, C-107, C-108, and C-112.

3.1 SYSTEM DESCRIPTION

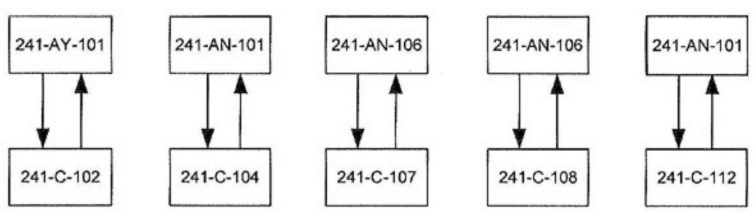
This section provides a description of the WRS and how it will be operated. Continued design development and incorporation of lessons learned may lead to changes in the design and/or operating strategy.

3.1.1 Physical System Description

The WRS will consist of a modified sludge sluicing system to mobilize and retrieve waste from tanks C-102, C-104, C-107, C-108, and C-112. The sluicing system will consist of two (or more) sluice nozzles and a slurry pump in each tank. The sluice nozzles or hydraulic sluicers will be controlled from a control trailer located near the tanks. The sluice nozzles will be installed in existing tank risers ~~located around the perimeter of the tank~~. The sluice nozzles will have the capability to direct liquid at various locations in the tanks. The flow rate through the sluice nozzles will be adjusted based on the pump-out rate so that the rate of liquid introduction will approximately equal the rate of solution removal with the objective of minimizing the liquid waste volume in the retrieval tank. The waste retrieved from tanks C-102, C-104, C-107, C-108, and C-112 will be transferred to a DST. To minimize the overall volume of waste requiring storage in the DST system, the waste retrieval project plans to use DST supernate as the primary sluice liquid (see Section 3.1.2 for operating description). The WRS will also have the capability to use raw water for sluicing with valving change or minor modifications.

The waste retrieval plan as of mid March 2005 for using DSTs for waste receipt and as source tanks for supernate recycle is shown in Figure 3-1. The DSTs were selected based on their location, available space, and existing or planned equipment upgrades. Additional detail on the planned use of supernate during waste retrieval is discussed in Section 3.2.

Figure 3-1. Waste Retrieval Liquid Supply and Double-Shell Tank Receiver Tank Designation.



Various monitoring instruments will be used to collect data to support operation of the WRS and perform environmental monitoring. Cameras will be installed in each of the SSTs to provide the capability to visually monitor and aid in control of waste retrieval operations. Instrumentation will also be provided to monitor process control data (e.g., pressures and flow rates). This information will be used to support material balance calculations. The existing ENRAF[1] level gauges will be retracted during waste retrieval operations and will be used periodically to monitor waste levels.

Before initiating waste retrieval, a formal waste compatibility assessment will be performed in accordance with HNF-SD-WM-OCD-015, *Tank Farm Waste Transfer Compatibility Program*. Formal issuance of the compatibility assessment will not be completed until just before waste retrieval operations begin to ensure that current conditions are captured in the assessment.

During waste retrieval operations, the tank(s) being retrieved will be actively ventilated. The ventilation system will consist of skid-mounted high-efficiency particulate air filtered portable exhauster(s). The ventilation system(s) are designed to pass air through the tank, thereby reducing condensation and fog within the tank. The vent systems required by Washington State Department of Health (WDOH) include a heater, prefilter, demister, two high-efficiency particulate air filters and test sections, exhaust fan, and stack. Project plans include the design and installation of ventilation system(s) to support waste retrieval operations for the C farm tanks as shown in Figure 3-2. Condensate drainage from the exhauster(s) will be routed back to an SST being retrieved. Any change to this drainage routing will covered by a Change Notice Form to this TWRWP. Details of the ventilation systems are provided in AIR 05-407, *Categorical Tank Farm Facility Waste Retrieval and Closure: Phase II Waste Retrieval Operations*, and DE05NWP-002, *Notice of Construction (NOC) Application for Operations of Waste Retrieval Systems in the Single-Shell Tank (SST) Farms*.

ORP and the TOC ~~CH2M HILL Hanford Group, Inc. (CH2M HILL)~~, pursuant to federal requirements for protection of their workers, will develop and implement a personal exposure sampling and monitoring plan for SST waste retrievals. This plan will be developed and implemented by the operations Industrial Hygiene (IH) departments per the ~~CH2M HILL~~TOC Environmental Health Program with consideration of input from Ecology. Subsequent to issuance of the IH sampling and monitoring plan, changes to that portion of the plan pertaining to sampling exhauster emissions at the stack will be provided to Ecology for Ecology's information in as timely a manner as possible.

New equipment will be installed in the tanks to support waste retrieval. Existing equipment will be removed if and as required to make room for the new equipment. The new slurry pump will be installed in the center riser located in the center pit. Each pump may be mounted on a winch system that will allow the pump to be lowered as waste retrieval progresses. The pump suction will be installed just under the waste surface to start, so little or no water should be required for installation due to the sludge nature (i.e., not hard saltcake) of the waste and the small submergence of the pump suction. The system will be designed to allow the pump suction to be

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[1] ENRAF is a trademark of Enraf, Inc., Enraf B.V., Delft, The Netherlands.

lowered as low as possible in each tank to facilitate maximum waste removal. This will allow approximately 10 ft of height adjustment.

The pump installation will be performed by lowering the pump into the tank with a crane. ~~The pump will be installed with the suction just into the waste surface a few inches. No water addition should be necessary for the pump installation because the pump suction will be located just under the waste surface. If the pump suction is too shallow when retrieval is started, the sluice nozzle discharges can be aimed at the pump inlet to enable to the pump to be inserted a little deeper.~~

A booster pump, if used, will be located within the central riser pit. The WRS for tanks C-107, C-108, and C-112 may require modifications to the saltwell pits to accommodate installation of a slurry pump in the center of the tanks.

The pump adjustment features described previously should allow the pump to be installed with little or no water additions. However, if tank conditions require water additions to successfully install the pumps (e.g., debris under the pump installation riser), water additions would be controlled in accordance with OSD-T-151-00013, *Operating Specifications for Single-Shell Waste Storage Tanks*, Section 4.1). This water would be added through one or both of the sluicers by lancing or by backflushing through the pump. Lancing refers to lowering a water lance into the waste and adding water to fluidize hard material under the addition point. The initial installation height of the pump will be determined using the in-tank video system.

The sluice nozzles in tanks C-102 and C-104 will be installed within the existing pump and sluice pits. The configuration of tanks C-107, C-108, and C-112 is different in that there are no concrete pits and only a single central corrugated metal saltwell pump pit. The WRSs for tanks C-107, C-108, and C-112 will require design and construction of riser extensions to support the installation of the two sluice nozzles and slurry pump. The in-tank imaging system will be installed in an available riser in the tank. Table 3-1 provides the planned riser usage for the tanks C-102, C-104, C-107, C-108, and C-112 WRSs. This riser usage may change.

An in-tank vehicle may be used to aid in removal of waste from a tank. This in-tank vehicle will have high pressure water spray nozzles and a movable blade. The high pressure water can be supplied at a nominal 3000 psig and a nominal 10 gpm. The blade will have a polymer 'squeegee' on the bottom when installed in the tank. The hydraulically powered vehicle will move about on polymer tracks. The in-tank vehicle will be designed to access the tank via a 12 in. diameter riser. The in-tank vehicle support system will include an above ground water supply skid and hydraulic power pack.

For C-104 a hydraulically operated tool will be inserted in riser 15 near the central pump pit. This tool will extend to the bottom of the tank and be used to attempt to move debris under the pump so the pump can be lowered. The tool is planned to also have water addition capability to aid retrieval if necessary.

Table 3-1. Planned Riser Usage for Tanks C-102, C-104, C-107, C-108, and C-112 Waste Retrieval System.

Riser Number	Tank C-102[2]	Tank C-104[2]	Tank C-107[2]	Tank C-108[2]	Tank C-112[2]
2	ENRAF[1] level gauge	Exhauster connection	Sluicer	Sluicer	Sluicer
3	Sluicer	Sluicer	Exhauster connection	Vacuum relief/camera port	Exhauster connection
5	--	--	--	--	ENRAF level gauge
6	Sluicer	Sluicer	Vacuum relief, camera port	Exhauster connection	Vacuum relief, camera port
7	Vacuum relief, camera port	Vacuum relief	Sluicer	Sluicer	Sluicer
8	--	ENRAF level gauge	ENRAF level gauge	ENRAF level gauge	--
13	Slurry pump	Slurry pump	Slurry pump	Slurry pump	Slurry pump
14	--	Camera port	--	--	--
Condenser hatchway	Exhauster connection	--	--	--	--

[1]ENRAF is a trademark of Enraf, Inc., Enraf B.V., Delft, The Netherlands.

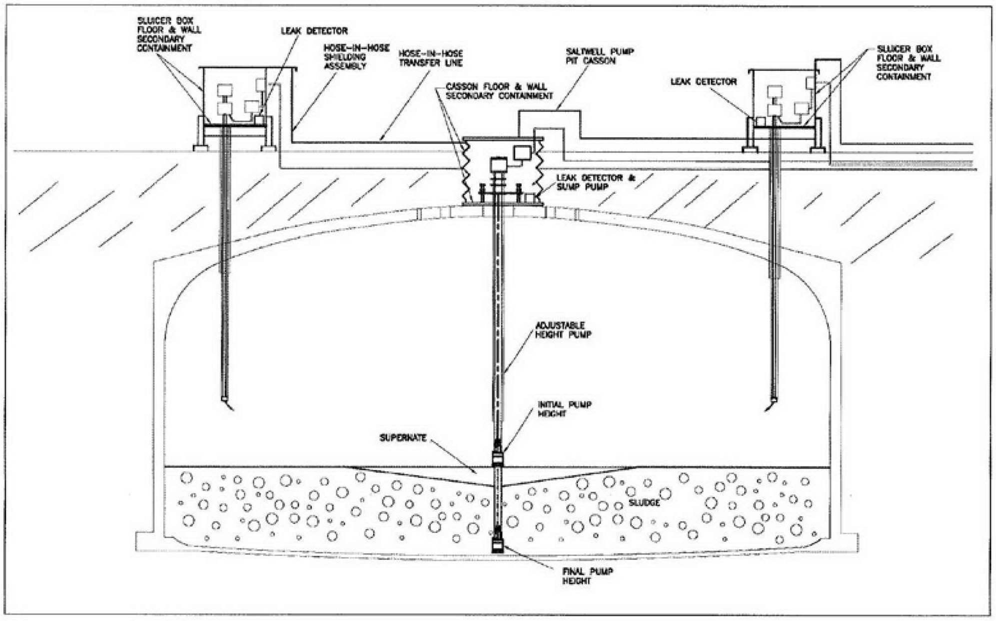
[2]Riser usage may change following detailed design and/or during operations. Should an in-tank vehicle be added to the tank to aid in waste heel removal the riser used will be selected during detailed design for the heel removal. For C-108 waste heel removal the riser used for the in-tank vehicle will be Riser 3 or 6.

A sketch of the WRS installation planned for tanks C-102 and C-104 is provided in Figure 3-3. A sketch of the WRS installation planned for tanks C-107, C-108, and C-112 is provided in Figure 3-4. A potential equipment layout in the tank farm is provided in Figure 3-2.

The portable valve boxes serve~~s~~ to control the routing and flow of liquid to the sluice nozzles and to control water additions to the waste retrieval process. The valve boxes provide~~s~~ secondary containment and the collection/detection of any leakage in a sump. The portable valve boxes have~~s a~~ leak detectors that ~~is~~are connected to the pump shutdown system in the control trailer. In the event that a leak is detected in the portable valve boxes, the transfer pumps in the SST being retrieved and in the receiver DST would be shut down. The portable valve boxes each ha~~s~~ve a sump and a sump pump that can be configured to transfer any leakage to the SST being retrieved.

Two portable diversion boxes will be added to the C-Farm retrieval system, both will be used for the tanks in this work plan. The transfer lines to and from up to three tanks will be routed through a valving arrangement in each box to permit switching retrieval operations between the tanks. The diversion boxes provide secondary containment and the collection/detection of any leakage in a sump. The diversion boxes each have a leak detector that is connected to the pump shutdown system in the control trailer. In the event that a leak is detected in a diversion box, the transfer pumps in the SST being retrieved and in the receiver DST would be shut down. The

Figure 3-4. Tank C-107, C-108, and C-112 Waste Retrieval System In-Tank Components.



3.1.2 Double-Shell Receiver Tanks

The supernate pump and slurry distributor installed in DST AN-106 in support of tank C-103 waste retrieval (RPP-21895) may continue to be used to pump supernate back to the C farm and distribute the sludge as received from ~~tanks C-107, C-108, and C-112~~ the SST. The pump ~~installed~~ in DST AN-101 ~~under Project W-211 may be~~will also be used to pump supernate in support of C farm retrieval. A new slurry distributor will be installed in DST AN-101 to distribute the sludge received from C farm tanks. A new supernate pump and a new slurry distributor are planned for DST AY-101 to support waste retrieval from C farm tanks.

Because the elevation of the AN farm is approximately 22 ft higher than the C farm and the elevation of the AY tank farm is approximately 32 ft higher than the C farm, the slurry distributor and the supernate pump incorporate anti-siphon devices to prevent unintentional flow from the DST to the SST. All waste transfers, including transfer of waste from the C farm tanks to the DSTs and the transfer of supernate from DSTs back to C farm tanks, will be performed using transfer lines that provide secondary containment. The waste retrieval project currently plans to use overground hose-in-hose transfer lines (HIHTLs) and the *Resource Conservation and Recovery Act of 1976* (RCRA)-compliant DST transfer system.

~~Assuming a 2,700-gal. liquid heel in a tank with no solids present before rinsing (solids are expected), rinsing with 33,333 gal. of fresh water, pumping down to 2,700 gal. and repeating twice more, the concentration of soluble constituents in the final 2,700 gal. in the tank would be approximately 5 × 10^{-4} of the original heel concentrations. If the pump heel is below 2,700 gal. or there are solids present in the heel, the dilution would be more. Performing the final tank flushes will remove residual solids to the extent practical on the walls and dilute soluble radionuclides and chemicals in the liquid in the tank.~~

The final flush volume will be dependent upon the final heel composition and volume. As a minimum, there will be three flushes with a minimum flush volume of three times the volume of the estimated waste heel volume.

~~The 'limit of technology' related to waste removal from a tank is predominantly concerned with solids removal; liquids can continue to be removed from the tank as long as the pump suction is submerged and not plugged by any solids or foreign material in the tank. The 'limit of technology' occurs when the point is reached that the quantity of waste removed per unit volume or per batch by the selected retrieval method has become so low as to no longer be effective on a meaningful scale. A final tank flush would not be expected to remove many insoluble solids, but it will proportionately dilute and remove any liquid heel. The 'technology' involved with liquid heel removal is dilution and pumping. As explained, a 2,700-gal. supernate heel subjected to three 30,000- to 35,000-gal. flushes will be diluted to a concentration of about 0.0005 of the initial starting concentration. This is a 99.95% removal. Should the 2,700 gal. contain more solids (and less liquid), the supernate dilution will be even greater. There is no 'limit of technology' wherein no more liquid is removed with dilution; the more dilution performed the more residual contaminated liquid that is removed. The question is one of benefit; when is the quantity of liquid removed per unit volume by a flush no longer of any significant meaning? RPP-21753 estimates the final technetium-99 concentrations in the tanks AY-101, AN-101, and AN-106 supernate solutions following completion of C tank farm waste retrieval to be in the nominal range of 2 × 10^{-5} to 2 × 10^{-4} Ci/L (2 × 10^{-2} to 2 × 10^{-1} µCi/mL). A 2,700-gal. supernate initial heel in one of the SSTs would thus be reduced to an estimated technetium-99 concentration range of 1 × 10^{-5} to 1 × 10^{-4} µCi/mL following three successive 30,000- to 35,000-gal. flushes. The technetium-99 concentrations in the tanks C-102, C-104, C-107, C-108, and C-112 wastes are estimated to be in the 7 × 10^{-4} to 2 × 10^{-1} µCi/mL range before retrieval. Thus, any heel flushing is expected to reduce the technetium-99 concentration in the liquid heel to below the average tank technetium-99 concentration before retrieval, and three 30,000- to 35,000-gal. flushes are expected to remove about 99.95% or more of the soluble constituents.~~

The timing for transfers out of tanks C-102, C-104, C-107, C-108, and C-112 is dependent upon personnel resource availability, equipment availability, and DST conditions. Once waste retrieval is started, it should follow the general pattern described, but no liquid additions or removals to/from these tanks can be predicted for more than a day or two in advance; therefore, no detailed timeline can be developed showing all liquid additions and removals. The water or supernate addition/removal may be intermittent or continuous. Based upon experience with tanks S-112 and C-203 waste retrieval, it will likely last 8 to 16 hours, then be followed by at least a few days wait, then continue. Work continuity will be dependent upon resource availability and external influences. Ideally the retrievals could be completed within a few

3.9 DISPOSITION OF WASTE RETRIEVAL SYSTEM FOLLOWING WASTE RETRIEVAL

3.9.1 Disposition of New Waste Retrieval System Components

Following completion of waste retrieval, the in-tank equipment will be left in place for disposition during component closure actions. The abovegrade equipment (e.g., transfer lines, portable valve and diversion boxes) will be reused to the extent possible for future waste retrieval activities in the C tank farm. Transfer lines and the portable valve and diversion boxes will be flushed to reach acceptable exposure rates for disconnecting and relocating the equipment. Any abovegrade equipment that needs to be removed and is not suitable for reuse will be packaged and disposed of onsite in accordance with the approved waste acceptance criteria for the Hanford Site burial grounds and TFC-OPS-WM-C-10, *Contaminated Equipment Management Practices*. The HIHTLs will be managed in accordance with RPP-12711, *Temporary Waste Transfer Line Management Program Plan.*

3.9.2 Disposition of Existing Ancillary Equipment

Ancillary equipment associated with tanks C-102, C-104, C-107, C-108, and C-112 is limited to waste transfer lines and equipment installed in pits and abovegrade risers. The current status of the ancillary equipment associated with tanks C-102, C-104, C-107, C-108, and C-112 is described in Section 2.6. Any contaminated equipment located within risers that needs to be removed following waste retrieval will be packaged and disposed of onsite in accordance with the approved waste acceptance criteria for the Hanford Site burial grounds and TFC-OPS-WM-C-10.

In accordance with the SST system closure plan (RPP-13774), disposition of the ex-tank ancillary equipment, including pipelines, will be performed in accordance with a separate component closure activity plan. Closure plans will be incorporated into the SST permit.

3.10 AIR MONITORING PLAN

ORP and ~~CH2M HILL~~the TOC, pursuant to federal requirements for protection of their workers, will develop and implement IH monitoring plans for exhauster stack emissions for the retrieval of tanks C-102, C-104, C-107, C-108, and C-112. The plans will be developed and implemented pursuant to the requirements of TFC-PLN-43, *Tank Farm Contractor Health And Safety Plan.* The constituents of potential concern (COPCs) for which exhauster stack sampling and analysis will be conducted will be identified in the IH monitoring plans for each tank retrieval.
The COPCs identified in the IH monitoring plans will be all or a subset, as determined to be appropriate by ~~CH2M HILL~~ the TOC IH, of those constituents listed in RPP-20949, *Data Quality Objectives For The Evaluation Of Tank Chemical Emissions For Industrial Hygiene Technical Basis*, Table 4-1, developed with input from Ecology. Once the initial subset of

COPCs is identified and listed in the IH monitoring plans, no COPC shall be dropped from that list without 90 days prior notification to and approval from Ecology. If ORP notifies Ecology of its desire to cease exhauster stack sampling for a COPC initially identified and listed in an IH monitoring plan and no response is received from Ecology within 90 days, the COPC will be deleted from the IH monitoring plan and sample and analysis activities for that COPC will cease. New COPCs may be added to an IH monitoring plan without notification to or approval from Ecology and without modifying or revising this tank waste retrieval work plan.

The sampling and analysis methods shall be EPA, National Institute for Occupational Safety and Health-approved, or Occupational Safety and Health Administration (OSHA)-approved methods or an equivalent ~~CH2M HILL~~TOC-approved method, as identified in RPP-20949. The exhauster stack samples will be analyzed at the 222-S Laboratory, the Waste Sampling and Characterization Facility, or an equivalent laboratory consistent with the quality assurance/quality control procedures for that laboratory. Further, laboratory analysis data will be kept on file at the laboratory consistent with the laboratory record keeping procedures for that laboratory for a period of not less than 5 years and will be available to Ecology, within 24 hours, upon request.

Ecology and ORP understand and agree that the activities discussed above do not restrict ORP and ~~CH2M HILL~~ the TOC from taking any and/or all steps necessary as ORP and ~~CH2M HILL~~the TOC deem appropriate to protect its workforce in response to data and information generated by an IH monitoring plan or incidents as they might arise during waste retrieval. Ecology and ORP also understand and agree that the preceding sampling and analysis discussion is presented to ensure ORP is achieving the agreed to sampling and analysis for the protection of the public and its workers and does not modify the exemption from the requirements of 40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities," and 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities," Subpart CC, granted to ORP under 40 CFR 265.1080(b)(6). Therefore, this discussion does not imply any change to the respective authority of either Ecology or ORP regarding the sampling, analysis, monitoring, and control of airborne emissions from Hanford Site tanks.

5.0 REGULATORY REQUIREMENTS IN SUPPORT OF RETRIEVAL OPERATIONS

Retrieval of waste from the SSTs will be performed under the requirements of HFFACO, *Atomic Energy Act of 1954*, RCRA, Chapter 70.105 RCW and its implementing regulations, and WAC-173-303. The SSTs do not provide secondary containment and are not compliant with RCRA and Chapter 70.105 RCW interim facility standards of Subpart J of 40 CFR 265. The SSTs are currently authorized to continue operations under Chapter 70.105 RCW pending closure in accordance with WAC 173-303-610, "Closure and Post-Closure," under the authority of the HFFACO Milestone M-45-00, "Complete Closure of all Single Shell Tanks Farms." Except as otherwise modified by HFFACO Milestone M-45-00, DOE conducts day-to-day operations of the SSTs in accordance with the interim facility standards established in WAC-173-303-400(3), "Interim Status Facility Standards." WAC 173-303-400(3) incorporates by reference the interim status performance standards set forth by the EPA in 40 CFR 265. Additionally, the SSTs are governed by federal regulations promulgated under the authority of the *Atomic Energy Act of 1954* and various DOE directives incorporated into the contract between ORP and ~~CH2M HILL~~ the TOC (DE-AC27-99RL-14047). These requirements are implemented through operating plans and procedures by the Tank Farm Contractor.

Interim status facility standards in WAC 173-303-400(3)(a) incorporate, by reference, the interim status standards set forth by EPA in 40 CFR 265 Subpart J for tank systems. Elements of the interim status standards relevant to the WRS along with the WRS features and/or operating plans and procedures are summarized in Table 5-1.

If necessary, DOE will seek approval to retrieve waste that could contain polychlorinated biphenyls from tanks C-102, C-104, C-107, C-108, and C-112 using supernate from the receiver DST and transfer the resulting slurry to the respective receiver DST from EPA before initiating waste retrieval operations. DST supernate is classified as polychlorinated biphenyl remediation waste in accordance with Ecology et al. (2000), *Framework Agreement for Management of Polychlorinated Biphenyls (PCBs) in Hanford Tank Waste*. Because the DST supernate is polychlorinated biphenyl remediation waste, the retrieval of waste from SSTs, when using DST supernate, requires a Risk-Based Disposal Approval, approved by EPA, pursuant to the *Toxic Substances Control Act of 1976*.

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval. (9 Sheets)

Regulation	Requirement	Compliance Method
	appropriate, at least bimonthly (c) The owner or operator must document in the operating record of the facility an inspection of those items *(above)*	
265.196 [WAC 173-303-400 (3)(c)(vii)], Response to leaks or spills and disposition of leaking or unfit-for-use tank systems	A tank system or secondary containment system from which there has been a leak or spill, or which is unfit for use, must be removed from service immediately, and the owner or operator must satisfy the following requirements; (a) Cessation of use; prevent flow or addition of wastes (b) Removal of waste from tank system or secondary containment system (c) Containment of visible releases to the environment (d) Notifications, reports	Response to leak or spills is defined in Section 4.0
WAC 173-303-283 (3), Performance standards	The owner/operator must design, construct, operate, or maintain a dangerous waste facility that to the maximum extent practical given the limits of technology prevents: (a) Degradation of ground water quality; (b) Degradation of air quality by open burning or other activities; (c) Degradation of surface water quality; (d) Destruction or impairment of flora and fauna outside the active portion of the facility; (e) Excessive noise (f) Conditions that constitute a negative aesthetic impact for the public using rights of ways, or public lands, or for landowners of adjacent properties; (g) Unstable hillsides or soils as a result of trenches, impoundments, excavations, etc.; (h) The use of processes that do not treat, detoxify, recycle, reclaim, and recover waste material to the extent economically feasible; and (i) Endangerment of the health of employees, or the public near the facility.	The following plans and procedures and their implementation provide the preventative measures required: (a) Groundwater monitoring plan (PNNL-13024). (b) No open burning is allowed. (c) Berms and gutters are in place to prevent surface runoff and surface run-on. (d) No destruction or impairment of flora and fauna occur outside of the tank farms. (e) Noise is monitored per ~~CH2M HILL~~ TOC procedures. (f) The tank farms are within the dangerous waste facility (i.e., Hanford site). (g) Appropriate permits are obtained before excavation work is started. No excavation work is associated with tank waste retrieval. (h) The waste retrieval process is designed, constructed and will be operated to treat

Table 5-1. 40 CFR 265 (WAC 173-303-400) Interim Status Standards Applicable to Waste Retrieval. (9 Sheets)

Regulation	Requirement	Compliance Method
		and recover waste to the limits of technology in accordance with HFFACO milestone M-45-00 (see Section 3.4). (i) The public is protected by the NOC per WAC 173-303-400 & 460. Workers are protected per TFC-PLN-43.
WAC 173-303-400, Interim Status Facility Standards	Incorporates by reference 40 CFR 265 with the exception of 265.1 (c)(4), 265.149-150 and 265.430. Replaces federal terms in 40 CFR 265 (i.e., regional administrator, hazardous) with state terms (i.e., department, dangerous)	

Note: Documents references information is provided in Section 9.0 of this document.

~~CH2M HILL = CH2M HILL Hanford Group, Inc.~~
DST = double-shell tank.
HFFACO = *Hanford Federal Facility Agreement and Consent Order.*
HIHTL = hose-in-hose transfer line.
IQRPE = independent, qualified, registered professional engineer.
ITEM = Integrated Training Electronic Matrix.
NOC = notice of construction.
SST = single-shell tank.
TOC = tank operations contractor
TSD = treatment, storage, and/or disposal.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

<table>
<tr><td colspan="3">1. Document Title and Number: RPP-22393, Rev. 4B, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tanks Waste Retrieval Work Plan</td></tr>
<tr><td rowspan="2">2. Minor Field Change:
(Section 12.4 HFFACO Action Plan)
□ Yes: (WRPS Signature Only – Attach signed form to Primary Document for record purposes)

x No: Proceed to Box 3</td><td>3. Document Issue Date:

9/25/09</td><td rowspan="2">5. Notice Number: 2010-4</td></tr>
<tr><td>4. Document Modification Notice Date: 4/28/10</td></tr>
<tr><td>6.
Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?)

□ Yes x No</td><td>7.
Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan?

□ Yes x No</td><td>8. (Check only one box)
□ Significant Modification
(Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.)
Minor Modification
x Requires modification of the document
x Can be accomplished with Modification Notice.</td></tr>
<tr><td colspan="3">9. Description and Justification of Change:

Change Description: A change is needed to add a description of the Mobile Arm Retrieval System (MARS) equipment that will be used for retrieval in C-107 instead of modified sluicing, and related changes. Modified sluicing wording is kept in the TWRWP in case it becomes necessary to use modified sluicing instead of the MARS. The changes covered by this modification notice are shown in redline/strikeout on the attached redline/strikeout pgs. 1-1, 2-1, 2-3, 2-20, 2-29, 3-1 through 3-5, 3-7, 3-9 through 3-11, 3-13, 3-18, 3-19, 3-22, 3-24, 6-1, C-2 through C-6, and C-9.

Note 1: Section 3.1.1 currently refers to the NOCs previously approved for use during retrieval. If revised NOCs are approved for use during C-107 (or other tank) retrievals, a separate modification notice will be provided to indicate any changed reference number.

Note 2: Wording changes are provided in Appendix C to make it consistent with the wording changes in Appendix B approved by Ecology in 2009. The estimated retrieval leak concentrations provided in Table C-1 are not changed as the stated concentrations are estimated at this time to still be bounding. If the concentrations in Table C-1 will not be bounding prior to C-107 retrieval a separate modification notice will be provided to update Appendix C accordingly.

Justification: The changes are needed as the MARS is a different method of retrieval from that currently described in the document for C-107.</td></tr>
<tr><td colspan="3">10. Impact of Change:

No impact.</td></tr>
</table>

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

11. Additional Requirements and/or Provisions[1]: see Ecology letter, Nov. 5, 2010: Update TWRWP to include changes indicated in your comment responses 11-5-2010		
Approvals		
Washington River Protection Solutions, LLC.	Office of River Protection	State of Wash., Dept. of Ecology
☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date
☑ Final Approval Date 8/16/10	☑ Final Approval Date 8-27-10	☐ Final Approval Date 11-5-10

Notes

1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision

2 – Provisional approval allows DOE and its contractors to take specific actions identified in section 11, prior to final approval of this modification.

The pages attached to Change Notice 2010-4 are omitted here for the sake of brevity. The pages attached to Change Notice 2010-4 when submitted to Ecology for approval have been incorporated into the main body of RPP-22393, with the following 9 additional changes:

- Per Comment 6, a new Section 3.1.1.1 has been added at the request of Ecology to describe the new riser installation in C-107
- Per Comment 8, revised dates in Section 2.1
- Per Comment 12, added words to Section 3.1.1 at the request of Ecology to describe MARS pressure sensor
- Per Comment 14, added words to Section 3.1.1 at the request of Ecology to mention MARS performance specification
- Per Comment 27, added words to Section 3.1.1.1 at the request of Ecology to describe riser backfill requirements reference
- Per Comment 30, added words on IQRPE evaluations to Sections 3.1.1.1 and 3.8 at the request of Ecology.
- Per Comment 61, added words on process hazards analysis to Section 3.1.1.1 at the request of Ecology
- Per Comment 62, added more words on cutting of hole for riser to Section 3.1.1.1 at the request of Ecology
- Several minor editorial revisions to Table 3-1 and Sections 3.1.1, 3.1.1.1, 3.3, and updating of references.

The original pages of Modification Notice 2010-4 sent to Ecology are on file with the environmental group of the tank farm contractor, and with Ecology.

The table on pages G-81 through G-122 documents the Ecology comments on Change Notice 2010-4 and the responses to these comments. This table is included in Appendix G at the request of Ecology. In order to maintain consistent pagination for Appendix G while not altering anything in the table transmitted by Ecology on November 5, 2010 the 'Page 1 of 42, Page 2 of 42, etc. page numbers in the transmitted table are kept, and made equal to Appendix G pgs. G-81 through G-122, as noted on the table footer.

Enclosure 1
Ecology Comments and United States Department of Energy-Office of River Protection Response
on RPP-22393 Change Notice 2010-4

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
1	A	In relationship to permit decisions on the WTP and holds Ecology had on vessel installation due to unresolved erosion issues, Ecology agreed to release the hold on the vessels in part based on using the new WTP Design Wear Rates curve used in 24590-WTP-MOC-50-00004 Rev E for all design questions issues and questions. It is not acceptable to Ecology or within permit space to use any other equations on the issues of wear allowance to WTP vessels.	The Ecology approved WTP Design Wear Rate curve and the Ecology approved design wear allowance equation in 24590-WTP-M0C-50-00004 Rev E are used in 24590-WTP-RPT-PET-10-019 Rev 0 to estimate the impact of adding garnet to the waste from cutting 22 nominal 55 inch diameter holes into SSTs to the predicted WTP wear allowance for vessels. 24590-WTP-RPT-PET-10-019 Rev 0 provides two separate erosion calculations. The impact to the WTP Design Wear allowance of adding garnet to the waste from cutting 22 holes is addressed in Appendix H. The main body of 24590-WTP-RPT-PET-10-019 Rev 0 discusses the impact of garnet on the predicted average wear rate, not the design wear allowance. If Ecology wants only the design wear allowance impact then the main body of 24590-WTP-RPT-PET-10-019 Rev 0 should be ignored and only Appendix H reviewed. These will be discussed separately below. **Design Wear Impact** The Design Wear Rate for the WTP is based upon the extremely conservative assumption that all the tank waste is silica sand. The WTP Design Wear Rates curve is shown in 24590-WTP-M0C-50-00004 Rev E, Figure 10.8-A on sheet 68. The WTP Design Wear Rate curve is the solid upper line. The equation upon which this solid upper line is based is Equation 7.2.4.6 on sheet 30. Equation 7.2.4.6 on sheet 30 is: $E = (31\ \text{mpy}) \times (V/8\ \text{m/s})^{3.46} \times (C/25\ \text{wt\%})^{0.5}$ This formula is based upon Equation 7.2.4.1. Equation 7.2.4.1 is given on sheet 28 as: $E = A \times (V)^n \times (d)^p \times (C)^q$ where: E = erosion rate A = constant	Closed 10/27/10, with the stipulation that the response is applicable for no more than three 55 inch nominal diameter holes being cut into SSTs. The comment at left is based upon the assumption of 22 holes being cut.

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
			V = velocity of particle against surface being eroded d = weighted mean particle diameter C = concentration of slurry in wt fraction n = velocity exponent p = particle diameter exponent q = solids content exponent Appendix H of 24590-WTP-RPT-PET-10-019 Rev 0 estimates the impact to the WTP design wear allowance from cutting 22 holes as less than or equal to a 3.7% increase, i.e., the garnet from 22 holes will increase the total wear by less than or equal to a factor of 1.037. This value is conservative and is calculated using factors from Equation 7.2.4.1 to revise the Equation 7.2.4.6 results as follows: Let X = the erosion rate in mils per year from Equation 7.2.4.6. Let X_g = the erosion rate in mils per year from Equation 7.2.4.6 with garnet in the waste Mass of garnet added to waste from cutting 22 holes = 27, 941 kg Mass of waste = 26,700,000 kg The increase in erosion rate between the design rate curve with garnet in the waste and the design rate curve without garnet is: $X_g/X = (A_g/A) \times (Vg/V)^n \times (d_g/d)^p \times (C_g/C)^q$ The velocity V and concentration C of the transferred solutions will be the same in the WTP regardless of the garnet content of the waste so this equation reduces to: $X_g/X = (A_g/A) \times (d_g/d)^p$ The 7.2.4.6 design rate curve formula is based upon an average particle diameter d of 24 µm, with the 24 µm being a round up from 23.9 µm. To calculate the average particle diameter of the waste with garnet added, assuming a garnet particle diameter of 400 µm:	

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
			wt. fraction garnet in waste = 27,941 kg ÷ (27,941 + 26,700,000) kg = 0.00105 d_g = 23.9 × (1 - 0.00105) + 400 × (0.00105) = 24.3 µm Assuming a garnet particle diameter of 700 µm: d_g = 23.9 × (1 – 0.00105) + 700 × (0.00105)= 24.6 µm From Section 7.2.4.2 on sheet 28 in 24590-WTP-M0C-50-00004 Rev E a value of 1.355 is used for the exponent p when the weighted particle size is less than 100 µm. Therefore, the increase in the design wear rate due solely to the change in weighted particle size when garnet from 22 hole cuts is added to the waste is: $(d_g/d)^p = (24.3/24)^{1.355}$ = 1.017 for a 400 µm garnet particle diameter $(d_g/d)^p = (24.6/24)^{1.355}$ = 1.034 for a 700 µm garnet particle diameter A value of 24 µm is used here for the average waste particle diameter instead of 23.9 µm because Equation 7.2.4.6 is based upon a 24 µm average waste particle diameter. The assumption of a 400 to 700 µm particle size is very conservative. Figure 3 in RPP-RPT-47353 compares pre- and post-cut garnet particle size. Approximately 90% of the pre-cut particle size is between 400 and 700 µm, while greater than 90% of the post-cut particle size is less than 200 µm. The smaller the particle size the smaller the erosion impact of the particle, so assuming the garnet doesn't reduce in size during the cutting is very conservative. The wear on equipment is dependent upon the sharpness of the particles, with garnet particles sharper than the rounded silica sand upon which Equation 7.2.4.6 is based. In 24590-WTP-M0C-50-00004 Rev E a factor of 0.55 (see Section 6.7.10 on sheet 23) is applied to account for the roundness of silica sand. This value is part of the constant A in Equation 7.2.4.1. Therefore, the impact to the design wear rate from garnet in the waste is: A_g/A to account for particle sharpness = ((27,941 ÷ 0.55) + 26,700,000) ÷ (27,941 + 26,700,000) = 1.0009	

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
			The wear on equipment is also dependent upon the hardness of the particles, with garnet particles harder than the rounded silica sand upon which Equation 7.2.4.6 is based. In 24590-WTP-M0C-50-00004 Rev E a factor of 0.60 (see Section 6.7.9 on sheet 23) is applied to account for a change in hardness of alumina vs. that of silica sand. This value is also part of the constant A in Equation 7.2.4.1. Therefore, conservatively equating the hardness of garnet with that of alumina, the impact to the design wear rate from garnet in the waste is: A_g/A to account for particle hardness = ((27,941 ÷ 0.60) + 26,700,000) ÷ (27,941 + 26,700,000) = 1.0007 Thus the change in the design wear rate curve in Figure 10.8-A using Equation 7.2.4.6, assuming garnet from 22 hole cuts is added to the waste is: $X_g/X = (A_g/A) \times (d_g/d)^p = 1.0009 \times 1.0007 \times 1.017 = 1.0186$ for a 400 μm garnet particle size, and $X_g/X = (A_g/A) \times (d_g/d)^p = 1.0009 \times 1.0007 \times 1.034 = 1.0357$ for a 700 μm garnet particle size These factors conservatively show the change in the design wear rate in mils per year with the garnet from 22 hole cuts added to the waste. The total wear is equal to the wear rate times the duration of operation of the WTP. With garnet added to the waste the duration increase is: WTP duration increase due to garnet = (27,941 + 26,700,000) ÷ 26,700,000 = 1.001 Therefore, the impact on WTP wear due to garnet in the waste from 22 hole cuts is the increase in wear rate times the increase in duration: $X_g/X = 1.0186 \times 1.001 = 1.0196 = 1.02$ for a 400 μm garnet particle size, and $X_g/X = 1.0357 \times 1.001 = 1.0367 = 1.037$ for a 700 μm garnet particle size Thus the increase is (1.02 – 1.0) × 100 = 2% for a 400 μm garnet particle size and (1.037 – 1.0) × 100 = 3.7% for a 700 μm garnet particle size. These values	

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
			are very conservative. The impact to the calculated WTP wear allowance of cutting one hole in C-107 is less than 1/22 times a 3.7% increase. This is because the calculated particle diameter is proportional to the mass of garnet added, but the ratio of $(d_g/d)^p$ is proportional to the 1.355 power. Simplifying the impact to 3.7% ÷ 22 = 0.17%, for a 700 μm particle size for a hole cut in one tank is thus conservative. Table 1 in RPP-RPT-47353 shows the post-cut particle size distribution for garnet ranges from 0.5 μm (0.5 wt%) to 425 μm (0.3 wt%) with the 50 wt% size about 75 μm. Assuming a 100 μm post-cut garnet size instead of 400 μm to 700 μm the impact on the WTP wear due to 22 hole cuts is negligible. **Average Wear Rate Impact** The average WTP wear rate curve is expected to conservatively indicate what actual erosion may be. Figure 10.8-A in 24590-WTP-M0C-50-00004 Rev E shows 4 lines, the WTP Design Wear Rate, DIE Predicted Maximum Wear Rate, FanAiming Wear Rate, and DIE Predicted Average Wear Rate. 24590-WTP-RPT-PET-10-019 Rev 0 summarizes and explains the calculations in 24590-WTP-M4C-V37T-00007 which estimate the impact to the predicted average WTP wear rate, the bottom line in Figure 10.8-A. Per sheet 36 in 24590-WTP-M0C-50-00004 Rev E, the DIE Predicted Average Wear Rate is calculated using Equation 7.2.5.1 with a waste slurry concentration of 24.58 wt% and a 33 μm average particle size. Equation 7.2.5.1 is used to represent the compilation of test data. Repeating Equation 7.2.5.1 here: $E_{DEI} = (18.42 \text{ mpy}) \times (V/13 \text{ m/s})^{3.90} \times (d \text{ μm}/24 \text{ μm})^{2.34} \times (C \text{ wt\%}/25 \text{ wt\%})^{0.36}$ Equation 7.2.5.1 is based upon the same Equation 7.2.4.1 as Design Wear Rate Equation 7.2.4.6, with different variables used to differentiate between the predicted wear rate and the design wear rate. Calc note 24590-WTP-M4C-V37T-00007 estimates the change in the Predicted	

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
			Average Wear Rate by two different methods. Method 1 In Section 7.1 in 24590-WTP-M4C-V37T-00007 provides the calculations or information to show: • There are 704,706 kg of Si in the Hanford waste tanks • The fraction of this Si that is in the form of SiO_2 is 0.115 • The inventory of Si that is in the form of SiO_2 is 81,041 kg • This calculates a waste inventory of SiO_2 of 173,300 kg • The estimated quantity of garnet added to the waste from cutting 22 large diameter holes into SSTs is 27,941 kg • The garnet used to cut the hole is 7.14 times as abrasive as silica sand • Garnet added to the waste would cause additional WTP erosion estimated to be equal to that from 7.14 × 27,941 kg = 199,499 kg silica sand • The conservative assumption is made (conservatism is explained below) that all erosion in the waste is caused by SiO_2, nothing else • The erosion caused by the existing sand plus the added garnet is therefore = (173,300 + 199,499) ÷ 173,300 = 2.15 times the erosion caused by existing sand alone • Therefore, cutting 22 holes will conservatively result in erosion that is 2.15 times more than the currently estimated average wear, or a (2.15 – 1.0) × 100 = 115% increase. The assumption that all the erosion from the waste is caused by sand is conservative because this assumption will maximize the calculated erosion from garnet. This is best shown by example. • Assume the erosion caused by all the waste, without garnet, will result in a wear depth of 100 'units'. The value of a 'unit' does not need to be quantified for this example. • Then, if the quantity of erosion caused by sand in the waste is X units, the erosion caused by everything else, including all other silicon compounds or other non silica constituents is equal to 100 – X units.	

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			• The added erosion caused by the addition of garnet is equivalent 1.15X units • The total erosion caused by the waste with garnet is equal to that caused by silica sand, garnet, and all remaining non-silica sand constituents, i.e., erosion with garnet = X + 1.15X + (100 – X) = 100 + 1.15X • The erosion impact of garnet is thus maximized when the value of X is maximum. X is the erosion caused by silica sand and is thus at a maximum when X = 100 units, i.e., when all other constituents are assumed to not contribute to the erosion A different way of looking at this would be to assume silica sand only contributes 10% to the WTP erosion. If this were the case the total erosion with garnet would be = 10 + 11.5 + (100 - 10) = 115 units. If silica sand contributed 50% to the WTP erosion the total erosion with garnet would be = 50 + 57.5 + (100 - 50) = 157.5 units. Therefore it can be seen that the predicted erosion with garnet is maximized by assuming all the erosion in the WTP caused by waste is due solely to silica sand. This method of estimation is <u>not applicable to the Design Wear Rate for the WTP because the design wear rate is based upon all the waste being silica sand, not 173,300 kg. If the same methodology used in Method 1 was applied to the design wear rate the multiplication factor wouldn't be 2.15 it would be 1.0075 based upon:</u> **(26,700,000 kg sand + 199,499 kg sand equivalent) ÷ 26,700,000 kg sand = 1.0075** **increase = (1.0075 – 1.0) × 100 = 0.75%** Method 2 estimates how much garnet equivalent may have been in an earlier simulant tested that contained *Pyrofrac* and which resulted in excessive wear during the testing. Method 2 calculated that the WTP predicted wear rate should be multiplied by a factor of 3.05, or a (3.05 – 1.0) × 100 = 205%	

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			increase. Therefore, 24590-WTP-RPT-PET-10-019 Rev 0 and 24590-WTP-M4C-V37T-00007 conservatively calculate the predicted wear rate with garnet will be a factor of 2.15 to 3.05 times the predicted wear rate without garnet, if the garnet from cutting holes in 22 tanks is added to the WTP feed. As can be seen from Figure 10.8-A, even if the bottom line is increased by a factor of 3.05 it would still be below the solid Design Wear Rate curve. Summary 24590-WTP-RPT-PET-10-019 Rev 0 conservatively predicts the WTP Design Wear should be multiplied by a factor of 1.037 (a 3.7% increase) should the garnet from 22 tank cuts be added to the waste. This is based upon the Ecology agreed to design wear rate curve and the Ecology agreed to design wear rate equation in 24590-WTP-M0C-50-00004 Rev E. The impact of a single cut in C-107 is estimated for this comment response at less than 0.17%. The 1.037 factor is conservative as it is based upon a 700 µm particle diameter for garnet rather than a more likely 75 µm average post-cut particle diameter. 24590-WTP-RPT-PET-10-019 Rev 0 also shows that even when conservatively estimating the impact of garnet on the WTP predicted wear rate, the predicted wear rate will not exceed the Design Wear Rate curve.	
2	B	To minimize uncertainty in theoretical extrapolations, Ecology recommends that 96-hour wear lab tests be done with tank waste simulant and garnet added. The particle size distribution of the garnet should be representative of what would end up inside the SSTs after attrition during dome cutting. A new Design Wear Rates curve, shown on Figure 10.8-A of #24590-WTP-M0C-50-00004 Rev E, must be developed.	This testing will take an estimated 12 months to complete when following the requisite planning and QA steps required for the previous formal wear testing. This includes preparation and issuance of a contract to perform the work, reaching agreement with all parties on a simulant composition, assembling equipment to prepare for the test, preparation of and obtaining agreement on a test procedure(s), performing the test, writing up the results, and obtaining concurrence on the test report. This testing would delay C-107 retrieval accordingly and could correspondingly impact the 2014 legal date for completion of C Farm retrieval. This testing is not warranted in light of the very small impact to the WTP, conservatively estimated at <0.17% increase in the vessel wear, from garnet added with the hole cut in C-107. Ecology has verbally stated that they are concerned the garnet addition to SST	Closed 10/19/10, Ecology agreed comment can be closed if ORP agrees with 2nd paragraph. ORP agreed per e-mail 10/19/10

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			wastes from cutting 22 holes may require physical changes to WTP equipment, and that schedules for fabrication/installation of this equipment may be impacted if garnet erosion testing data are not provided in a timely manner. No physical changes will be made to the WTP to accommodate predicted wear from garnet. Erosion testing with garnet, should it be done, will either support the current conclusion that garnet from cutting 22 holes will not have a significant impact on the WTP, or it will show that wear could be significant enough to require an alternate method be developed to cut large diameter holes in a tank.	
3	C	A demonstration has been verbally mentioned to Ecology as planned. Please provide a discussion, in the TWRWP, of any testing planned to address Ecology's concerns and comments.	The demonstration cut on the simulated concrete dome was completed on October 2, 2010. Ecology field staff are updated on testing plans as they develop. Test plans are not appropriate for inclusion in the TWRWP per Appendix I, Section 2.1.3 or letter 04-TPD-083.	Closed 10/19/10
4	T1	Various documents have mentioned different numbers of tanks that may be cut using garnet. Evaluate impacts mentioned in comments below for the total number of tanks, using maximum values such as abrasion, velocity, etc., (i.e., worst case) to provide impacts to potentially affected systems. This can be used to support all future retrievals using this system.	The TWRWP change notice requests approval for one tank. The TOC contract includes plans for three tanks. Various documents refer to 1, 3, 14, or 22 tanks to be cut with garnet. The 2010-4 TWRWP change notice, which is the subject of this Ecology review, is for installation of the MARS in only one tank, C-107, which means only one hole is to be cut within the scope of the change notice. The 24590-WTP-RPT-PET-10-019, Rev 0 calculation note that evaluates garnet impact on the WTP conservatively assumed 22 holes would be cut to bound the garnet impacts to the WTP. This number should be adequate to bound retrieval operations for the future. If the C-107 cut, and the subsequent deployment of the MARS in C-107 is successful it is planned that 2 more large diameter hole cuts would be made in C-Farm. At the end of C-Farm retrieval there would thus potentially be up to 3 tanks with large holes cut for the MARS equipment. This is where the use of garnet for 3 tanks comes from. Future ~55 inch (or similar) holes for other SSTs would not be needed for a decade or more. During this time the hole cutting method could be revised or alternate methods developed if needed, so there is a potential that garnet may	Closed 10/21/10

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			not be used for more than 3 tanks. RPP-PLAN-40145 (the SST Retrieval Plan), Rev 1, lists a total of 14 tanks (includes the 3 for C-Farm) which may need a large central riser added for the MARS. This number may be reduced when/if these 14 tanks have their leak status re-evaluated. Or, the number of tanks needing a new large central riser could increase if it is decided to use the MARS vacuum system on a tank scheduled for MRS, assuming the MRS tank leak status is not changed following any leak status review. Calc note 24590-WTP-RPT-PET-10-019, Rev 0, conservatively assumed 22 holes would be cut. Whether 1 or 3, 14, or 22 holes should be assumed is dependent upon what level of impact is desired to be evaluated. Assuming 22 holes to be cut shows the WTP fixed equipment design life is not reduced. For the purpose of review for this change notice however, the focus should just be on one hole to be cut with garnet.	
5	T2	**Note: Numbers in bold added by WRPS to segregate the individual Ecology comments.** Provide **(5-1)** the necessary information on the change in hazardous material composition so that Ecology can ascertain that the hazardous waste handling systems will continue to function correctly in containing wastes. i. Document that this added cutting medium (water and garnet) to C-107 will not impact **(5-2)** the DST system, **(5-3)** 242-A Evaporator **(5-4)** and/or processing/treatment at WTP. ii. Discuss technical basis for determining no impacts to these	**(5-1)** Adding the garnet and water to C-107 will result in no change to the hazardous material composition of the waste. Waste Technical Services has evaluated Barton Mines Garnet Abrasive Grains and Powders (MSDS #055485) according to the procedure in WAC 173-303-070, Designation of Dangerous Waste, and determined that garnet will not be regulated as a Dangerous or Extremely Hazardous Waste (for garnet not mixed with tank waste). The garnet content of the C-107 waste after the hole is cut in the tank dome, assuming 2,800 lbs is added, is estimated to be 0.03 vol % (0.0003 vol fraction). **(5-2)** Adding a nominal 4,200 gal of water and 2,800 lbs of garnet to the estimated 247,000 gal of waste in C-107 will not adversely impact the DST system as discussed below (5-5). **(5-3)** Adding a nominal 4,200 gal of water and a maximum of 2,800 lbs of garnet to the estimated 247,000 gal of waste in C-107 will not adversely impact the 242-A evaporator as discussed below (5-6). **(5-4)** Addressed elsewhere in other comments in this document. See (5-7). **(5-5)** The DST system is assumed here to mean DSTs, DST pumps, installed RCRA compliant steel transfer lines, diversion boxes, pump pits and jumpers.	All ten **5-x** comments closed 10/27/10, with the stipulation that the response is applicable for no more than three 55 inch nominal diameter holes being cut into SSTs. The comment at left is based upon the assumption of 22 holes being

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		(5-5) **(5-6)** **(5-7)** systems including their associated piping, pumps, filters, valves, iii. Discuss the potential effects on the **(5-8)** SST systems including **(5-9)** the MARS and **(5-10)** its ancillary equipment.	The water and garnet will drop into C-107. The 2,800 lbs of garnet will add approximately 80 gal of garnet based upon particle density or a nominal 100-150 gal based upon bulk density (includes air around the particles) to the tank. The water will mix with the waste and be pumped out along with the sludge slurry. The garnet will fall to the top of the waste and get mixed in as the waste is slurried out, but may not all mix intimately with the sludge during retrieval. Any garnet not removed with the waste sludge by the replaceable in-tank pump will remain in the tank in the residual heel. Once the sludge with the garnet is added to a DST it will be further diluted by the DST sludge in the receiver tank. Pumping waste with the concentration of garnet given in the response to Comment #5 (1) throughout the DST system at the nominal 150-200 psi pressures and nominal 100 gpm flow rates (~10.2 ft/sec in a 2 inch line) will have negligible impact to the DST system as this concentration is too low to have any measurable effect. See Comment #(6 -1) to compare these concentrations, pressures and velocities with those used for cutting the concrete. This statement is based upon Operational experience and Engineering judgment. See response to Comment #2 (Ecology Comment B.) concerning future testing of simulated waste slurries containing low levels of garnet. **(5-6)** The evaporator feed is supernate, not a supernate-sludge slurry. The C-107 supernate-sludge waste slurry is pumped to the receiver DST where the sludge will settle to the tank bottom. The sludge in the DST will eventually be slurried out a number of years in the future to another DST where it will either settle out again or be suspended for transfer to the WTP. Feed to the evaporator consists of supernate which is decanted from settled solids in a DST (i.e., the solids remain behind) to the 102-AW evaporator feed tank. Any sludge/garnet particles that may be so tiny that they do not settle out of the supernate (i.e., they remain suspended) would have a very small mass and thus possess negligible kinetic energy when transferred through evaporator equipment. Coupling this with the very low garnet concentration in the sludge prior to settling, the negligible concentration of sludge in the supernate after settling and there will be no noticeable impact to 242-A systems by the garnet. **(5-7)** See response to Comments #31, 32, and 36 (Ecology Comments W1, W2,	cut.

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			and W6) for basis for negligible impact to WTP. **(5-8)** The comment asks for a discussion of 'potential effects' on the SST system. The SST system involved with C-107 retrieval is C-107 itself, its slurry pump, the exhauster used during retrieval, and the retrieval equipment associated with C-107 operation. There are no impacts to any of this equipment. The garnet and water used for cutting will fall into the tank. The water will mix with the waste and be pumped out along with the sludge slurry. The garnet will fall on top of the waste and get mixed in as the waste is slurried out. Any garnet not removed with the waste sludge by the replaceable in-tank pump will remain in the tank in the residual heel. Slurrying waste sludge with the low concentrations of garnet given in the response to Comment #5 (1) within the tank will not have any impact on the SST wall, the vast majority of the sludge slurry is not even agitated against the steel bottom until near the end of retrieval. Pumping the waste slurry with the low concentration of garnet to DST at the nominal 150-200 psi pressures and nominal 100 gpm flow rates usually used will have negligible impact as this concentration is too low to have any noticeable effect. This statement is based upon Operational experience and Engineering judgment. See response to Comment #2 (B.) concerning future testing of simulated waste slurries containing low levels of garnet. **(5-9)** See response to (5-8) above, the pump, rotary union, and transfer hoses are the only MARS equipment that internally contacts the waste. **(5-10)** See response to (5-8) above.	
6	T3	**Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** **(6-1)** Provide a detail description of the dome cutting operation, including the riser cut (size, material,…?). **(6-2)** This should include general arrangement diagrams, **(6-3)** system description, **(6-4)** P&IDs, **(6-5)** information demonstrating compliance with WAC	**(6-1)** The dome cutting and riser installation will be done as described on drawing H-14-107697 Sheets 1-3, "Large Riser Installation Sequence". Latest copies of these drawings were provided to Ecology on 10/7/10. The actual cutting and riser installation will be performed under the direction of a work package. The water-garnet slurry used for cutting the hole in C-107 uses a 48,000 psi water supply and has a velocity out the cutting nozzle orifice of greater than 150 ft/sec. See response to Comment #17 for garnet-water composition. **(6-2)** There are no general arrangement diagrams for the cutting operation, but	**6-1** closed 10/27/10 **6-2** closed 10/22/10 **6-3** closed 10/22/10 **6-4** closed 10/19/10

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		173-303-640 as requirement by TPA Appendix I, 2.1.3. **(6-6)** This should include a technical description cutting system support and **(6-7)** analysis of dome loading due to the dome cutting activities and **(6-8)** the potential impacts from accidents during this operation, in keeping with the requirements of a pre-retrieval risk assessment.	drawing H-14-107694, "Site Plan" shows the equipment locations. A copy of this drawing was provided to Ecology on 10/7/10. **(6-3)** See response to (6-1) above. New riser details are shown on drawings H-14-107695 Sheets 1-5, "Large Riser Details" and H-14-107696, "Pad Details", H-14-107698, Sheets 1-2, "Riser Plug and Anchor Plate Details". A copy of this drawing was provided to Ecology on 10/7/10. **(6-4)** There are no P&IDs for the dome cutting operation. **(6-5)** An IQRPE report will demonstrate compliance with WAC 173.303.640 for the tank dome integrity. The integrity assessment plan to be used as the basis for the IQRPE report is VET-1642-PLAN-001, *Large Riser Installation Integrity Assessment Plan.* A copy of this document was provided to Ecology on 10/7/10. **(6-6)** Cutting system support equipment will be listed in the work package for installation of the new riser on C-107. **(6-7)** An analysis of dome loading due to the dome cutting activities is provided in RPP-CALC-43416, *An Evaluation of Single-Shell Tank 241-C-107 for The Addition of A Large Penetration in The Tank Dome,* Rev 0, and RPP-CALC-47657, *Single-Shell Tanks Large Penetration Addition: Tank 241-C-107 Dome And Haunch Comparative Analysis,* Rev 0. Copies of these documents were provided to Ecology on 10/7/10. **(6-8)** See response to Comment #61 on process hazards review. The pre-retrieval risk assessment required by Section 2.1.1 of Appendix I is a risk assessment of the groundwater and intruder impacts of key constituents of concern, not an accident analysis. The C-107 pre-retrieval risk assessment information is in RPP-22393, Rev 4B, Section 7 and Appendix C. There are no changes to Section 7 required, and necessary changes to Appendix C for Change Notice 2010-4 were provided to Ecology with the change notice. **Change from 10/5/10 e-mail wording –** Redline wording added by Ecology to the ORP meeting minutes from 9/24/10 stated:	**6-5** closed 10/19/10 **6-6** closed 10/19/10 **6-7** closed 10/27/10 **6-8** closed 10/19/10 Change at bottom closed 10/19/10

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			Ecology requested that a summary of the riser installation process and ECN be provided in the TWRWP. A description of the process has been added to new Section 3.1.1.1, but applicable drawings are listed (H-14-107697, *Large Riser Installation Sequence*, H-14-107694, *Site Plan*, H-14-107695, *Large Riser Details*, H-14-107696, *Pad Details, and* H-14-107698, *Riser Plug and Anchor Plate Details*) not the ECN. ECNs are not normally listed in a TWRWP.	
7	T4	Describe the disposal path of the dome 'plug' and if there will be any testing, including the opportunity for others (like SST Integrity Panel and K Quigley/ closure group) to have samples.	The plug will be packaged and stored within C-Farm or another radiologically controlled area as contaminated equipment per procedure TFC-OPS-WM-C-10, *Contaminated Equipment Management Practices*. When investigation and/or sampling of the plug is complete and there is no further use for it, it will be disposed of as waste per existing procedures.	Closed 10/19/10
8	T5	2.1 We would like the retrieval, or re-retrieval, start dates in section 2.1 to match the dates in draft BCR-237 proposed changes, C-Farm retrieval. These bulk retrieval start dates are: a. C-102: Nov. 2012 b. C-104: re-start Oct. 2010 c. C-107: June 2011 d. C-108: re-start Feb. 2011 e. C-112: Oct. 2011	The retrieval start dates in Section 2.1 that were provided to Ecology with Change Notice 2010-4 will be revised to dates below (as of 10/6/10): C-102: November 2012 C-104: No change required, the change notice states retrieval began in January 2010 C-107: June 2011 (note that the BCR date is the end of May) C-108: restart January 2011 C-112: October 2011	Closed 10/19/10 with added words at left
9	T6	Establishment of limits of technology, as bulleted on page 3-13 of RPP-22393, Rev. 4B attached to this mod notice, will be considered by Ecology in agreeing to the use of and definition of a 2nd technology.	No response required, the words bulleted on page 3-13 of RPP-22393, Rev. 4B attached to the change notice are already approved by Ecology.	Closed 10/19/10
10	T7	**Note: Numbers in bold added by**	**(10-1)** There are other cutting methods but they all have significant drawbacks.	Closed

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		WRPS to segregate the individual Ecology comments **(10-1)** Explain why another cutting technique is not viable. **(10-2)** What would need to happen to make another cutting technique viable	Abrasive garnet cutting was selected as it is believed to be the best and most effective method. The method was selected considering constructability, operability, ALARA, and availability. Details of the selection process are documented in the construction methods study, RPP-36609, *Construction Method Study for Installation of a Large Riser in a Single-Shell Tank*, Rev 1. A copy of this document was provided to Ecology on 10/7/10. **(10-2)** In order to implement either diamond cable or band saw cutting, development testing would need to be performed, the testing would have to successfully show the method was as good as garnet, and effective contamination and dust control methods would have to be developed, tested and concurred with by WDOH. If a coring method were to be implemented a nominal 55 inch coring bit and handling system would need to be developed and successfully tested. (One of the problems with a 55 inch core size is keeping the core bit from binding up and wedging in the hole kerf.) If a different abrasive grit was to be used, one with a lower hardness value than garnet would have to be successfully tested and shown to be as effective as garnet without any of the perceived drawbacks.	10/19/10
11	NA	NA	NA	NA
12	T8	Explain the probability of the mobile arm bumping into a tank wall or bottom and the potential damage. Explain what safe guards are in place to prevent this.	The arm movement is monitored with a video camera during use to minimize contact with the tank wall or bottom, but the probability that the MARS arm will bump into the tank wall, bottom, or internal equipment item has been assumed to happen in the equipment design. The MARS design includes features to stop the movement of the arm when a preset force is reached so as to avoid damage to the MARS components or the tank wall/bottom. The following wording has been added to Section 3.1.1 of RPP-22393: The MARS is equipped with a sensing system that detects back pressure when the arm bumps into a tank wall or bottom, and halts motion of the arm in that direction before excessive pressure is exerted. This is expected to minimize damage to the arm (or the tank wall/bottom). Visual monitoring of the MARS head will also minimize bumping of the MARS head into the tank wall or bottom. The sensor will be operable prior to insertion of the MARS into the	Closed 10/27/10 with Ecology review of the words about the MARS sensor added to the TWRWP

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			tank, but it is not planned to remove the arm to repair the sensor should it fail after the MARS is installed.	
13	T9	**Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** **(13-1)** What purpose does the caisson serve for the C-107 tank? **(13-2)** How is it connected/attached to the tank? **(13-3)** How will it be removed? **(13-4)** How will WRPS/ORP ensure that no damage to the tank or any surrounding components occur during this effort? **(13-5)** Will they monitor or inspect the SST or surrounding components during this effort so that structural integrity of the tank and surrounding system components remain intact?	**(13-1)** The caisson serves no purpose at this time other than enclosing a tank access riser. The caisson was installed after the tank was built. **(13-2)** How the caisson is attached to the tank is described on pg 2-7 of RPP-22393, Rev 4B, the TWRWP for C-107. This wording references H-2-38597, *Salt Well-Pump Pit Assembly for Std. 12" Riser*, as showing the installation method for the caisson. A copy of this drawing was provided to Ecology on 10/7/10. **(13-3)** See response to Comment #(6 -1) above (Ecology Comment T3). **(13-4)** The hole cutting and new riser installation will be done following a thorough planning process that plans for and implements controls to eliminated or mitigate expected hazards. Details of these controls are provided in the work package. See response to Comment #(6 -8) above. **(13-5)** See the response to Comments #(6-5) and (13-4).	All five **13-x** comments closed 10/19/10 with added words at left
14	T10	The new ancillary equipment (prior to installation) must be designed to protect against damage and excessive stress due to settlement, vibration, expansion or contraction. Any unusual operating stresses should be identified to verify that all flow of waste and internal stresses are within the design limits specified by the piping and ancillary equipment/component manufacturer. (Tank dome loading calculations or a summary with reference to another document should be included here.)	The MARS equipment, including the ancillary equipment, is designed to the standards, requirements, and conditions delineated in the performance specification for the retrieval equipment. The items listed in the comment are all part of design subjects for retrieval equipment. See the response to Comment #(6-7) for the large riser installation dome loading calculations, the response to Comment #(6-5) for the IQRPE report on large riser installation, and/or the response to Comment #30 for IQRPE report for MARS equipment installation as applicable. The following wording has been added to Section 3.1.1 of RPP-22393: The MARS is designed to meet the requirements in RPP-SPEC-39989, *Performance Specification for The Mobile Arm Retrieval System for Tank 241-C-107.*	Closed. In 10/19/10 meeting with Ecology it was agreed this comment would be closed when words have been added to RPP-22393 that the MARS is designed to

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				meet the requirements of referenced specification. This was added on 10/20/10.
15	T11	**Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** **(15-1)** Will one or more emergency shut-off and /or check valves be included with the new ancillary system, slated to be installed? **(15-2)** Will an overfill or over-pressurization alarm or control be present?	**(15-1)** It is assumed this comment refers to the pump and transfer line used for C-107 retrieval. The pump will have leak detector shutdown as described in RPP-22393 Rev 4B, Section 3.1.1. The system will also have a pressure relief valve (PRV) as required by the DSA, if the head pressure of the selected pump will exceed the design pressure of the DST transfer system. **(15-2)** Overfilling the receiver DST (AN-106) is prevented by monitoring of the waste level in the tank during retrieval and halting retrieval when a preset limit is reached. The C-107 headspace pressure is also monitored during retrieval, with an alarm when the negative pressure maintained by the exhauster gets close to zero. See response to Comment 12 on MARS pressure sensor.	Closed for both **15-x** comments 10/21/10 when added words at left for **15-2**.
16	T12	Please provide a reference to the IQRPE assessment and findings (WAC 173-303-640(3)(a)) on the design.	See the response to Comment #(6-5) for IQRPE report on large riser installation. See the response to Comment #30 for IQRPE report for MARS equipment installation. The IQRPE reviewed the large riser installation design. During this review they noted several key welds that they wanted to observe during fabrication. Hold points were established in the fabrication documentation for this observation. No other comments have been formally documented.	Closed, per 10/21/10 meeting comment will be closed when Ecology notified of IQRPE review of riser installation design, and whether there were any

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				documented comments or not. The second paragraph at left was provided to Ecology on 10/25/10.
17	T13	**Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** **(17-1)** Estimate the amount of water and garnet to be used and subsequently drained into C-107 during the tank dome cut. **(17-2)** Provide a maximum and minimum and the basis of the estimate.	**(17-1)** It is planned to cut the hole with a nominal water flow rate of 3.2 to 3.3 gpm and a nominal garnet flow rate of about 1.25 to 1.8 lbs/min. Testing has indicated it may take 17 to 21 hours to cut the hole. Assuming 21 hours cutting time, a calculated 4,030 to 4,160 gal of H_2O and 1,575 to 2,265 lbs of garnet would be added to C-107. During the demonstration cut performed onsite from September 30 to October 2, 2010 the water usage was 3,695 gal, the garnet usage was 2,145 lbs and the cut time was 20 hours. **(17-2)** At 17 hours to cut the hole at 3.2 gpm the minimum water usage calculates to be about 3,260 gal. At 21 hours to cut the hole at 3.3 gpm the maximum water usage calculates to be about 4,160 gal. A 'probable' maximum of 4,200 gal of water is a reasonable estimate at this time, but the final water usage could be more than this depending upon circumstances. At 17 hours to cut the hole at 1.25 lbs garnet/min the minimum garnet usage calculates to be about 1,280 lbs. At 21 hours to cut the hole at 1.8 lbs garnet/min the maximum garnet usage calculates to be about 2,270 lbs. A 'probable' maximum of 2,800 lbs garnet is assumed for conservatism.	Closed for both **17-x** comments 10/21/10
18	T14	RPP-CALC-47657, Rev. 0 **Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** **(18-1)** What is the as-built configuration of the tank and	**(18-1)** The tank as-is configuration is described in the TWRWP RPP-22393, Rev 4B, Sections 2.2.2 and 2.3 for this change notice. The as built condition is similar to the as-is except the as-is includes the central saltwell caisson, plus there may be different equipment items in some risers. RPP-CALC-47657, Rev 0, Section 3.1 states the geometry for the model used the design drawing and the as-built specification for the tank. Tables 4-1 and 4-2 list more of the tank structural and load conditions.	Closed for the three **18-x** comments 10/21/10 with new words at left added to

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		(18-2) has it been considered in the analysis? **(18-3)** Has the tank's operating history been fully evaluated to assess its impact on the tank's structural integrity?	**(18-2)** The tank fabrication drawings and the current drawings were used in the analysis. So, the as-built was considered and used, but the analysis is of the current tank condition. Section 3.1 states the geometry for the model used the design drawing and the as-built specification for the tank. Tables 4-1 and 4-2 list more of the tank structural and load conditions. **(18-3)** The applicable tank history was reviewed to determine any impact to the analysis. Table 4.2 identifies the maximum temperature exposure and the Sections that follow 4.4 describe how degrading factors were applied to the model. See response to Comment 62-2 for further words on tank condition.	**18-3**.
19	T15	RPP-CALC-47657, Rev. 0 **Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** **(19-1)** What is the as-is condition of the tank and **(19-2)** has it been factored into the analysis?	**(19-1)** See response to Comment #(18-1) **(19-2)** See response to Comment #(18-2) See response to Comment 62-2 for further words on tank condition.	Closed for both **19-x** comments 10/21/10 with new words at left added to **19-2**.
20	T16	RPP-CALC-47657, Rev. 0 Strength reduction factors taken from ACI-349-06 have been applied to account for uncertainties in material properties. These factors are considered to be appropriate for new structures. What is the technical justification for using these factors for evaluation of older concrete structures that may have been exposed to extreme operating conditions?	The strength reduction factors for the older materials need not be reduced because of exposure to the elements or extreme operating conditions. The concrete surface of the dome was covered with 3 layers of asphalt felt and then by a protective layer of mesh reinforced gunite. This precludes the infusion of water that could initiate corrosion. Video inspection of the inside surface of the tank in the central region shows no evidence of corrosion, cracking or spalling that could be evidence of rebar corrosion. The concrete has not been exposed to freezing conditions due to soil cover. The moderate operating temperatures of the tank (<200°F) and high humidity are conducive to strength gain of the concrete. The Hanford concretes subjected to long term elevated temperature exposure did not show any strength loss when exposed to temperatures less than 200°F.	Closed 10/21/10
21	T17	RPP-CALC-47657, Rev. 0	Yes. See Section 1.0. The PNNL Quality Assurance program is compliant with	Closed

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		Have the finite element models and computer codes been verified and validated?	DOE Order 414.1C and ASME NQA-1-2000. Compliance requires verification and validation of the software.	10/21/10
22	T18	RPP-CALC-43416, Rev. 0 **Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** **(22-1)** What is the as-built configuration of the tank and **(22-2)** has it been considered in the analysis? **(22-3)** Has the tank's operating history been fully evaluated to assess its impact on the tank's structural integrity?	**(22-1)** See response to Comment #(18-1) **(22-2)** See response to Comment #(18-2) **(22-3)** See response to Comment #(18-3)	Closed for all three **22-x** comments 10/21/10
23	T19	RPP-CALC-43416, Rev. 0 **Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** **(23-1)** What is the as-is condition of the tank and **(23-2)** has it been factored into the analysis?	**(23-1)** See response to Comment #(18-1) **(23-2)** See response to Comment #(18-2)	Closed for both **23-x** comments 10/21/10
24	T20	RPP-CALC-43416, Rev. 0 Strength reduction factors taken from ACI-349-06 have been applied to account for uncertainties in material properties. These factors are considered to be appropriate for new structures. What is the technical justification for using these factors for evaluation of older concrete structures that may have been exposed to extreme	See response to Comment #20	Closed 10/21/10

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		operating conditions?		
25	T-21	RPP-CALC-43416, Rev. 0 Have the finite element models and computer codes been verified and validated?	Yes. See Section 1.1. The PNNL Quality Assurance program is compliant with DOE Order 414.1C and ASME NQA-1-2000. Compliance requires verification and validation of the software.	Closed 10/21/10
26	T-22	RPP-CALC-43416, Rev. 0 Has the possibility of dome buckling been assessed?	The C-106 Structural Integrity Analysis for In-situ Conditions (WHC-SD-W320-ANAL-001, *Tank 241-C-106 Structural Integrity Evaluation for In Situ Conditions*) completed a dome buckling assessment with the uniform and concentrated loads and passed the buckling evaluation guidelines of ACI 318 and 349, Chapter 19 which has a safety factor of 3.5. The evaluation accounted for time dependent creep, thermal effects and imperfections. The C Farm tanks are identical in construction so this is applicable to the C-107 tank as well.	Closed 10/21/10
27	T-23	RPP-CALC-43416, Rev. 0 The assumption in Section 3.2 needs to be explained in more detail.	The assumption listed in 3.2 identifies that the large riser will not transmit a load to the dome by means of direct contact (i.e. the large riser will not contact the dome). The loads from the riser and concrete pad are instead distributed to the soil. The backfill requirements for the riser installation process are provided in RPP-SPEC-41963, *Construction Specification for Installation of A Large Riser on A Single-Shell Tank.* This reference has been added to RPP-22393 Section 3.1.1.1 at Ecology's request.	Closed. Per 10/21/10 meeting it was agreed that this comment was closed if a reference was added to RPP-22393 for backfill requirements associated with the large riser installation.
28	T-24	RPP-CALC-43416, Rev. 0 The use of unfactored loads is questionable. The purpose of using load factors is to account for loading uncertainties. By not applying load factors the assumption is being made that	The approach used for the evaluation of existing structures for the load conditions including creep or other similar loads use load case C4 from 349 Appendix C. The reason the load factors are not applied is because it un-conservatively increases the moment capacity by using a greater axial load. The actual margins to safety are evaluated by comparing the ratio of the applied moment to the allowable moment at the P-M boundary line (ductile behavior).	Closed 10/21/10

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		there are no loading uncertainties.		
29	T-25	RPP-CALC-43416, Rev. 0 4.6 Evaluation of MARS-Induced Moment on the Tank Dome Demands In addition to the weight of the MARS, the MARS equipment generates moments that are reacted through the concrete pad on which the MARS equipment rests. The reaction is transmitted through the soil above the tank and into the tank dome. The effect of the weight of the MARS equipment has been included in the seismic analysis and in the TOLA analysis, but the effects of the operational moment of the equipment have not yet been considered. What will be the effects of the operation moment of the MARS equipment in use on the structural integrity of the C-107 dome from any vibration, torque, force, rotation…etc. with the new 55-inch riser configuration? I realize that the force will extend to the dimensions of the concrete pad and then translate into the backfilled soil, but no calculations have been performed to suggest what if any additional loads would result.	The operating Moment of 80 kip-feet was applied to the tank through the footing of the Large Riser foundation pad. The overturning moment produces 86 psf at the surface of the dome compared to the Dead Load of the MARS unit (100 kips) which produces about 270 psf at the dome surface. Compared to the normal soil pressure at the dome surface of 720 psf, the increase due to the overturning load is not significant. The loads due to the telescopic arm are limited due to the "curb feeler" feature that shuts off the hydraulics if the end-effector senses hard contact with the tank or other appurtenances in the tank. The slewing motor that rotates the MARS arm assembly also has a limited stall capacity that precludes large loads due to rotational movement being stalled. See responses to Comments #12 and #27.	Closed 10/21/10 with words added at left.
30	T-26	Will an IQRPE or trained representative be present on site to observe and verify that correct materials and procures are	IQRPE reports will demonstrate compliance with WAC 173.303.640. The following wording is added to new Section 3.1.1.1: "An independent, qualified registered professional engineer (IQRPE)	Closed 10/21/10

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		used for the following: a. Visual inspection and pressure testing b. Subgrade and foundation preparation c. Placement and compaction of backfill d. Placement of reinforcing steel and anchor bolts (if applicable) e. Concrete placement (if applicable) f. Installation of secondary containment liner or vault (if applicable) g. Installation of piping, pumping, and other ancillary equipment h. Installation of cathodic protection systems (if applicable) i. Tightness testing prior to placing tank system (in this case retrieval system) in service.	report will be prepared and issued for the large riser installation. This report will be separate from the IQRPE report for the MARS retrieval equipment. See Section 3.8 for clarifying words on WAC compliance." The wording previously accepted by Ecology for C-107 modified sluicing on information to demonstrate WAC 173-303-640 compliance for a new tank system is given in Section 3.8 *Information for New Aboveground Tank Systems* in RPP-22393, Rev 4B. For the later C-110 and C-111 TWRWPs (RPP-33116 and RPP-378739) it was agreed to between Ecology, DOE, and the tank operations contractor to add additional clarifying words to Section 3.8. These additional clarifying words are given below. If Ecology requests these same words can be added to the RPP-22393 TWRWP also. "A written integrity assessment, reviewed and certified by an independent, qualified registered professional engineer (IQRPE), attesting that the transfer-related equipment and associated transfer lines are suitable for use during waste retrieval operations will be prepared in accordance with WAC 173-303-640(3), "Design and Installation of New Tank Systems or Components," and submitted to Ecology following completion of the design and field installation of the WRS. This includes verification that the subject equipment meets the requirements set forth in WAC 173-303-640(3) and WAC 173-303-640(4), "Containment and Detection of Releases." If additional systems or additional transfer line systems are used, each system will be evaluated by an IQRPE. The design provided to the IQRPE for review will include all new or existing transfer systems, structures or components, including secondary containment (e.g., central caisson if used) and leak detection equipment used for waste transfer lines. The requirements for an IQRPE assessment and the permitting decision logic for new equipment or repairs/upgrades to equipment will be performed in compliance with RPP-16922, *Environmental Specification Requirements*, latest revision, Section 13.0, *IQRPE Assessment Need and Permitting Decision Logic*.	

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			Risers were reviewed as part of the original SST System Integrity Assessment (RPP-10435). SST system components (e.g., risers, pits, etc.) that were identified as part of the SST system for the original Integrity Assessment are not part of the retrieval system (unless specifically identified as such) and do not require a separate or additional integrity assessment if the function of the equipment doesn't change from its original purpose (e.g., the original purpose of risers is to provide tank access) and changes to the component are not outside the original component design basis and specifications." **Change from 10/5/10 e-mail wording –** Wording in the ORP meeting minutes from 9/24/10 state: *Ecology also requested that a statement be included in the TWRWP that the guidance in document WDOE Guidance for Assessing and Certifying Tank Systems that Store and Treat Dangerous Waste was incorporated into the IQRPE Review Plan as appropriate.* The IQRPE review plan is put together by the IQRPE. The Statement of Work for the large riser IQRPE support states *"The purpose of these integrity assessments is to perform and document an independent review of the tank system to meet the requirements of Washington Administrative Code (WAC), Dangerous Waste Chapter 173-303-640 (Tank Systems). Guidelines provided by Washington State Department of Ecology, Publication No. 94-114, "Guidance for Assessing and Certifying Tank Systems that Store and Treat Dangerous Waste" shall be followed in preparation of these integrity assessments."* The IQRPE review plan for the large riser installation provided to Ecology for Comment (6-5) is believed to meet the WDOE guidance document. However, requiring guidance document usage normally is not included in a TWRWP.	
31	W1	**Note: Numbers in bold added by WRPS to segregate the individual Ecology comments**	**(31-1)** There is little or no impact to the ultra filters. The filters are replaceable. They are designed for a 0.1 µm particle size. Per Table 1 in RPP-47353 approximately 0.3 wt% of the post-cut garnet is 425 µm	**31-1** closed 10/19/10 **31-2** closed

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		What are project impacts to **(31-1)** ultra filters and **(31-2)** piping and **(31-3)** pumps? **(31-4)** Provide a reference and summary in the TWRWP.	or above, the 50 wt% fraction is at about 75 µm, and approximately 0.5 wt% is 5 µm or less, so the garnet should not plug up the filters any more than other waste particles. A coating of waste builds up on the outside of the filter that is periodically backflushed for removal. The presence of garnet in the waste will have no impact on the filters in part due to the presence of this coating of waste. **(31-2)** 24590-WTP-RPT-PET-10-019 Rev 0, Section 7 summarizes Appendix I which conservatively calculates that adding the garnet from cutting 22 holes to the waste will increase the erosion in WTP piping by 2 mils, or 4%. The calculations were done consistent with the method used in calculation note 24950-WTP-M0C-50-00004, which estimated piping erosion rates in the WTP for waste slurries. Neither 24950-WTP-M0C-50-00004 nor 24590-WTP-RPT-PET-10-019 Rev 0, Appendix I evaluated erosion of piping elbows, tees, or other fittings. There is believed to be more than adequate erosion margin for piping and components with or without the levels of garnet assumed in the calculations. There is no basis to address elbow wear for erosion of piping elbows, tees, or other fittings with garnet present if such erosion was not specifically evaluated for the WTP piping without garnet. **(31-3)** The pumps have not been purchased yet. The performance spec against which the pumps will be purchased will be based upon a conservative estimate of whatever materials the pumps will be expected to move, thereby accounting for garnet additions to the waste. There are planned to be ≤3 large diameter holes cut into SSTs with garnet before WTP pump specs are issued for purchase. If additional holes are cut after the pump specs are issued the WTP will need to reevaluate the pump specs prior to submittal for future pump purchases. **(31-4)** The TPA in Appendix I, Section 2.1.3 states "TWRWPs will address only those actions associated with waste retrieval." The addition to RPP-22393 of the requested WTP information is not within the scope of retrieval as defined in either the TPA, Appendix I, Section 2.1.3 or letter	10/27/10, with the stipulation that the response is applicable for no more than three 55 inch nominal diameter holes being cut into SSTs. The comment at left is based upon the assumption of 22 holes being cut. **31-3** closed, in the 10/19/10 meeting it was agreed that words would be added that if ≥3 holes are cut the WTP pump spec needed to be reevaluated. These words have been added at left. **31-4** closed per

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			04-TPD-083. However, for completeness, all Ecology comments and questions have been addressed and are tabulated in this comment table, which will be added to Appendix G, *Washington State Department of Ecology Approved Change Notice(s)*, of RPP-22393.	10/21/10 meeting, with words added at left
32	W2	**Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** On 10/19/10 Comments 32-1 and 32-2 were deleted by Ecology and rewritten as new Comment 32-1: **(32-1)** ~~How will the erosion with increase velocity and~~**(32-2)** ~~garnet impact PJM nozzles~~ (words deleted) How will the addition of garnet to the waste stream in addition to the increased PJM nozzle velocities affect the PJM nozzle erosion? • **(32-3)** With more PJM and reoriented nozzles and sequential firing? **(32-4)** Provide a reference and summary in the TWRWP.	**(32-1)** The impact of garnet on the erosion resistant stellite nozzles is expected to be negligible with the current planned velocities. Increased velocities through PJM nozzles will be the addressed in a revision to 24590-WTP-M0C-50-00004 that will reflect WTP modifications due to M3 testing. It is expected that the impact of garnet on the nozzles will still be negligible at these higher velocities. **(32-2)** Comment deleted, combined in new 32-1) **(32-3)** There will be negligible impact from changes to nozzle orientation and operation. This topic will be addressed in a revision to 24590-WTP-M0C-50-00004. As part of WTP modifications due to M3 testing the review of impacts will be evaluated. The addition of additional PJMs and impacts to their firing sequences are subject to IQRPE evaluation. **(32-4)** The TPA in Appendix I, Section 2.1.3 states "TWRWPs will address only those actions associated with waste retrieval." The addition to RPP-22393 of the requested WTP information is not within the scope of retrieval as defined in either the TPA, Appendix I, Section 2.1.3 or letter 04-TPD-083. However, for completeness, all Ecology comments and questions have been addressed and are tabulated in this comment table, which will be added to Appendix G, *Washington State Department of Ecology Approved Change Notice(s)*, of RPP-22393.	**32-1** closed 10/27/10, with the stipulation that the response is applicable for no more than three 55 inch nominal diameter holes being cut into SSTs. The comment at left is based upon the assumption of 22 holes being cut. **32-2** deleted **32-3** closed on 10/19/10 with change shown at left **32-4** closed per 10/21/10 meeting, with words added at

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
				left
33	W3	**Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** • **(33-1)** How does the garnet impact the basic premises of the erosion testing with the addition of garnet? • **(33-2)** Is the testing still valid – **(33-3)** is the simulate still bounding • **(33-4)** Are the resulting equations and **(33-5)** variables still valid and representative	**(33-1)** See response to Comment #1. **(33-2)** See response to Comment #2 **(33-3)** See response to Comment #2 **(33-4)** Yes. See response to Comment #2. **(33-5)** Yes. See response to Comment #2.	All five **33-x** comments closed 10/19/10 with changes shown at left
34	W4	**Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** On 10/19/10 Comment 34-1 was deleted by Ecology and rewritten as new Comment 34-1: **(34-1)** ~~What impact does the increase in velocity do to the calculation of the garnet and erosion issues?~~ How will the M3 study increased PJM velocities affect the erosion on the bottom of the tank? **(34-2)** Provide a reference and summary in the TWRWP.	**(34-1)** The impact of garnet on the wear rates with the current velocities is described in the response to Comment #1. Per 24590-WTP-M0C-50-00004 Rev E erosion is proportional to the velocity raised to the power n. Equation 7.2.4.6 for the design wear rate shows a value of n = 3.46, and uses the factor $(V/8\ m/s)^{3.46}$. Increased velocities through PJM nozzles will be the addressed in a revision to 24590-WTP-M0C-50-00004 that will reflect WTP modifications due to M3 testing. The response to Comment #1 conservatively states that the impact on the wear rate of cutting 22 holes will be less than 3.7% and the impact of one hole less than 0.17%. This impact percentage is expected to not change with velocity, Figure 10.8-A in 24590-WTP-M0C-50-00004 shows the calculated design wear rates at velocities up to 18 m/s. **(34-2)** The TPA in Appendix I, Section 2.1.3 states "TWRWPs will address only those actions associated with waste retrieval." The addition to RPP-22393 of the requested WTP information is not within the scope of retrieval as defined in either the TPA, Appendix I, Section 2.1.3 or letter 04-TPD-083. However, for completeness, all Ecology comments and questions have been addressed and are tabulated in this comment table, which will be added to Appendix G, *Washington State Department of Ecology Approved Change Notice(s)*, of RPP-22393.	**34-1** closed 10/27/10, as the calculations show minimal impact for no more than three 55 inch nominal diameter holes being cut into SSTs. The comment at left is based upon the assumption of 22 holes being cut. **34-2** closed per 10/21/10

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				meeting, with words added at left
35	W5	**Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** **(35-1)** Erosion: it appears that known erosion and margin calculations have not included garnet as a contributor to wear. Please verify that erosion and margin calculations have, in fact, accounted the increased erosion potential associated with garnet. **(35-2)** Provide a reference and summary in the TWRWP	**(35-1)** See response to Comment #1. **(35-2)** The TPA in Appendix I, Section 2.1.3 states "TWRWPs will address only those actions associated with waste retrieval." The addition to RPP-22393 of the requested WTP information is not within the scope of retrieval as defined in either the TPA, Appendix I, Section 2.1.3 or letter 04-TPD-083. However, for completeness, all Ecology comments and questions have been addressed and are tabulated in this comment table, which will be added to Appendix G, *Washington State Department of Ecology Approved Change Notice(s)*, of RPP-22393.	**35-1** closed 10/19/10 **35-2** closed per 10/21/10 meeting, with words added at left
36	W6	**Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** **(36-1)** Suspension: mixing calculations for PJMs and information for SpG transport of fluids and solids in lines and pumps, and such, either have not been done or the information is not currently available to ensure that this material will move through the process train as anticipated. The inverse of that is that there is concern that this material will get "caught" in valve sleeves, pump seals, filters, etc, and cause a sub-optimization of the process flow. • **(36-2)** What analyses have been done	**(36-1)** The current design transport velocities are more than adequate to suspend solids in the waste and meet the ICD-19 requirements and the required critical velocities. There is no change required to any planned transport velocity to account for garnet in the waste. WTP required velocities for suspension are documented in 24590-WTP-ES-PET-08-001 Rev 1, *Technical and Risk Evaluation of Proposed ICD-19 rev 4*. **(36-2)** The response to Comment #2 describes the analyses. **(36-3)** The mean time between failures for replaceable components such as valves is based upon industrial standard estimates, e.g. a 3-5 year life for many components. As stated earlier, several components have not been procured, the impact of garnet will be considered as necessary when these components are procured. The model used to estimate plant attainment and availability is based on industry information and a Monte Carlo random failure evaluation. The impact to the mission life as a result of garnet additions is expected to be minimal based on the conservatively calculated erosion rates.	**36-1** closed, at 10/19/10 meeting the response at left was accepted and it was agreed comment would be closed when reference was added for suspension velocities. The reference has been added. **36-2** closed

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		to ensure that WTP systems, structures, and components will continue to operate as designed, when garnet is added? • **(36-3)** If analyses have been done, what is in place or planned to ensure that operational mean time between failures, for example, are known and are being planned for? **(36-4)** Reference this information in the TWRWP.	**(36-4)** The TPA in Appendix I, Section 2.1.3 states "TWRWPs will address only those actions associated with waste retrieval." The addition to RPP-22393 of the requested WTP information is not within the scope of retrieval as defined in either the TPA, Appendix I, Section 2.1.3 or letter 04-TPD-083. However, for completeness, all Ecology comments and questions have been addressed and are tabulated in this comment table, which will be added to Appendix G, *Washington State Department of Ecology Approved Change Notice(s)*, of RPP-22393.	10/19/10 with change at left **36-3** closed 10/27/10, with the stipulation that the response is applicable for no more than three 55 inch nominal diameter holes being cut into SSTs. The comment at left is based upon the assumption of 22 holes being cut. **36-4** closed per 10/21/10 meeting, with words added at left
37	W7	**Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** **(37-1)** Abrasion: The reports so far do not adequately show that abrasions effects on system components have been considered. In fact, it seems clear that	**(37-1)** See response to Comment #(31-1) and (31-3). **(37-2)** The TPA in Appendix I, Section 2.1.3 states "TWRWPs will address only those actions associated with waste retrieval." The addition to RPP-22393 of the requested WTP information is not within the scope of retrieval as defined in either the TPA, Appendix I, Section 2.1.3 or letter 04-TPD-083. However, for completeness, all Ecology comments and questions have been addressed and are tabulated in this comment table,	**37-1** closed 10/19/10 **37-2** closed per 10/21/10 meeting, with words added at

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		abrasion was not in many cases considered at all. For example, filter components, valving components - any components that may be subject to degradation because of the potential increased abrasion factors applied by the addition of garnet. **(37-2)** Provide an evaluation of abrasion effects (or a reference to a support document) in the TWRWP.	which will be added to Appendix G, *Washington State Department of Ecology Approved Change Notice(s)*, of RPP-22393.	left
38	W8	Dissolution/dissolving: a claim has been made that the garnet will dissolve in caustic solutions and not add a 'solids' problem as it moves through the process stream. There is no objective evidence to support that claim; in fact, one circulated report shows that garnet *does not* dissolve, even after 12 weeks in caustic solution. Provide a conclusion and technical basis for your calculations on whether garnet dissolves in the TWRWP and any other support documents. (one document mentioning this issue: WRPS-1000793, "Report on Dissolution Test Results of Garnet Abrasive Material for Hydrocutting in Tank 241-AN-101")	No credit is taken for dissolution of garnet in the analyses.	Closed 10/19/10
39	W9	**Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** **(39-1)** Glass loading: if garnet is used and the garnet is a sulpher-based	**(39-1)** Garnet is not sulfur based. Garnet composition is normally stated as $A_3B_2(SiO_4)_3$, where Ca, Mg, Fe^{2+}, or Mn^{2+} occupy the A site, and the B site contains Al, Fe^{3+} or Cr^{3+}. **(39-2)** The type of garnet used is specified in the controlling work	Both **39-x** comments Closed 10/19/10

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
		compound, then the capability of the waste glass could be compromised. Depending upon the make-up of garnet, there could be a possibility that the integrity of the glass formers could be compromised and not meet quality standards. **(39-2)** Provide clear material specifications in the TWRWP for the garnet and any associated materials with it that may end up in the SST	documentation.	
40	W10	**Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** Mass balance/hardness/particle size: **(40-1)** How does the insertion of the garnet into a suspended mix (already having to be diluted below contract requirements because of the inability to suspend at % solids load) impact the ability of WTP components to accommodate the mix? **(40-2)** Provide a reference and summary in the TWRWP.	**(40-1)** There is no impact. The garnet will be suspended in the waste slurry during transport, transport velocities are chosen to ensure materials are adequately suspended (critical velocity). The mixer designs at the WTP are selected to suspend slurries within specified composition limits. The waste feed to the WTP from cutting up to 3 holes in tanks in C-Farm will still meet the ICD-19 feed acceptance requirements with garnet in the waste, as shown in RPP-47353. **(40-2)** The TPA in Appendix I, Section 2.1.3 states "TWRWPs will address only those actions associated with waste retrieval." The addition to RPP-22393 of the requested WTP information is not within the scope of retrieval as defined in either the TPA, Appendix I, Section 2.1.3 or letter 04-TPD-083. However, for completeness, all Ecology comments and questions have been addressed and are tabulated in this comment table, which will be added to Appendix G, *Washington State Department of Ecology Approved Change Notice(s)*, of RPP-22393.	**40-1** closed 10/19/10 **40-2** closed per 10/21/10 meeting, with words added at left
41	D1	We don't understand and can't track the wear allowance calculations thru the various documents that were provided – we need detailed clarification.	See response to Comment #1.	Closed 10/19/10
42	D2	24590-WTP-RPT-PET-08-008, Rev 0	**(42-1)** See Comment #1.	All seven **42-x**

Enclosure 1
Ecology Comments and United States Department of Energy-Office of River Protection Response
on RPP-22393 Change Notice 2010-4

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
		Note: Numbers in bold added by WRPS to segregate the individual Ecology comments Shows that several tanks exceed the wear allowances and need wear plates. Some tanks are in the negative and others are right at a threshold. 1. **(42-1)** How does this change with the addition of garnet – If you multiply the 3.05 from garnet – what are the impacts 2. **(42-2)** How many wear plates need to be reinforced and **(42-3)** by how much and **(42-4)** which tanks? a. **(42-5)** Have those wear plates already been installed? **(42-6)** How many new tanks (which ones) now have (-) wear allowances or are on the threshold and now need wear plates added? **(42-7)** Have those tanks been installed	**(42-2)** through **(42-7)** See response to Comment #2.	comments closed 10/19/10 with changes at left
43	D3	DRAFT-RPP-RPT-44252 Rev A Report DRAFT-RPP-RPT-44252 Rev A: the report is insufficient in its entirety. There assertions made that are not substantiated in the report, and there seem to be inaccuracies and inconsistencies in the information.	This draft document was superseded by RPP-RPT-47353, *Evaluation of Downstream Impacts from Garnet as A Cutting Media*. A copy of this document was provided to Ecology on 10/7/10.	Closed 10/19/10 with changes at left
44	D4	24590-WTP-RPT-PET-10-019, Rev 0 Please provide the calculations for Figures 1 and 2 that support the available	The Figure 1 was originally done via an Excel spreadsheet titled, *Erosion evaluation worksheet Min velocity w-Garnet.xls*. This worksheet was modified to include the impact of garnet as shown in Figure 2. A copy of this file was	Agreed 10/21/10 will be closed with

Enclosure 1
Ecology Comments and United States Department of Energy-Office of River Protection Response
on RPP-22393 Change Notice 2010-4

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
		wear allowances and the wear based on experimental data. The data was not readily available in the referenced EFRT Issue M2 Closure Report	provided to Ecology on 10/21/10. Should more than 3 large diameter holes need to be cut in SSTs (including the C-107 cut) with garnet, the garnet erosion issue in the WTP will have to be mutually resolved with Ecology before such cuts are formally planned.	changes at left when file sent. File sent to Ecology 10/21/10.
45	D5	24590-WTP-RPT-PET-10-019, Rev 0 Please provide the explanations for the calculations that produce the values in Tables 6 and 7 (24590-WTP-M4C-V37T-00007). This will explain why the tables in this report are different from the Table 10-7 of the reference 24590-WTP-M0C-50-00004, Rev E and Table 10.3 of the 24590-WTP-MVC-50-00002 Rev B (draft) calculation.	Tables 6 and 7 were calculated using the spreadsheet used for the original vessel erosion calculation, with garnet impact added, as described in 24590-WTP-M4C-V37T-00007. These calculations are documented in two Excel files. One file is for the 2.15% increase factor and the other is for the 3.05% The file names are: *24590-WTP-MVC-50-00002 Rev B 24-Micron DEI x 2 15 v00.xls* *24590-WTP-MVC-50-00002 Rev B 24-Micron DEI x 3 05 v00.xls* Copies of these files were provided to Ecology on 10/21/10. Should more than 3 large diameter holes need to be cut in SSTs (including the C-107 cut) with garnet, the garnet erosion issue in the WTP will have to be mutually resolved with Ecology before such cuts are formally planned.	Agreed 10/21/10 will be closed with changes at left when files sent. Files sent to Ecology 10/21/10
46	D6	24590-WTP-RPT-PET-10-019, Rev 0 BNI committed to use the DEI test results based on 24 micron silica sand for the new design basis wear allowance calculations which is labeled the "WTP Design Wear Rates" in Figure 10.8-A of the calculation 24590-WTP-M0C-50-00004, Rev E, and Figure 3 of this document. The earlier WTP design curve is represented by the curve labeled "FanAiming Wear Rates." Note that both curves graphically show wear rates for 29.1% solids loading, as a function of PJM velocity. Table 10-4 of 24590-WTP-M0C-50-00004, Rev E, applies the FanAiming results to the WTP vessels.	See the response to Comment #1 for explanation. The conservative 2.15 or 3.05 factors are not applied to the WTP Design Wear Rate curve in Figure 10.8-A. They are applied to the bottom line in the same figure that is for the predicted average wear rate.	Closed 10/19/10

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
		This table provides adjustment for actual solids loading, jet velocity and percent of time the PJMs are actually impinging on the tank bottom. DEI's tests revealed that the FanAiming curve was not sufficiently conservative. The new "WTP Design Wear Rates" curve predicts twice the amount of erosion than the FanAiming curve predicts. The worst case numbers populate the column L in Attachment 10.3 of the calculation 24590-WTP-M0C-50-00002 Rev B (draft). When multiplying the increased erosions by factors of 2.15 and 3.05, the results from this table indicate several of the erosion allowances will breach the tanks integrity. Spreadsheets are attached. Please provide a clear and concise explanation of how the garnet can be added to the waste and this document has lower erosion estimates that what is reported in the calculations 24590-WTP-M0C-50-00004 Rev E and 24590-WTP-M0C-50-00002 Rev B (draft).		
47	D7	24590-WTP-RPT-PET-10-019, Rev 0 Page 1 "Cutting risers for 22 tanks will add an estimated 27,941 kg garnet." Report RPP-PLAN-40145, SST Waste Retrieval Plan, only lists 14 SSTs needing a new 42" riser. Twenty-two tanks is an overestimate. Correct number	See response to Comment #4 (Ecology Comment T1)	Closed 10/19/10

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
		of tanks planned to possibly need a tank dome enlarged opening.		
48	D8	24590-WTP-RPT-PET-10-019, Rev 0 **Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** Page 1 "Garnet is hard, with a Mohs harness (sic) value between 8 and 9 (Appendix B),…" • **(48-1)** Garnet hardness is 6-8.5, not 9. The expected garnet used will be between andradite garnet [hardness is 6.5-8.5] and pyrope garnet [hardness is 6.5-8.5]. Use correct hardness. **(48-2)** From Page A-12: For this analysis, a narrow size range (150-180 microns), was used. Figure 3 shows the general appearance of the garnet sample. The 150-180 micron size fraction shows mostly irregular fracture surfaces, most are conchoidal (the way glass breaks). This is consistent with the garnets since they generally have only one cleavage plane, and it is a poor one. Because of the weak cleavage, some of the fragments have a thin, platy appearance. The chemistry is consistent with a garnet that is intermediate between the andradite (Ca-Fe garnet) and pyrope (Mg-Al garnet) varieties of garnet.	**(48-1)** It is agreed the wording could be revised on the garnet hardness, but the wording has no impact on the document calculations or conclusions. If the document needs to be revised for some other reason this sentence can be revised accordingly at that time. **(48-2)** No response required, it is assumed that this insert was meant for Comment #54 (Ecology Comment D14). Lab report was not used in the analysis.	Closed both **48-X** comments 10/19/10
49	D9	24590-WTP-RPT-PET-10-019, Rev 0 Page 3 "The Fe2O3 and some of the aluminum and silicon oxides present in *Pyrofrac* could combine to form a garnet-like material [Fe3Al2(SiO4)3]." Correct statement. Garnet does not form from the iron oxide and Al and Si oxides just being mixed.	It is agreed the wording is incorrect or cannot readily be substantiated. However, the wording has no impact on the document calculations or conclusions. If the document needs to be revised for some other reason this sentence can be revised accordingly at that time.	Closed 10/19/10
50	D10	24590-WTP-RPT-PET-10-019, Rev 0 Page 3 "Table 5 takes this percentage and estimates that there was approximately 0.24 wt% garnet in the simulant. This equates to an estimated	The abrasiveness is not being measured, the change in abrasiveness/erosion of waste with garnet is being conservatively estimated. See response to Comment #1 for explanation of the 205% increase estimate.	Closed 10/19/10

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
		205 % increase in abrasiveness in the tank waste due to garnet." Offer an explanation on how such abrasiveness is being measured.		
51	D11	24590-WTP-RPT-PET-10-019, Rev 0 Page 6 "The waste is modeled as alumina, which has a hardness of 9 Mohs which is equivalent to garnet, so no adjustment has to be made for the sharp edges or the density of garnet with respect to the actual waste." Correct the statement above. Hardness is different from having sharp edges.	It is agreed the wording is incorrect. However, the wording has no impact on the document calculations or conclusions. If the document needs to be revised for some other reason this sentence can be revised accordingly at that time.	Closed 10/19/10
52	D12	24590-WTP-RPT-PET-10-019, Rev 0 **Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** Page 8 "Estimates show that garnet added to the Hanford tank waste will significantly increase the erosion of the WTP process equipment." Figures 1 and 2 of Predicted 40-Year Wear Allowances with and without garnet only show a 'Significant" increase for some of the test materials. **(52-1)** Define significant. **(52-2)**Is the conclusion here that some material with garnet showed an increase in wear, but within the wear allowance?	**(52-1)** The word 'significant' should not be in the document. However, the word has no impact on the document calculations or conclusions. If the document needs to be revised for some other reason this word will be revised accordingly at that time. **(52-2)** Yes.	Closed both **52-x** comments 10/19/10
53	D13	24590-WTP-RPT-PET-10-019, Rev 0 The testing described in this report was done with AN-101. The waste from the	No change required. Lab report was not used in the analysis.	Closed 10/19/10

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
		first SSTs [C-107] to have a new riser cut will be going to AN-106. The waste from the other 2 C farm tanks (C-101 and -105) will go to AN-101. State whether there are different waste contents between AN-101 and AN-106 to effect the garnet testing.		
54	D14	24590-WTP-RPT-PET-10-019, Rev 0 Page A-12 Correct statement. Garnets lack cleavage. **4.2 Scanning Electron Microscopy Analysis of Post-Cutting Sample Used in Caustic Dissolution Tests** For this analysis, a narrow size range (150-180 microns), was used. Figure 3 shows the general appearance of the garnet sample. The 150-180 micron size fraction shows mostly irregular fracture surfaces, most are conchoidal (the way glass breaks). This is consistent with the garnets since they generally have only one cleavage plane, and it is a poor one. Because of the weak cleavage, some of the fragments have a thin, platy appearance. The chemistry is consistent with a garnet that is intermediate between the andradite (Ca-Fe garnet) and pyrope (Mg-Al garnet) varieties of garnet.	No change required. Lab report was not used in the analysis.	Closed 10/19/10
55	D15	24590-WTP-RPT-PET-10-019, Rev 0 Page A-28 Enclosure 1 **Summary:** Conclusive evidence that alteration of the garnets held at 25 °C was finally seen. This came in the form of loose sodium aluminosilicate particulate from the Test #12 sample. Add more data on volume of loose particulate, this is also important.	No change required. Lab report was not used in the analysis.	Closed 10/19/10
56	D16	24590-WTP-M4C-V37T-00007 **Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** Section 8 Results • **(56-1)** It is stated that the tables are provided for informational purposes and the tables are being revised.	**(56-1)** These tables will be provided in a revision to 24590-WTP-M0C-50-00004 that will be provided to Ecology within the upcoming year. This revision is required to document additional mixing tests. Change to the tanks as result of the M3 testing have added additional PJMs and those changes will, as stated earlier, require changes to the packages submitted to the IQRPE . See response to Comment #2. **(56-2)** This is a subjective statement. The presence of other waste particles near the metal surfaces is assumed to 'cushion' moving garnet particles to an	Closed both **56-x** comments 10/19/10 with changes added at left

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
		Provide the updated tables so an accurate conclusion can be drawn. **(56-2)** It is stated that the presence of other solids in the waste will dilute the abrasive effect of the garnet. Further information on this is not provided. This needs further discussion.	unqualified degree by absorbing some of their energy. The wording has no impact on the document calculations or conclusions. See response to Comment #2.	
57	D17	24590-WTP-M4C-V37T-00007 **Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** Section 2 Inputs 1. For Method 1**(57-1)** It is stated that there will be 22 tanks that will have garnet added. The latest documentation (RPP-PLAN-40145, rev. 1, *SST Waste Retrieval Plan*) states only up to 14 tanks will need a larger riser cut and only 3 (in C Farm) tanks by FY2014. If the calculations are run for 22 tanks, these numbers are over conservative. Make appropriate corrections. For Method 2 **(57-2)** It is incorrect to state that Fe_2O_3 and some Al and Si oxides in *Pyrofrac* are representative of garnet. These oxides as individual components do not behave the same as a garnet mineral; therefore, these assumptions cannot be used to determine the garnet erosion estimates.	**(57-1)** See response to Comment #4 (Ecology Comment T1) **(57-2)** See response to Comment #49 (Ecology #D9)	Closed both **57-x** comments 10/19/10

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
58	D18	24590-WTP-M4C-V37T-00007 Section 7 Calculations, subsection 7.1 The calculations have overestimated the number of tanks needing a large riser cut, resulting in a conclusion of 115% increase in abrasiveness in the tank waste. Correct calculations.	See response to Comment #4 (Ecology Comment T1)	Closed 10/19/10
59	D19	24590-WTP-M4C-V37T-00007 Attachment B Explain why Al oxide was not selected as an abrasive additive to the water jet cutting; it has a higher 'index' of the cutting performance than garnet.	Garnet was originally selected because it is what most of industry uses for water jet cutting and we wanted a commercially available technology that successfully deployed for the C-107 dome cut. Other abrasives were looked at when concerns were raised about garnet in the WTP. Aluminum oxide was not selected for testing as it has a higher hardness rating than garnet and thus could cause the same or a higher level of concern than garnet. It was deemed prudent to only use an abrasive that will provide the cutting action needed. Based upon verbal discussion with Ecology it appears Ecology believes we may be able to use aluminum oxide for cutting and then dissolve it in caustic. This is not practical. The 19M NaOH dissolution planned for the C-108 hard heel is intended to break down Gibbsite (or similar compounds) which are hydrated aluminates of the form $Al(OH)_3 \cdot XH_2O$, not Al_2O_3. The hydrated aluminates have been shown in the lab to break down with time under 19M NaOH to form sodium aluminate solids, $Na_2O \cdot Al_2O_3$ ($NaAlO_2$). The 19M NaOH would not significantly affect Al_2O_3. Garnet is an industry standard for many cutting applications, there are numerous vendors and methods for cutting concrete or other materials with garnet. Aluminum oxide is generally used more for surface preparation or related cutting actions.	Closed 10/19/10
60	D20	RPP-RPT-47353 The report identifies that the near term tanks requiring a large riser are C-101, -105, and -107. The calculation for	See response to Comment #2.	Closed 10/19/10 with change at left

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
		dilution of material only uses these 3 tanks. This is satisfactory for the C Farm work, but if an overall, life-of-project evaluation for all projected tanks needing a large riser cut, then there needs to be further calculations.		
61	1.	9/21/10 Ecology noted that potential failures or anomalies encountered during the riser installation process had not been thought about. Because of the significance of this project and the costs, Ecology asks that a detailed review of the design, preparation activities, work activities, procedures, etc. be conducted and where necessary identify appropriate risk reduction/mitigation measures to assure that the installation portion of the project is a success. Ecology requests that ORP/WRPS share this information as it is developed. (i.e. An evaluation should be performed to develop a backup plan to address this scenario or to mitigate the possibility of it happening by installing more anchors.)	A detailed process hazards analysis is being performed and will be completed prior to the large riser installation, as required by current contractor procedures. This process hazards analysis document was provided to Ecology on 11/03/10. The following words are added to a new Section 3.1.1.1 in RPP-22393: Installation of the large riser will be evaluated for hazards following current TOC hazards review procedures prior to performing the installation.	Closed 10/19/10
62	2.	9/21/10 **Note: Numbers in bold added by WRPS to segregate the individual Ecology comments** Current plans call for cutting a concrete core from the dome plug for testing after it is the plug is removed. It would be	**(62-1)** A core of the tank dome should not be taken until the plug is removed. The anchor bolts used to lift the plug are drilled with a drill bit and have a different diameter than that of a core needed for compressive tests. Not only would obtaining a core from the dome plug before removal result in more personnel exposure, sample packaging and transport to a suitable lab to perform compressive strength results, and waiting for those results will delay the project accordingly. The dome cutting plan	Closed 10/27/10. Response to both **62-x** comments was accepted 10/21/10, but

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
		more helpful to take a core from the dome of the tank before the plug is cut and removed. This would allow for testing of the concrete in the tank's dome to assure that it's compressive strength is greater than the design strength of 3,000 psi. and verification of the as-is thickness of the concrete at the apex region of the tank's dome. Both of these key characteristics are unknown and should be verified prior to cutting of the dome rather than after. **(62-1)**However, if a small core of the dome's concrete cannot be acquired and sampled, Ecology requests that ORP/WRPS provide concrete core testing data from other tank domes of the same age, thickness, and design and construction. **(62-2)**Ecology anticipates that this information will be added to the Modification for the C-107 TWRWP.	is based upon a very conservative method of suspending the dome plug. The number of anchor bolts used, the safety factors for each anchor bolt, and the installation method for the anchor bolts serve to minimize the potential for dropping or wedging the plug. Per the Ecology request in the last sentence of their comment, provided to Ecology on 10/7/10 was a copy of WHC-SD-W236A-ES-009, Rev 0, *Compilation of Inspection Data on Aging Hanford Concrete Structures*. This document was never released. Also included are copies of RHO-C-22, *Strength and Elastic Properties of Concretes from Waste Tank Farms*, 1978, and RHO-RE-CR-2, *Strength and Elastic Properties Tests of Hanford Concrete Cores – 241-SX-115 Tank and 202 A PUREX Canyon Building.* **(62-2)** The following paragraph is added to a new Section 3.1.1.1 in RPP-22393 that describes the new riser addition: Prior to cutting the central hole, the anchor bolts used to support the plug during cutting and removal will be installed by qualified personnel following manufacturer's recommendations and checked as described in the controlling work documentation to verify the bolts have acceptable contact with the plug. The method for suspending the plug during and after the cutting step is designed to be quite conservative. The concrete present in the dome is believed to have more than adequate strength to support the plug with the anchor bolts in place. Based upon in-tank video of the tank dome, the tank thermal history, and the construction method for the dome there is no reason to suspect any concrete degradation has occurred. **Change from 10/5/10 e-mail wording –** Redline wording added by Ecology to the ORP meeting minutes from 9/24/10 stated: *It was also agreed by Ecology, DOE, and WRPS that on-going deflection measurements of the dome's surface during the excavation/ construction process would provide some indication of the concrete's strength. Deflection measurements will be taken during this process and the data sent "real-time" to qualified personnel which can then assess the dome's condition and response to these activities.*	there were concerns by Ecology with the frequency of taking dome deflection measure-ments. The very last statement in the next to last paragraph under **Change from 10/5/10 e-mail wording** was revised as shown and agreed to by Ecology on 10/27/10, with the agreement to add the additional words shown in the last paragraph to Section 3.1.1.1 of RPP-22393. These were added to RPP-22393 on

Comment #	Ecology Comment #	Ecology Comment	ORP Response	Status
			In reviewing the redline/strikeout changes to the ORP meeting minutes this addition by Ecology wasn't noted. Taking deflection measurements was discussed during the 9/24/10 meeting but no commitment was made to take on-going deflection measurements that would be sent out in "real time". The large riser installation work packages will call for a deflection measurement to be made prior to beginning excavation, periodically during the excavation and installation process, and at the end of the large riser installation. The following words shown in bold have been added to Section 3.1.1.1 of RPP-22393: *Structural evaluations have been performed evaluating the tank dome loading conditions resulting from cutting the hole into C-107 and adding the large riser for support of the MARS equipment,* ***and monitoring/evaluation will be performed during the riser installation process****.*	10/27/10.
63		NA (verbal requests from Ecology in 9/16/10 meeting)	Ecology has verbally requested a more detailed description of the MARS equipment. Provided to Ecology with this list of responses are copies of H-14-107936, *MARS Assembly Installation Details*; H-14-107929, *Mobile Arm Retrieval System Range of Motion*; H-14-107937, sheets 1-8, *MARS Bulk Retrieval General Arrangement*; H-14-107926, *MARS P&ID Bulk Retrieval Specific Components*; and H-14-107928, *MARS P&ID Generic Components*.	Closed, documents delivered 10/7/10

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

<table>
<tr><td colspan="3">1. Document Title and Number: RPP-22393, Rev. 5, 241-C-102, 241-C-104, 241-C-107, 241-C-108 nd 241-C-112 Tanks Waste Retrieval Work Plan</td></tr>
<tr><td rowspan="2">2. Minor Field Change:
(Section 12.4 HFFACO Action Plan)
□ Yes: (WRPS Signature Only – Attach signed form to Primary Document for record purposes)

X No: Proceed to Box 3</td><td>3. Document Issue Date:

11/30/10</td><td rowspan="2">5. Notice Number: 2011-1</td></tr>
<tr><td>4. Document Modification Notice Date: 3/9/11</td></tr>
<tr><td>6.
Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?)

□ Yes X No</td><td>7.
Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan?

□ Yes X No</td><td>8. (Check only one box)
□ Significant Modification
(Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.)
Minor Modification
X Requires modification of the document
X Can be accomplished with Modification Notice.</td></tr>
<tr><td colspan="3">9. Description and Justification of Change:</td></tr>
</table>

Change Description: A change is needed to reflect the planned leak detection instrumentation change in Double Shell Tank Annuli. The changes covered by this modification notice are shown below in italics and strikeouts.

Section 4.1.3:
Tanks C-102, C-104, C-107, C-108 and C-112 currently have operable Enraf level gauges installed. The DST receiver tanks also have the same type of level gauge installed. Each DST receiver tank *annulus* has *leak detection devices* ~~three conductivity probe gauges~~ installed *such as conductivity gauges, Enraf level gauges or similar instruments* ~~in the annulus. These annulus level gauges are used~~ for detection of leaks from the tank primary tank liner.

The primary level monitoring in the receiver DST is performed as described in OSD-T-151-00031, Section 4.0. The ~~three~~ annulus leak detector ~~probes~~ *instruments* provide indication of tank leaks as described in OSD-T-151-00031, Section 4.0.

Section 4.2.1.5:
The existing leak detection systems in the receiver DST will be utilized as required in OSD-T-151-00031. A leak from the primary vessel of the receiver DST will be detected by ~~a conductivity probe~~ *leak detection instruments* installed in the annulus.

Justification: Modifications are being made in the DST annuli to enhance leak detection capability.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

˙mpact of Change: ı.. ımpact.		
11. Additional Requirements and/or Provisions[1]:		
Approvals		
Washington River Protection Solutions, LLC.	Office of River Protection	State of Wash., Dept. of Ecology
□ Provisional Approval[2] Date	□ Provisional Approval[2] Date	□ Provisional Approval[2] Date
□ Final Approval Date 4/10/11	□ Final Approval Date 3/10/11	□ Final Approval Date 3-14-11

Notes

1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision

2 – Provisional approval allows DOE and its contractors to take specific actions identified in section 11, prior to final approval of this modification.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

1. Document Title and Number: RPP-22393, Rev. 5, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tanks Waste Retrieval Work Plan		
2. Minor Field Change: (Section 12.4 HFFACO Action Plan) ☐ Yes: (WRPS Signature Only – Attach signed form to Primary Document for record purposes) x No: Proceed to Box 3	**3.** Document Issue Date: 11/30/10 **4.** Document Modification Notice Date: 5/10/11	**5.** Notice Number: 2011-2
6. Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?) ☐ Yes x No	**7.** Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan? ☐ Yes x No	**8.** (Check only one box) ☐ Significant Modification (Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.) Minor Modification x Requires modification of the document x Can be accomplished with Modification Notice.

Description and Justification of Change:

Change Description: A change is needed to implement the requirements of Consent Decree No. 08-5085-FVS, United States District Court Eastern District of Washington, October 25, 2010. This opportunity is being taken to clean up a number of out-of-date or inaccurate words in the TWRWP. The changes covered by this modification notice are shown in redline/strikeout on the attached redline/strikeout pgs. xii, 1-1, 2-1, 2-13, 3-1, 3-3, 3-4, 3-6, 3-8, 3-12 to 3-15, 3-17 to 3-25, 4-1, 4-6, 4-14, 5-1, 5-2, 7-1, 9-1, 9-2, 9-5, 9-6, 9-7, 9-8, 9-9, 9-10.

Justifications:

- pg xii, added high pressure water definition for clarity, editorial change, added TOC as acronym
- pg 1-1, para 1 change for clarification, para 2 change to update for Consent Decree wording, para 3 deleted unnecessary old wording
- pg 2-1, revised date wording for consistency with Consent Decree wording
- pg 2-13, changed to show revised document number
- pgs 3-1, changed to comply with Consent Decree wording on second technologies
- pgs 3-3 to 3-4, waste compatibility assessment, exhauster condensate, and vent system wording changes made to be consistent with Ecology approved C-111 TWRWP (see addition on pg 5-1), fixed TOC typo, deletes unnecessary reference
- pg 3-6, deletes wording on in-tank vehicle use previously approved by Ecology. In order to comply with Consent Decree this has to be deleted. Revised unnecessarily specific wording on number of diversion boxes.
- pg 3-8, deletes additional wording on in-tank vehicle use previously approved by Ecology.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

- pg 3-12, added in listing of C-107 where it was erroneously deleted in last revision
- pg 3-13, deletes additional wording on in-tank vehicle use previously approved by Ecology
- pgs 3-14 and 3-15, change notify to inform, the words have erroneously stated the formal 'notify' instead of 'inform' and not recognized before
- pg 3-17, deletes additional wording on in-tank vehicle use previously approved by Ecology.
- pg 3-17 to 3-18, added explanatory words on heel dissolution
- pg 3-18, modifies out of date wording on sluicing experience
- pgs 3-19 to 3-21, revises wording on supernate use to be consistent with Ecology approved C-111 TWRWP including adds supernate advantages and disadvantages table requested and approved by Ecology, and deletes reference to deleted TSR control in same table
- pgs 3-21 to 3-22, added rationale words for second technology required by Consent Decree and updated 360 ft^3 reference
- pgs 3-23 and 3-24 to 3-25, clarified reference to Consent Decree for 360 ft^3 wording
- pg 4-1, added words referencing Consent Decree for TWRWP requirements
- pgs 4-6 and 4-14, adds in words approved by Ecology in Modification Notice 2011-1
- pg 5-1, para 1, clarified Consent Decree applicability and updated TOC and contract number, last para, added words consistent with Ecology approved C-111 TWRWP
- pg 5-2, updated reference
- pg 5-7, changed form to from in item (4)
- pg 7-1, added reference to Consent Decree and made editorial change shown
- pgs 9-1, 9-2, 9-5 to 9-10, updated references

10. Impact of Change:

Change revises document to meet Consent Decree wording. If selected second technologies are not the desired ones to implement following bulk retrieval in a tank, another change(s) will be required to the document.

11. Additional Requirements and/or Provisions[1]: See attached 1 page attachment 1 with comment. [signature] 9.20.11

Approvals

Washington River Protection Solutions, LLC.	Office of River Protection	State of Wash., Dept. of Ecology
☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date
☒ Final Approval John [signature] per telecon for Kent Smith Date 6/16/11	☒ Final Approval [signature] Date 7/6/11	☐ Final Approval [signature] Date 9-20-11

Notes

[1] – For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision
2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 11, prior to final approval of this modification.

Additional page to Modification Notice Number 2011-2 for

RPP-22393, REVISION 5, 241-C-102, 241-C-104, 241-C-107, 241-C-108, and 241-C-112 TANKS STE RETRIEVAL WORK PLAN

#11 Additional Requirements and/or Provisions

Approval is given with the understanding that:

1. Section 2.1 RETRIEVAL START DATES will be updated with the most current planned retrieval start dates as communicated in the last TPA Project Managers Meeting. Revision 5 currently lists some **out-of-date** planned start dates for waste retrieval operations:
   a) C-102: November 2012
   b) C-104: began in January 2010 *[no restart date is given]*
   c) C-107: June 2011
   d) C-108: hard heel removal-January 2011
   e) C-112: October 2011

Ecology will be notified, in the TPA Project Managers Meeting, if the retrieval start dates are changed.

2. RPP-22393 will be changed as indicated in the disposition of the attached RCR comments.
3. Ecology is anticipating another RPP-22393 modification notice to include reference to a Definition for Limit of Technology (LOT) For Modified Sluicing document, with additional text to be added to the TWRWP that describes the USDOE process for determining LOT for other technologies.
4. Correspondence 0401281, in RCR comment #1 is 04-TPD-083, "Agreement on Content of Tank Waste Retrieval Work Plans, dated Aug. 20, 2004
5. In RPP-22393, reference to RPP-21753, *C Farm 100 Series Tanks, Retrieval Process Flowsheet Description*, Rev. 1, CH2MHILL will be removed where it is no longer applicable.
6. ORP/WRPS will continue to forward to Ecology the retrieval operations status reports that include
   a) estimated waste retrieved
   b) estimated waste remaining
   c) estimated water used
   d) estimate supernate transferred to the SST
   e) summary of recent operations
7. The following references are in the Ecology library and do not need to be added to the RCR form:
   a) TFC-ENG-FACSUP-CD-22, *Post Retrieval Tank Waste Volume Determination*
   b) TFC-ENG-CHEM-P-47, *Single-Shell Tank Retrieval Completion Evaluation.*
   c) TFC-ENG-DESIGN-C-32, *Spreadsheet Development and Verification*

REVIEW COMMENT RECORD (RCR)

1. Date 8/4/11	2. Review No.
3. Project No.	4. Page

5. Document Number(s)/Title(s)	Project Manager Name	Reviewer Name		
RPP-22393, Revision 6, **241-C-102, 241-C-104, 241-C-107, 241-C-108 AND 241-C-112 TANKS WASTE RETRIEVAL WORK PLAN**	Chris Kemp	Jeff Lyon Nancy Uziemblo		

	10. Agreement with indicated comment disposition(s)	
Organization Manager (Optional)	Reviewer/Point of Contract Date Author/Originator	Reviewer/Point of Contact Date Author/Originator

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/resolve the discrepancy/problem indicated.)	14. Reviewer Concurrence Required	15. Disposition (Provide justification if NOT accepted.)	16. Status
1.	Entries in red added by WRPS for clarity. (A) Include a section following 3.1.3 titled "Performance Monitoring and Measurement"		Rejected. The Consent Decree does not require a Performance Monitoring and Measurement section describing methods for estimating the performance of each technology in the TWRWP. Required TWRWP content can be found in three places 1) the Consent Decree, 2) Appendix I, and 3) Correspondence 0401281. (A) The requested information in the rest of Comment 1 is provided below for information purposes only in response to this comment.	Closed See notes 1, 2, and 3

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	3. Project No. N/A	4. Page 2 of 11

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/resolve the discrepancy/problem indicated.)	14. Reviewer Concurrence Required	15. Disposition (Provide justification if NOT accepted.)	16. Status
			The requested section is not addedto the TWRWP because adding such information would unduly restrict the ability of DOE-ORP and the TOC to make changes in the method, equipment, and procedures as needed.	
	Include (B) the monitoring measurements/systems,		(B) The monitoring measurement/systems currently planned for installation and use in measuring retrieval performance include: a receiving DST level gauge; a flowmeter/totalizer on the slurry line out of the SST; a flowmeter/totalizer on the liquid line into the SST; flowmeter(s)/ totalizer(s) on the water line(s) used; video camera(s) in the tank headspace; and local time indication device(s).	
	(C) methods, and		(C) The method(s) planned to be used include, but may not be limited to: 1) estimation of the volume of SST waste removed based upon DST level change as measured between time periods when the SST liquid is pumped down to comparable levels, minus the water added to the system in the time period; and/or 2) estimation of the concentration of waste in the slurry out of the tank; and/or 3) estimation of the volume of SST waste removed based upon	

A-6400-090.1 (03/9

REVIEW COMMENT RECORD (RCR)	1. Date 8-4-11	2. Review No.
	3. Project No. N/A	4. Page 3 of 11

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/resolve the discrepancy/problem indicated.)	14. Reviewer Concurrence Required	15. Disposition (Provide justification if NOT accepted.)	16. Status
			visual observation at different times; and/or 4) estimation of the volume of SST waste removed based upon volume displacement measurements. The concentration of waste in the slurry out of the tank may be measured by the volume of SST waste into the DST divided by the slurry volume, or by comparison between inlet and outlet flowmeter values. During retrieval operations Ecology receives status reports daily that include: estimated waste retrieved; estimated waste remaining; estimated water used; estimated supernate transferred to the SST; and a summary of recent operations. From these reports rate and percent complete can be estimated. The TWRWP contains information regarding tracking and monitoring retrieval in Section 3.1.3 and, although not required, the definition of "limit of technology" from the Consent Decree has been added to Section 3.1.3.	
	(D) estimating procedures that will be used for estimating each technology performance for each tank to: (1) obtain the CD volume goal (include both (a) active retrieval and		(D)(1)(a) During active retrieval operations data are collected and calculations performed in an Excel file filled out by engineering	

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12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/resolve the discrepancy/problem indicated.)	14. Reviewer Concurrence Required	15. Disposition (Provide justification if NOT accepted.)	16. Status
	(b) post retrieval), (2) and if different monitoring measurements/systems, methods, and estimating procedures will be used for determining "limits of technology", please include those		personnel. This file will be similar for each tank, although C-107 will likely have additional data points because it has more and slightly different flowmeters/totalizers. There are no written procedures for filling out the Excel file, it is filled out by knowledgeable personnel and the data reviewed and verified. The file normally goes through a software verification at key points (e.g., at 50% retrieved, etc.) within the process. Software verification is done per TFC-ENG-DESIGN-C-32, Spreadsheet Development and Verification. A copy of which is attached to this RCR response. Procedures/methods used for monitoring equipment performance are revised as needed and a description of them have no place in a TWRWP. D)(1)(b) The post retrieval volume determination is performed following procedure TFC-ENG-FACSUP-CD-22, *Post Retrieval Tank Waste Volume Determination* and TFC-ENG-CHEM-P-47, *Single-Shell Tank Retrieval Completion Evaluation*. Attached to this RCR response are copies of each procedure. (D)(2)(a) Monitoring methods are	

REVIEW COMMENT RECORD (RCR)

	1. Date 8-4-11	2. Review No.
	3. Project No. N/A	4. Page 5 of 11

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/resolve the discrepancy/problem indicated.)	14. Reviewer Concurrence Required	15. Disposition (Provide justification if NOT accepted.)	16. Status
	(include both (a) active retrieval and (b) post retrieval),		not used for determining "limits of technology" during active retrieval operations. Monitoring methods are used to measure system performance using the equipment and methods as described above in (B), (C), and (D)(1)(a). The information obtained on the system performance is used to determine when a "limit of technology" is met. (D)(2)(b) There are no "limits of technology" for post-retrieval as there are no retrieval operations taking place (D)(3)(a-d) There are no alternate methods, currently planned to be used other than those described above. It is beyond the scope of a TWRWP and this RCR to list all potential failures and the alternate equipment which may be used to obtain information should the equipment not be repairable.	

A-6400-090.1 (03/99)

REVIEW COMMENT RECORD (RCR)

1. Date 8-4-11	2. Review No.
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12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/resolve the discrepancy/problem indicated.)	14. Reviewer Concurrence Required	15. Disposition (Provide justification if NOT accepted.)	16. Status
	3) if alternate methods will be employed or considered if the primary methods or equipment fails, please include the description of those (a) monitoring measurements/systems, (b) methods, and (c) estimating procedures and (d) the basis for implementing these methods.			
2.	IN RETRIEVAL START DATES Add Completion date as specified in the Decree, Appendix B, Project B-1 is 9/30/2014.		Accepted but modified. See redline strikeout page 2-1.	Closed
3.	Entries in red added by WRPS for clarity. Add to section 3.0 the **bold** sections below: If required to meet the tank residual waste conditions in the Decree, the second technology for C-102, C-104, C-108 or C-112 will be a chemical retrieval process. (A)**Should the chemical retrieval process as the second technology not be the preferred method when the primary technology has been deployed to its limits, a TWRWP change will be made to seek approval for the different technology.** (B)**This chemical retrieval process is considered to be a series of steps designed to remove as much waste as possible. The steps, in part, are determined by the remaining waste volume and physical and chemical composition. The chemical retrieval process will include one or more steps until the limit of technology for the chemical retrieval process has been reached.** Ecology will be informed of the pre-retrieval estimated volume of liquids to be added to the tank prior to the initial additions. **(C)The limit of technology for the chemical retrieval process will follow the Decree (page 37) definition:** **"The 'limits of technology' means that the recovery rate of that retrieval**		(A) Accepted but modified. See redline strikeout section 3.3 page 3-25. (B) Accepted but modified, see redline strikeout section 3.1.4, page 3-16. (C) Accepted see redline strikeout	Closed

REVIEW COMMENT RECORD (RCR)

1. Date 8-4-11	2. Review No.
3. Project No. N/A	4. Page 7 of 11

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/resolve the discrepancy/problem indicated.)	14. Reviewer Concurrence Required	15. Disposition (Provide justification if NOT accepted.)	16. Status
	technology for that tank is, or has become, limited to such an extent that it extends the retrieval duration to the point at which continued operation of the retrieval technology is not practicable, with the consideration of practicability to include matters such as risk reduction, facilitating tank closures, costs, the potential for exacerbating leaks, worker safety, and the overall impact on the tank waste retrieval and treatment mission."		section 3.1.3 page3-15.	
	(D)In addition, in accordance with the Decree, Appendix C, Part 1: "If the waste residual goal of 360 cubic feet is not achieved using the established two technologies, an additional retrieval technology established in a revised TWRWP shall be deployed to the "limits of technology;" provided that DOE may request that the State agree that DOE may forego implementing a third retrieval technology if DOE believes implementing such technology is not practicable under the criteria set forth above [in Appendix C, Part 1 of Decree]. If DOE and Ecology are unable to reach agreement, the resolution of the issue of whether a third retrieval technology shall be deployed shall be resolved through the dispute resolution process set forth in Section IX of this Decree."		(D) No change required. This definition is already included in redline strikeout section 3.0 page 3-1.	
	The primary technology for C-107 will be sluicing. The second technology will be high-pressure water spray. Both of these technologies will be deployed via MARS-S. (E)**The MARS-S is a mobile arm capable of rotating and extending in the tank. The head of the arm is equipped with two technologies (supernate nozzles and high pressure water spray nozzles) to mobilize the waste and direct it to a pump for removal.**		(E) Accepted but modified see redline strikeout section 3.1.1, page 3-2 and section 3.0, 3-1.	
	(F)The MARS-S is designed to implement both the primary and the secondary technology without any additional installations. The primary technology is a low pressure/sluicing with supernate; the secondary technology is the addition of a high pressure water spray.		(F) Accepted but modified. See redline strikeout section 3.0, page 3-1.	
	(G)For determination of "Limit of Technology", data will be used after		(G) Accepted but modified. See redline strikeout section 3.1.3,	

REVIEW COMMENT RECORD (RCR)

1. Date 8-4-11	2. Review No.
3. Project No. N/A	4. Page 8 of 11

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/resolve the discrepancy/problem indicated.)	14. Reviewer Concurrence Required	15. Disposition (Provide justification if NOT accepted.)	16. Status
	implementation of both of low pressure and high pressure operations (each technology will not be evaluated for its limit of technology separately). **(H)In accordance with the Decree, Part IV, B., 5: "When DOE completes retrieval of waste from a tank covered by this Decree, DOE will submit to Ecology a written certification that DOE has completed retrieval of that tank. For purposes of this Consent Decree, "complete retrieval" means that retrieval of tank waste in accordance with Part 1 of Appendix C and with the retrieval technology/systems that were established by Part 1 of the TWRWP either by approval of Ecology or after dispute resolution by the Court under Section IX of the Decree."**		page 3-15. (H) Accepted, see redline strikeout section 3.1.3, page 3-16.	
4.	Add to section 3.1.3 Ecology is **notified** when it appears that the limits of technology have been reached.		Accepted but modified. See redline strikeout section 3.1.3, page 3-15.	Closed
5.	**IN TECHNOLOGIES CONSIDERED AND RATIONALE FOR SELECTION** Candidate waste retrieval technologies currently available for deployment at tanks C-102, C-104, C-107, C-108, and C-112 are (1) modified sluicing, (2) the mobile retrieval system, and (3) the MARS. Consider: At this location in the report, clarify what technologies will be used for each tanks and why they were selected for each tank.		No change required. See redline strikeout section 3.3 paragraph 6 on page 3-24.	Closed
6.	**IN TECHNOLOGIES CONSIDERED AND RATIONALE FOR SELECTION** The second technology alternatives, should one be required for residual waste removal following modified sluicing, are an in-tank vehicle and chemical dissolution. Consider in adding clarification on chemical technology vs. chemical retrieval process and/or chemical dissolution.		Accepted but modified. See redlines strikeout section 3.3, page 3-24.	Closed

REVIEW COMMENT RECORD (RCR)

1. Date 8-4-11	2. Review No.
3. Project No. N/A	4. Page 9 of 11

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/resolve the discrepancy/problem indicated.)	14. Reviewer Concurrence Required	15. Disposition (Provide justification if NOT accepted.)	16. Status
	For example in the locations highlighted in yellow: Chemical retrieval **process** is preferable for heels where the volume is relatively low so the impact on DST space and the WTP throughput volume is less. **The** chemical retrieval **process** may also be preferable if the particles are small because the surface area for dissolution is greater and an in-tank vehicle may just push the fine particles around the tank. **The** chemical retrieval **process** was selected as the second technology for C-104 and C-108 as it can be deployed in less time than an in-tank vehicle and because it is believed the estimated residual heel volume could be chemically reduced to below 360 ft^3 without causing a significant impact to the available DST space or the WTP throughput volume. **The** chemical retrieval **process** was selected as the second technology for C-102 and C-112 as it can be deployed in less time than an in-tank vehicle when the primary technology is no longer effective and the tank residual waste volume in the Decree is exceeded.			
7.	**IN TECHNOLOGIES CONSIDERED AND RATIONALE FOR SELECTION** Add: **The primary and second technologies have been selected based on the anticipated success of reaching their "limits of technology" in an effort to obtain a waste residue goal of 360 cubic feet of waste or less for each tank, as defined in the Decree (page 37): definition:** **"The 'limits of technology' means that the recovery rate of that retrieval technology for that tank is, or has become, limited to such an extent that it extends the retrieval duration to the point at which continued operation of the retrieval technology is not practicable, with the consideration of practicability to include matters such as risk reduction, facilitating tank closures, costs, the potential for exacerbating leaks, worker safety, and the overall impact on the tank waste**		Accepted but modified. See redline strikeout section 3.3, page 3-25.A reference to section 3.1.3 and the limit of technology definition is made rather than repeating the limit of technology definition.	Closed

<table>
<tr><td colspan="4">REVIEW COMMENT RECORD (RCR)</td><td colspan="2">1. Date 8-4-11
3. Project No. N/A</td><td>2. Review No.
4. Page 10 of 11</td></tr>
<tr><td>12. Item</td><td colspan="3">13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/resolve the discrepancy/problem indicated.)</td><td>14. Reviewer Concurrence Required</td><td>15. Disposition (Provide justification if NOT accepted.)</td><td>16. Status</td></tr>
<tr><td></td><td colspan="3"><u>retrieval and treatment mission.”</u></td><td></td><td></td><td></td></tr>
<tr><td>8.</td><td colspan="3">IN ANTICIPATED PERFORMANCE GOALS
add <u>bold</u> highlighted words:
The WRS for tanks C-102, C-104, C-107, C-108, and C-112 will be <u>designed to deploy the selected technologies to each of their “limits of technology” in an effort to obtain a waste residue goal of 360 cubic feet of waste or less for each tank. The limit of technology will follow the Decree (page 37).</u>in accordance with the requirements of the Decree.</td><td></td><td>Accepted, but modified. See redline strikeout section 3.4, page 3-25.</td><td>Closed</td></tr>
<tr><td>9.</td><td colspan="3">In table 3-4, add <u>bold</u> highlighted words:<table><tr><td>Remove waste from tanks C-102, C-104, C-107, C-108, and C-112</td><td>The WRS shall be <u>designed to deploy the selected technologies to each of their “limits of technology” in an effort to obtain a waste residue goal of 360 cubic feet of waste or less for each tank. The limit of technology will follow the Decree</u></td><td>WAC 173-303 Decree</td><td>The WRS shall provide the ability to retrieve <u>a waste residue goal of 360 cubic feet of waste or less for each tank.</u></td></tr></table></td><td></td><td>Accepted, but modified. See redline strikeout section 3.6, page 3-26.</td><td>Closed</td></tr>
</table>

Final Notes

Based on modification notice 2011-02 Ecology additional requirements (section 11) the following changes were made:

- Retrieval start dates were updated in section 2.1
- The references to RPP-21753 were deleted in sections 7.1.1.2 and 7.1.3.1 and the appropriate appendices referenced because the appendices have more current information for retrieval leak concentrations.

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1. Correspondence 0401281 is jointly recognized as 04-TPD-083 Agreement on Content of Tank Waste Retrieval Work Plans.
2. The TOC will continue to inform Ecology of retrieval status as noted in the response to comment 1 and modification notice additional requirements.
3. Ecology has acknowledged that the documents identified in response to comment 1 have been received and do not need to added as an attachment to this RCR.

A-6400-090.1 (03/99)

The pages attached to Change Notice 2011-02 are omitted here for the sake of brevity. A red-line strike out document was transmitted to Ecology attached to correspondence 11-TF-094.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

1. Document Title and Number: RPP-22393, Rev. 5, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tanks Waste Retrieval Work Plan		
2. Minor Field Change: (Section 12.4 HFFACO Action Plan) □ Yes: (WRPS Signature Only – Attach signed form to Primary Document for record purposes) X No: Proceed to Box 3	**3.** Document Issue Date: 11/30/10 **4.** Document Modification Notice Date: 8/2/11	**5.** Notice Number: 2011-3
6. Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?) □ Yes X No	**7.** Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan? □ Yes X No	**8.** (Check only one box) □ Significant Modification (Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.) Minor Modification X Requires modification of the document X Can be accomplished with Modification Notice.

9. Description and Justification of Change:

Change Description: RPP-22393, Rev 5, Appendix C, uses an AN-106 supernate nitrite concentration of 2.55 E+04 mg/L for a leak during retrieval. This number is increased to 3.2 E+04 mg/L. This 25% proportional impact will be reflected on Figure C-3, in Table C-1, and in Section C2.3.

Justification: The current concentration assumes the C-108 heel is retrieved into AN-106 before C-107 retrieval. Recent schedule changes now show C-107 retrieval may precede C-108 retrieval. Without the C-108 liquid addition to AN-106 the higher current AN-106 nitrite concentration is conservatively assumed for a leak.

10. Impact of Change:
None.

11. Additional Requirements and/or Provisions[1]: 1) units changed to mg/L in box 9 per telecom with J Schofield, 8/29/11 ; 2) footnote a in Table C-1 changed to 2011

Approvals

Washington River Protection Solutions, LLC.	Office of River Protection	State of Wash., Dept. of Ecology
□ Provisional Approval[2] Date	□ Provisional Approval[2] Date	□ Provisional Approval[2] Date
☑ Final Approval [signature] Date 8/2/11	☑ Final Approval [signature] Date 8/11/11	□ Final Approval [signature] Date 8-24-11

tes
For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision
2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 11, prior to final approval of this modification.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

1. Document Title and Number: RPP-22393, Rev. 5, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tanks Waste Retrieval Work Plan		
2. Minor Field Change: (Section 12.4 HFFACO Action Plan) ☐ Yes: (WRPS Signature Only – Attach signed form to Primary Document for record purposes) X No: Proceed to Box 3	**3.** Document Issue Date: 11/30/10 **4.** Document Modification Notice Date: 9/27/11	**5.** Notice Number: 2011-5
6. Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?) ☐ Yes X No	**7.** Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan? ☐ Yes X No	**8.** (Check only one box) ☐ Significant Modification (Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.) Minor Modification X Requires modification of the document X Can be accomplished with Modification Notice.

9. Description and Justification of Change:

Change Description: Delete existing words on limit of technology in RPP-22393, Rev 5, Section 3.1.3 as shown on attached redline-strikeout pages and insert new limit of technology words as shown. Revise references section of document accordingly.

Justification: The wording changes on the attached redline-strikeout pages were agreed to in a meeting between DOE and Ecology on 10/5/11. On 9/27/11 Ecology verbally agreed to accept a 0.6 volume percent waste concentration in the waste slurry stream as the limit of technology for modified sluicing. This value was derived in a white paper provided to Ecology in 2010. It was agreed to by Ecology, DOE, and the TOC in the same meeting on 9/27/11 that this white paper should be issued as a referenceable document and that the TWRWP would be revised to refer to this document as the basis for a modified sluicing limit of technology. Subsequent to this agreement, at the 9/27/11 TPA Project Managers' Meeting, Ecology reiterated this agreement for the Administrative Record.

10. Impact of Change:
None.

11. Additional Requirements and/or Provisions[1]: Modification approved with attached changes to justification. [illegible] 10-11-11 (redline)

Approvals

Washington River Protection Solutions, LLC.	Office of River Protection	State of Wash., Dept. of Ecology
☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date	☒ Provisional Approval[2] Date
☒ Final Approval [signature] Date 10/6/11	☒ Final Approval [signature] for Tom Fletcher Date 10/7/2011	☒ Final Approval [signature] Date 10-11-11

Notes

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Modification Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision
2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 11, prior to final approval of this modification.

Below is the revision to section 9 of the modification notice provided by Ecology.

RPP-22393, Rev. 5, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tanks Waste Retrieval Work Plan

Notice Number: 2011-5

October 13, 2011

9. Description and Justification of Change:
Change Description: Delete existing words on limit of technology in RPP-22393, Rev 5, Section 3.1.3 as shown on attached redline strikeout pages and insert new limit of technology words as shown. Revise references section of document accordingly.
Justification: The wording changes on the attached redline-strikeout pages were agreed to in a meeting between DOE and Ecology on 10/5/11. On 9/27/11 Ecology verbally agreed to accept a 0.6 volume percent waste concentration in the waste slurry stream as the limit of technology for modified sluicing. This value was derived in a white paper provided to Ecology in 2010. **Ecology emphasized the need to complete an evaluation of risk associated with the remaining waste to improve our understanding of when to stop the selected retrieval technology. Until an evaluation of risk is available, i**t was agreed to by Ecology, DOE, and the TOC in the same meeting on 9/27/11 that this white paper should be issued as a referenceable document and that the TWRWP would be revised to refer to this document as the basis for a modified sluicing limit of technology. Subsequent to this agreement, at the 9/27/11 TPA Project Managers' Meeting, Ecology reiterated this agreement for the Administrative Record.

10-13-11

of these occur and the waste not breakup effectively when hit with solution from the sluicing nozzles, adding liquid to the waste surface may be tried to soften it for retrieval. Liquid breaks down the bonds in dried out waste or dissolves most salt crystals. The supernate used will not be saturated at the start of retrieval in a tank and thus will be expected to dissolve such salts or break the crystal structure down sufficiently to permit retrieval.

The volume of free liquid added to soften any waste would be minimized by keeping the free liquid height above the waste to as small as practical. Any free liquid added beyond this would provide little benefit. The time period needed to soften the waste is unknown, but would not be expected to be more than a few hours to a few days.

Pumping during sluicing will maintain minimum liquid volume in the tanks. This will be performed by initially directing the nozzle flow towards the center of the tanks. As the sluice liquid contacts the tank waste, the sludge will be mobilized and retrieved via the slurry pumps. Typically, one sluicer will be operated at a time operating at a flow rate of approximately 60 to 120 gal/min.

When needed, the in-tank vehicle will be lowered through a riser to the tank bottom. It will be moved about the tank with the blade employed as needed to push waste towards the pump inlet. The high pressure water nozzles will be used as needed to break up and mobilize the waste. The vehicle tracks may also break up some of the waste agglomerations.

During all field activities, standard operating procedures and safety precautions will be implemented to protect worker health and safety, the public, and the environment. In accordance with standard operating procedures, health physics and industrial health technicians will monitor conditions within the tank farm in accordance with approved monitoring plans.

When the level of residual solids gets low in the tank, the volume of solids removed per unit volume of sluicing fluid removed from the tank will be tracked. The units used will be selected by engineering personnel. Waste retrieval operations will continue ~~until~~ in an effort to obtain the goal of 360ft^3 or less ~~than 360 ft^3~~ of residual waste ~~remains~~ in the tank, and/or the limits of technology have been reached for this retrieval method. ~~The limit of technology will occur when there are little or no waste solids being removed per unit volume of sluicing fluid used.~~The project will determine when a tank retrieval is complete, by following the Consent Decree requirements stating "that the recovery rate of that retrieval technology for that tank is, or has become, limited to such an extent that it extends the retrieval duration to the point at which continued operation of the retrieval technology is not practicable, with the consideration of practicability to include matters such as risk reduction, facilitating tank closures, costs, the potential for exacerbating leaks, worker safety and the overall impact on the tank waste retrieval and treatment mission."

Until a risk evaluation is available, the limit of technology for modified sluicing is defined in RPP-50910, *Single-Shell Tank Waste Retrieval Limit of Technology Definition for Modified Sluicing* as when the concentration of SST waste in the retrieved slurry sent to the DST is within, or bracketing, the range of 0 to 0.6 volume percent.

There is no limit of technology definition for a MARS-S waste retrieval process. A limit of technology definition will not be developed until sufficient MARS-S retrieval operations have been performed to enable development of a justifiable definition. Until a MARS-S limit of technology definition is developed the same value used for modified sluicing in RPP-50910 is applied to MARS-S retrieval operations.

There is no limit of technology definition for a chemical retrieval process. A limit of technology definition will not be developed until sufficient chemical heel retrieval operations have been performed to enable development of a justifiable definition. It is estimated that this will take 3 to 4 heel retrieval operations.

~~The following information will be used to evaluate termination of retrieval and will be shared with Ecology before a decision to terminate field retrieval activities:~~

- ~~System performance and efficiency data~~
- ~~In-tank visual confirmation of tank condition and waste retrieval~~
- ~~Preliminary volume estimates using tank geometry and in-tank structural features~~
- ~~Presentation and discussion of alternate system configurations and process modifications to enhance retrieval performance~~
- ~~Presentation and discussion of residual sample location.~~

~~TFC-ENG-CHEM-P-47, *Single-Shell Tank Retrieval Completion Evaluation*, provides the methodology to follow for determining when an SST undergoing waste retrieval has reached the end of the retrieval process. Following is a summary of this procedure. This summary does not take the place of TFC-ENG-CHEM-P-47; for any differences between this summary and the latest version of the procedure, the procedure takes precedence. Refer to TFC-ENG-CHEM-P-47 for details of the summary steps.~~

~~When waste retrieval starts, engineering personnel will begin tracking retrieval performance (i.e., percent of waste retrieved) and provide a weekly status report. Weekly status information will be forwarded to Ecology to brief them on retrieval activities, including residual volume estimates and performance parameters. Ecology will be invited to view waste retrieval activities and video images of the in-tank operations.~~

~~Engineering shall recommend configuration or procedure changes to enhance recovery as warranted. Management is notified after performance efficiency reduces to about 10% of the starting retrieval performance.~~

~~An attachment to the procedure provides guidance for retrieval performance and limit of technology evaluations. Establishment of when the limits of technology have been reached includes:~~

- ~~Examination of in-tank images to observe/record waste contours and characteristics~~

- ~~Estimation of waste retrieval performance efficiency and remaining waste volume~~
- ~~Using performance data to demonstrate that a consistent pattern is present indicating limits of technology have been reached~~
- ~~Evaluation of waste retrieval performance against system limitations.~~

Ecology is ~~notifi~~informed when it appears that the limits of technology have been reached. Status reports are continued until waste retrieval operations cease. An SST waste retrieval evaluation form and a retrieval report are then prepared and issued.

Following completion of waste retrieval and final tank flushing, the residual waste volume will be determined using the methodology defined in RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*, and RPP-PLAN-23827, *Sampling and Analysis Plan for Single-Shell Tanks Component Closure*.

3.2 LIQUID ADDITIONS DURING WASTE RETRIEVAL

Supernate from DST AN-101, AN-106, or AZ-101 will be introduced to tanks C-102, C-104, C-107, C-108, and C-112 to mobilize sludge. Supernate will be added at a rate of approximately 60 (or less) to 120 gal/min. The retrieval liquid, along with tank solids, will be removed from these tanks at approximately the same rate. Utilizing recycled supernate to retrieve the waste from the tanks will minimize the overall volume of waste generated during the waste retrieval process. The modified sludge sluicing process will minimize the volume of liquid in the SST during waste retrieval operations.

The use of supernate will be limited by the following:

1. The waste compatibility assessment for supernate recycle will be completed and reported to Ecology. This compatibility assessment shall be made to determine if the solution is acceptable for use in retrieving the SST solids. Ecology will be notified of the results of this assessment, before initiation of retrieval operations. Following notification of the results of this assessment, a copy of the assessment report shall be provided to Ecology

2. Submittal of a retrieval data report, as described in the HFFACO Action Plan, Appendix I, Section 2.0, Figure I-1, 120 days following DOE's completion of retrieval actions for each tank. That report shall include a review of the efficiency and performance of the in-tank settling of the retrieved solids in the receiving DST, an estimate of the amount of solids that were recycled during waste retrieval, and the impacts those solids have on removing additional solids from the SSTs.

3. Should the SST be shown to leak during the retrieval process, a liquid sample will be taken if needed to verify the ^{99}Tc concentration in the DST supernate used for sluicing.

1212018

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Change Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

<table>
<tr><td colspan="3">1. Document Title and Number: RPP-22393, Rev. 6, 241-C-102, 241-C-104, 241-C-107, 241-C-108, and 241-C-112 Tanks Waste Retrieval Work Plan</td></tr>
<tr><td rowspan="2">2. Minor Field Change: (Section 12.4 HFFACO Action Plan)
☐ Yes: (WRPS Signature Only – Attach signed form to Primary Document for record purposes)

X No: Proceed to Box 3</td><td>3. Document Issue Date:

11/30/11</td><td rowspan="2">5. Notice Number: 2012-02

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FEB 16 2012
EDMC</td></tr>
<tr><td>4. Document Modification Notice Date: 2/13/12</td></tr>
<tr><td>6.
Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?)

☐ Yes X No</td><td>7.
Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan?

☐ Yes X No</td><td>8. (Check only one box)
☐ Significant Modification
(Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.)
Minor Modification
X Requires modification of the document
X Can be accomplished with Modification Notice.</td></tr>
</table>

9. Description and Justification of Change:

Change Description: A change is needed to reduce the volume of rinse water required after retrieval that does not use supernate. Other minor updates are included to provide consistency with other TWRWPs

Justifications:

- 3.1.3 clarified that softening pre-soaks may be a few days or longer.
- Section 3.2 added a clarification to allow for reducing heel rinse volumes.
- Section 4.6.1 clarified that liquid inventories will be removed during sluicing operations.

See the attached redline strikeout

10. Impact of Change:

The change allows the Tank Operations Contractor to conserve double shell tank space for other retrieval activities. After sluicing with supernate was discontinued in C-108 there was a 6,800 gallon heel. The TWRWP currently requires that a tank heel with residual supernate be rinsed with 3 heel volumes 3 times; which for C-108 would require 9 X 6,800 = 61,200 gallons. A comparable rinse of the heel has been done in C-108 already since using supernate. Approximately 12,500 gallons of water was used to flush equipment and rinse the sodium from the heel. Approximately 78,300 gallons was used for natrophosphate dissolution. Another 20,000 gallons of non-supernate (sodium hydroxide and water) will be used for gibbsite dissolution. The soluble supernate constituents will be rinsed from the heel with more volume than the prescribed triple rinse.

11. Additional Requirements and/or Provisions[1]:
Provide assurance that USDOE will collect samples using the off riser sampler.

WMAC

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Change Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

Approvals		
Washington River Protection Solutions, LLC.	Office of River Protection	State of Wash., Dept. of Ecology
☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date
☑ Final Approval Date 2/14/12	☒ Final Approval Date 2/16/2012	☒ Final Approval Date 2-16-2012

note requirement on 1st page

Notes

1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision

2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 11, prior to final approval of this modification.

could also be held together with salt crystals from supernate that had evaporated. Should either of these occur and the waste not breakup effectively when hit with solution from the sluicing nozzles, adding liquid to the waste surface may be tried to soften it for retrieval. Liquid breaks down the bonds in dried out waste or dissolves most salt crystals. The supernate used will not be saturated at the start of retrieval in a tank and thus will be expected to dissolve such salts or break the crystal structure down sufficiently to permit retrieval.

The volume of free liquid added to soften any waste would be minimized by keeping the free liquid height above the waste to as small as practical. Any free liquid added beyond this would provide little benefit. The time period needed to soften the waste is unknown~~,~~; ~~but would not be expected to be more than a few hours~~ it is expected to be a few days or longer.

Pumping during sluicing will maintain minimum liquid volume in the tanks. This will be performed by initially directing the nozzle flow towards the center of the tanks. As the sluice liquid contacts the tank waste, the sludge will be mobilized and retrieved via the slurry pumps. Typically, one sluicer will be operated at a time operating at a flow rate of approximately 60 to 120 gal/min.

During all field activities, standard operating procedures and safety precautions will be implemented to protect worker health and safety, the public, and the environment. In accordance with standard operating procedures, health physics and industrial health technicians will monitor conditions within the tank farm in accordance with approved monitoring plans.

When the level of residual solids gets low in the tank, the volume of solids removed per unit volume of sluicing fluid removed from the tank will be tracked. The units used will be selected by engineering personnel. Waste retrieval operations will continue in an effort to obtain the goal of 360 ft^3 or less of residual waste remains in the tank, and/or the limits of technology have been reached for this retrieval method. The project will determine when a tank retrieval is complete by following the Consent Decree requirements stating "that the recovery rate of that retrieval technology for that tank is, or has become, limited to such an extent that it extends the retrieval duration to the point at which continued operation of the retrieval technology is not practicable, with the consideration of practicability to include matters such as risk reduction, facilitating tank closures, cost, the potential for exacerbating leaks, worker safety and the overall impact on the tank waste retrieval and treatment mission."

Until a risk evaluation is available, the limit of technology for modified sluicing is defined in RPP-50910, *Single-Shell Tank Waste Retrieval Limit of Technology Definition for Modified Sluicing* as when the concentration of SST waste in the retievaed slurry sent to the DST is within, or bracketing, the range of 0 to 0.6 volume percent.

There is no limit of technology definition for a MARS-S waste retrieval process. A limit of technology definition will not be developed until sufficient MARS-S retrieval operations have been performed to enable development of a justifiable definition. Until a MARS-S limit of technology definition is developed the same value used for modified sluicing in RPP-50910 is applied to MARS-S retrieval operations.

this assessment, before initiation of retrieval operations and a copy of the assessment report shall be provided to Ecology

2. Submittal of a retrieval data report, as described in the HFFACO Action Plan, Appendix I, Section 2.0, Figure I-1, 120 days following DOE's completion of retrieval actions for each tank. That report shall include a review of the efficiency and performance of the in-tank settling of the retrieved solids in the receiving DST, an estimate of the amount of solids that were recycled during waste retrieval, and the impacts those solids have on removing additional solids from the SSTs.

3. Should the SST be shown to leak during the retrieval process, a liquid sample will be taken if needed to verify the ^{99}Tc concentration in the DST supernate used for sluicing.

4. Should a DST sample be required during the C-102, C-104, C-107 or C-112 retrieval process for corrosion control or other reasons, a ^{99}Tc analysis will be requested on the sample. A DST sample has already been obtained during the C-108 retrieval process.

5. Ecology will be informed by email when the cumulative volume of supernate liquid being recycled exceeds the estimated quantity of 1 million gal., and for each incremental 1 million gal. recycled.

6. Following the use of supernate, a minimum of three tank heel rinses using a minimum volume of raw water that is three times the estimated residual waste volume will be required to ensure that residual waste is removed to the extent practical. If the TOC shows that a comparable reduction in soluble supernate constituents has been accomplished through other retrieval actions, the rinse may be omitted.

When adding liquid to the SST for the sole purpose of obtaining a waste level measurement, the following conditions apply:

1. The HRR leak detection system for the tank described in Section 4.2.1 must be continuously operable for at least 48 hours prior to the liquid addition.
2. The benchmark level described in Section 4.6.1 will not be exceeded during the liquid addition.
3. Excess liquid will be removed from the tank as soon as practical once a usable waste level measurement is obtained.
4. The liquid to be used for volume displacement measurement should only be supernate. Use of raw water for volume displacement instead of or in addition to supernate shall be discussed with Ecology prior to use.

A process flowsheet has been prepared for the C farm 100-series tanks (RPP-21753, *C Farm 100-Series Tanks, Retrieval Process Flowsheet Description*). The calculations performed in support of the flowsheet assume that the retrieved solids are about 3 vol% in the slurry transferred to the receiving DST. The waste retrieval process flowsheet estimate of the total liquid volume transferred during the sluicing of each tank is provided in Table 3-2. In addition, the flowsheet allocates a nominal 105,000 gal. of water for tank and equipment flushing during each tank's waste retrieval operations. Following the initiation of C-104 active retrieval operations, solutions currently contained in the CR vault sumps for Cells 1, 2, 3, and 11, and line

4.6 MITIGATION STRATEGY

Mitigation strategy including a response plan to a detected leak (identify responses to various leak rates) including notifications and provisions for obtaining approval of any remedial actions.

4.6.1 Leak Mitigation for Waste Retrieval Tank Leak

The leak mitigation strategy (i.e., reduction of leak loss potential) is to minimize the liquid volume within the tank during waste retrieval operations. Leak minimization for a waste retrieval tank leak will be provided by actions taken during waste retrieval. These include the following:

- The in-tank liquid inventory during waste retrieval will be less than liquid level present in the tank before interim stabilization activities were undertaken.
- Addition of liquid to the retrieval tank is minimized and liquid pools that form are removed as practical.
- Liquid inventories during sluicing retrieval operations will be removed between waste retrieval campaigns. Liquid inventories during heel removal operations will be maintained to the limits specified in the process control plan.
- Waste is retrieved to the extent practical by working from the center of the tank outwards.
- Evaluating HRR system data as specified in Section 4.2.1.3.
- Equipment handling controls are used to minimize the potential for dropping equipment into the tank, which could penetrate the tank bottom during installation.
- Maintaining a benchmark level in the tank. The waste level shall not exceed this benchmark. The benchmark level is defined in the process control plan.

If there is a need to operate the system longer than currently planned to demonstrate the limit of the technology to recover waste that is difficult to retrieve, the basic leak minimization step is still to limit the volume of any free liquid in the tank.

The 'timeliness' of any leak response action is dictated in part by how often the HRR data (or drywell monitoring data when used as a backup means of leak detection), are reviewed. Until a potential leak is noted there is no leak response, only the steps enumerated above to minimize the leak potential and leak volume. Anomalies noted during HRR data review are evaluated for leak potential. When this data review indicates an unexplained anomaly exists that may be caused by a potential tank leak, all liquid additions to the tank are stopped and the leak assessment process is begun.

The leak assessment process steps are:

1214393

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Change Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

1. Document Title and Number: RPP-22393, Rev. 6, 241-C-102, 241-C-104, 241-C-107, 241-C-108, and 241-C-112 Tanks Waste Retrieval Work Plan
1212098.

2. Minor Field Change: (Section 12.4 HFFACO Action Plan) ☐ Yes: (WRPS Signature Only – Attach signed form to Primary Document for record purposes) X No: Proceed to Box 3	3. Document Issue Date: 11/30/11 4. Document Modification Notice Date: 4/16/12	5. Notice Number: 2012-03
6. Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?) ☐ Yes X No	7. Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan? ☐ Yes X No	8. (Check only one box) ☐ Significant Modification (Check if the answer to question in either section 6 or 7 is "yes". Significant modifications require revision of the primary document.) Minor Modification X Requires modification of the document X Can be accomplished with Modification Notice.

9. Description and Justification of Change:

Change Description: A change is needed to identify the tank 241-C-102 will be retrieved into. Tank 241-AN-101 will be used as the supernate supply and receiver tank for sluicing 241-C-102 rather than 241-AZ-101. The groundwater risk calculations will be updated prior to the start of 241-C-102 retrieval after the 241-AN-101 constituents of concern are updated with mass of the constituents of concern from tanks that will be retrieved before 241-C-102.

Justifications:

- Section 3.1.1, changed Figure 3-1 to show 241-C-102 being retrieved into 241-AN-101.
- Section 3.1.3, pg 3-14—corrected a typo adding the word "when."
- Section 3.1.4, pg 3-13—corrected a typo to spell retrieved correctly.
- Section 3.2, pg 3-16—updated the timing for submitting the retrieval data report.
- Section 3.4, pg 3-23—corrected the reference from Table 3-3 to Table 3-2.
- Section 3.8, pg 3-27—updated reference
- Section 3.10 pgs 3-28 and 3-29—updated references
- Section 4.2.1.2, pg 4-12—added previously approved updates for ENRAF method of leak detection
- Section 4.6.1, pg 4-22—added previously approved clarification for minimizing volume in the SST
- Section 9—updated references

See the attached redline strikeout

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Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Change Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

10. Impact of Change: The change allows the Tank Operations Contractor to align the TWRWP with the most up to date retrieval plan with sufficient time to obtain EPA approval.		
11. Additional Requirements and/or Provisions[1]:		
Approvals		
Washington River Protection Solutions, LLC.	Office of River Protection LJK for Joni Grindstaff	State of Wash., Dept. of Ecology
☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date
☒ Final Approval Date 5/1/12	☒ Final Approval Date 5-3-12	☒ Final Approval Date 5-3-12

Notes

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2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 11, prior to final approval of this modification.

3.1.1 Physical System Description

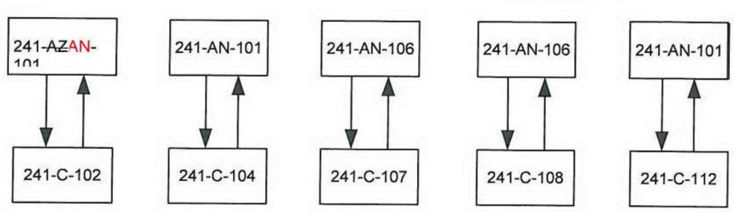
The WRS will consist of a modified sludge sluicing system to mobilize and retrieve waste from tanks C-102, C-104, C-108, and C-112. The sluicing system will consist of two (or more) sluice nozzles and a slurry pump in each tank. The sluice nozzles or hydraulic sluicers will be controlled from a control trailer located near the tanks. The sluice nozzles will be installed in existing tank risers. The sluice nozzles will have the capability to direct liquid at various locations in the tanks. The flow rate through the sluice nozzles will be adjusted based on the pump-out rate so that the rate of liquid introduction will approximately equal the rate of solution removal with the objective of minimizing the liquid waste volume in the retrieval tank.

The WRS for tank C-107 will be the Mobile Arm Retrieval System-Sluicing (MARS-S). Standard modified sluicing is maintained as an alternate WRS for C-107 in the event this first deployment of the MARS-S has to be halted. The MARS-S sluicing process consists of an extendable robotic arm suspended from a large central riser added to the tank and serves as the deployment platform for two separate retrieval technologies. The MARS-S is a mobile arm capable of rotating and extending in the tank. The system is equipped with two technologies to mobilize the waste and direct it to a pump for removal. For one technology, the end of the arm is equipped with sluice nozzles that direct supernate and/or water onto the waste surface from a short distance away, and directs the mobilized waste slurry backwards to a slurry pump. A second technology provided by the MARS-S is the addition of high pressure water spray nozzles that serve to break up hard waste agglomerations and direct them to the slurry pump. The slurry pump may use a backstop that can capture the slurry waste and is equipped with more supernate and water nozzles to further break the waste up for removal by the pump.

The waste retrieved from tanks C-102, C-104, C-107, C-108, and C-112 will be transferred to a DST. To minimize the overall volume of waste requiring storage in the DST system, the waste retrieval project plans to use DST supernate as the primary sluice liquid (see Section 3.1.2 for operating description). The WRS will also have the capability to use raw water for sluicing with valving change or minor modifications.

The waste retrieval plan as of October 2010 for using DSTs for waste receipt and as source tanks for supernate recycle is shown in Figure 3-1. The DSTs were selected based on their location, available space, and existing or planned equipment upgrades. Additional detail on the planned use of supernate during waste retrieval is discussed in Section 3.2.

Figure 3-1. Waste Retrieval Liquid Supply and Double-Shell Tank Receiver Tank Designation.



could also be held together with salt crystals from supernate that had evaporated. Should either of these occur and the waste not breakup effectively when hit with solution from the sluicing nozzles, adding liquid to the waste surface may be tried to soften it for retrieval. Liquid breaks down the bonds in dried out waste or dissolves most salt crystals. The supernate used will not be saturated at the start of retrieval in a tank and thus will be expected to dissolve such salts or break the crystal structure down sufficiently to permit retrieval.

The volume of free liquid added to soften any waste would be minimized by keeping the free liquid height above the waste to as small as practical. Any free liquid added beyond this would provide little benefit. The time period needed to soften the waste is unknown; it is expected to be a few days or longer.

Pumping during sluicing will maintain minimum liquid volume in the tanks. This will be performed by initially directing the nozzle flow towards the center of the tanks. As the sluice liquid contacts the tank waste, the sludge will be mobilized and retrieved via the slurry pumps. Typically, one sluicer will be operated at a time operating at a flow rate of approximately 60 to 120 gal/min.

During all field activities, standard operating procedures and safety precautions will be implemented to protect worker health and safety, the public, and the environment. In accordance with standard operating procedures, health physics and industrial health technicians will monitor conditions within the tank farm in accordance with approved monitoring plans.

When the level of residual solids gets low in the tank, the volume of solids removed per unit volume of sluicing fluid removed from the tank will be tracked. The units used will be selected by engineering personnel. Waste retrieval operations will continue in an effort to obtain the goal of 360 ft^3 or less of residual waste remains in the tank, and/or the limits of technology have been reached for this retrieval method. The project will determine when a tank retrieval is complete by following the Consent Decree requirements stating "that the recovery rate of that retrieval technology for that tank is, or has become, limited to such an extent that it extends the retrieval duration to the point at which continued operation of the retrieval technology is not practicable, with the consideration of practicability to include matters such as risk reduction, facilitating tank closures, cost, the potential for exacerbating leaks, worker safety and the overall impact on the tank waste retrieval and treatment mission."

Until a risk evaluation is available, the limit of technology for modified sluicing is defined in RPP-50910, *Single-Shell Tank Waste Retrieval Limit of Technology Definition for Modified Sluicing* as when the concentration of SST waste in the retrievaed slurry sent to the DST is within, or bracketing, the range of 0 to 0.6 volume percent.

There is no limit of technology definition for a MARS-S waste retrieval process. A limit of technology definition will not be developed until sufficient MARS-S retrieval operations have been performed to enable development of a justifiable definition. Until a MARS-S limit of technology definition is developed the same value used for modified sluicing in RPP-50910 is applied to MARS-S retrieval operations.

There is no limit of technology definition for a chemical retrieval process. A limit of technology definition will not be developed until sufficient chemical heel retrieval operations have been performed to enable development of a justifiable definition. It is estimated that this will take 3 to 4 heel retrieval operations.

Appendix C, Part 1 of the Decree defines the limit of technology as follows:

> "The "limits of technology" means that the recovery rate of that retrieval technology for that tank is, or has become, limited to such an extent that it extends the retrieval duration to the point at which continued operation of the retrieval technology is not practicable, with consideration of practicability to include matters such as risk reduction, facilitating tank closures, costs, the potential for exacerbating leaks, worker safety, and the overall impact on the tank waste retrieval and treatment missions."

For MARS-S, data for retrieval performance measurement used to show the limits of technology have been met will be used after implementation of one or both low pressure sluicing and high pressure water operations (each technology will not be evaluated separately for its limit of technology).

Ecology is notified in the Tri-Party Agreement project manager's monthly meeting when the limits of technology have been reached. Status reports are continued until waste retrieval operations cease. An SST waste retrieval evaluation form and a retrieval report are then prepared and issued and in accordance with the Decree, Part IV, B. 5:

> "When DOE completes retrieval of waste from a tank covered by this Decree, DOE will submit to Ecology a written certification that DOE has completed retrieval of that tank. For purposes of this Consent Decree, "complete retrieval" means the retrieval of tank waste in accordance with Part 1 of Appendix C and with the retrieval technology/systems that were established by Part 1 of the TWRWP either by approval of Ecology or after dispute resolution by the Court under Section IX of the Decree."

Following completion of waste retrieval and final tank flushing, the residual waste volume will be determined using the methodology defined in RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*, and RPP-PLAN-23827, *Sampling and Analysis Plan for Single-Shell Tanks Component Closure*.

3.1.4 Chemical Retrieval Process

Chemical retrieval process details are contained in the process control plan for each tank using a chemical retrieval process. When samples are available the retrieval process is tested on samples of tank waste. If hard heel samples are not obtained the hard heel composition is deduced from tank historical data. The hard heel volume to be treated is normally not known until sluicing retrieval is complete. The hard heel volume can be determined from visual observation, level sensors, or liquid displacement using tank level sensors. The composition and volume of the heel are used to determine the quantity and type of chemicals used for chemical retrieval process.

this assessment, before initiation of retrieval operations and a copy of the assessment report shall be provided to Ecology

2. Submittal of a retrieval data report, as described ~~in the HFFACO Action Plan, Appendix I, Section 2.0, Figure I-1,~~ in M-045-86, 12~~0 days~~ months following DOE's ~~completion of retrieval actions for each tank~~certification to Ecology that retrieval is complete. That report shall include a review of the efficiency and performance of the in-tank settling of the retrieved solids in the receiving DST, an estimate of the amount of solids that were recycled during waste retrieval, and the impacts those solids have on removing additional solids from the SSTs.

3. Should the SST be shown to leak during the retrieval process, a liquid sample will be taken if needed to verify the ^{99}Tc concentration in the DST supernate used for sluicing.

4. Should a DST sample be required during the C-102, C-104, C-107 or C-112 retrieval process for corrosion control or other reasons, a ^{99}Tc analysis will be requested on the sample. A DST sample has already been obtained during the C-108 retrieval process.

5. Ecology will be informed by email when the cumulative volume of supernate liquid being recycled exceeds the estimated quantity of 1 million gal., and for each incremental 1 million gal. recycled.

6. Following the use of supernate, a minimum of three tank heel rinses using a minimum volume of raw water that is three times the estimated residual waste volume will be required to ensure that residual waste is removed to the extent practical. If the TOC shows that a comparable reduction in soluble supernate constituents has been accomplished through other retrieval actions, the rinse may be omitted.

When adding liquid to the SST for the sole purpose of obtaining a waste level measurement, the following conditions apply:

1. The HRR leak detection system for the tank described in Section 4.2.1 must be continuously operable for at least 48 hours prior to the liquid addition.
2. The benchmark level described in Section 4.6.1 will not be exceeded during the liquid addition.
3. Excess liquid will be removed from the tank as soon as practical once a usable waste level measurement is obtained.
4. The liquid to be used for volume displacement measurement should only be supernate. Use of raw water for volume displacement instead of or in addition to supernate shall be discussed with Ecology prior to use.

A process flowsheet has been prepared for the C farm 100-series tanks (RPP-21753, *C Farm 100-Series Tanks, Retrieval Process Flowsheet Description*). The calculations performed in support of the flowsheet assume that the retrieved solids are about 3 vol% in the slurry transferred to the receiving DST. The waste retrieval process flowsheet estimate of the total liquid volume transferred during the sluicing of each tank is provided in Table 3-2. In addition, the flowsheet allocates a nominal 105,000 gal. of water for tank and equipment flushing during each tank's waste retrieval operations. Following the initiation of C-104 active retrieval new data is obtained that shows chemical retrieval is not the preferred second technology for tanks C-104, C-108, C-102, and C-112 a TWRWP modification will be made to seek approval for the preferred technology.

The primary and second technologies selected are anticipated to provide the best methods to achieve the 360 cubic feet target volume goal specified in the Decree, when deployed to their "limits of technology." The "limits of technology" as defined in the Decree is noted in section 3.1.3.

3.4 ANTICIPATED PERFORMANCE GOALS

The retrieval technology equipment selected for tanks C-102, C-104, C-107, C-108, and C-112 will be designed, operated, and deployed to each of their limits of technology, as defined in this document, in an effort to obtain a waste residue goal of 360 cubic feet of waste or less for each tank in accordance with the Decree (see Table 3-~~3~~2).

3.5 WASTE RETRIEVAL SYSTEM DIAGRAM

A preliminary diagram of the modified sluicing WRS in-tank components is provided in Figures 3-3 and 3-4. A preliminary diagram of the MARS-S sluicing WRS is provided in Figure 3-5. As noted in Section 3.1.1, the elevation in the AN tank farm is approximately 22 ft higher than the elevation in the C tank farm and the elevation in the AZ tank farm is approximately 25 ft higher than the elevation in the C tank farm.

3.6 WASTE RETRIEVAL SYSTEM FUNCTIONS AND REQUIREMENTS

This section defines the upper-level functions and corresponding requirements to which the tanks C-102, C-104, C-107, C-108, and C-112 WRSs must be designed and operated. This work plan is not a system specification that defines design criteria for the WRSs. However, the system specification for the tanks WRSs will be consistent with this work plan. The functions and requirements are provided in Table 3-3 and are focused on defining the upper-level requirements for the tanks.

a tank system in accordance with WAC-173-303-040, "Definitions." The waste tank system equipment is described in Section 3.1.1.

A written integrity assessment, reviewed and certified by an IQRPE, attesting that the transfer-related equipment and associated transfer lines are suitable for use during waste retrieval operations will be prepared in accordance with WAC 173-303-640(3), "Design and Installation of New Tank Systems or Components," and submitted to Ecology following completion of the design and field installation of the WRS. This includes verification that the subject equipment meets the requirements set forth in WAC 173-303-640(3) and WAC 173-303-640(4), "Containment and Detection of Releases." If additional systems or additional transfer line systems are used, each system will be evaluated by an IQRPE. The design provided to the IQRPE for review will include all new or existing transfer systems, structures or components, including secondary containment (e.g., central caisson if used) and leak detection equipment used for waste transfer lines.

The requirements for an IQRPE assessment and the permitting decision logic for new equipment or repairs/upgrades to equipment will be performed in compliance with ~~RPP-16922, *Environmental Specification Requirements*, latest revision, Section 13.0, *IQRPE Assessment Need and Permitting Decision Logic*.~~TFC-ESHQ-ENV_PP-C-11, *IQRPE Assessment Process* (currently in draft) or successor document.

Risers were reviewed as part of the original SST System Integrity Assessment (RPP-10435). SST system components (e.g., risers, pits, etc.) that were identified as part of the SST system for the original Integrity Assessment are not part of the retrieval system (unless specifically identified as such) and do not require a separate or additional integrity assessment if the function of the equipment doesn't change from its original purpose (e.g., the original purpose of risers is to provide tank access) and changes to the component are not outside the original component design basis and specifications.

3.9 DISPOSITION OF WASTE RETRIEVAL SYSTEM FOLLOWING WASTE RETRIEVAL

3.9.1 Disposition of New Waste Retrieval System Components

Following completion of waste retrieval, the modified sluicing in-tank equipment will be left in place for disposition during component closure actions. The abovegrade modified sluicing equipment (e.g., transfer lines, portable valve and diversion boxes) will be reused to the extent possible for future waste retrieval activities in the C tank farm. Disposition of the C-107 MARS-S in-tank and abovegrade equipment will be determined following retrieval. Transfer lines and the portable valve and diversion boxes will be flushed to reach acceptable exposure rates for disconnecting and relocating the equipment. Any abovegrade modified sluicing or MARS-S equipment that needs to be removed and is not suitable for reuse will be packaged and disposed of onsite in accordance with the approved waste acceptance criteria for the Hanford Site burial grounds and TFC-OPS-WM-C-10, *Contaminated Equipment Management Practices*. The HIHTLs will be managed in accordance with RPP-12711, *Temporary Waste Transfer Line Management Program Plan.*

3.9.2 Disposition of Existing Ancillary Equipment

Ancillary equipment associated with tanks C-102, C-104, C-107, C-108, and C-112 is limited to waste transfer lines and equipment installed in pits and abovegrade risers. The current status of the ancillary equipment associated with tanks C-102, C-104, C-107, C-108, and C-112 is described in Section 2.6. Any contaminated equipment located within risers that needs to be removed following waste retrieval will be packaged and disposed of onsite in accordance with the approved waste acceptance criteria for the Hanford Site burial grounds and TFC-OPS-WM-C-10.

In accordance with the SST system closure plan (RPP-13774), disposition of the ex-tank ancillary equipment, including pipelines, will be performed in accordance with a separate component closure activity plan. Closure plans will be incorporated into the SST permit.

3.10 AIR MONITORING PLAN

ORP and the TOC, pursuant to federal requirements for protection of their workers, will develop and implement IH monitoring plans for exhauster stack emissions for the retrieval of tanks C-102, C-104, C-107, C-108, and C-112. The plans will be developed and implemented pursuant to the requirements of TFC-PLN-~~43~~34, ~~*Tank Farm Contractor Health And Safety Plan*~~*Industrial Hygiene Exposure Assessment Strategy*. The constituents of potential concern (COPCs) for which exhauster stack sampling and analysis will be conducted will be identified in the IH monitoring plans for each tank retrieval. The COPCs identified in the IH monitoring plans will be all or a subset, as determined to be appropriate by the TOC IH, of those constituents listed in

RPP-20949, *Data Quality Objectives For The Evaluation Of Tank Chemical Emissions For Industrial Hygiene Technical Basis*, Table 4-1, developed with input from Ecology and RPP-22491, *Industrial Hygiene Vapor Technical Basis*. ~~Once the initial subset of COPCs is identified and listed in the IH monitoring plans, no~~No COPC shall be dropped from ~~that~~ the Tank Vapor Information Sheet (TVIS) list developed for C-Farm without 90 days prior notification to and approval from Ecology. If ORP notifies Ecology of its desire to cease exhauster stack sampling for a COPC initially identified and listed in an IH monitoring plan and no response is received from Ecology within 90 days, the COPC will be deleted from the IH monitoring plan and sample and analysis activities for that COPC will cease. New COPCs may be added to an IH monitoring plan without notification to or approval from Ecology and without modifying or revising this tank waste retrieval work plan.

The sampling and analysis methods shall be EPA, National Institute for Occupational Safety and Health-approved, or Occupational Safety and Health Administration (OSHA)-approved methods or an equivalent TOC-approved method, as identified in RPP-20949. The exhauster stack samples will be analyzed at the 222-S Laboratory, the Waste Sampling and Characterization Facility, or an equivalent laboratory consistent with the quality assurance/quality control procedures for that laboratory. Further, laboratory analysis data will be kept on file at the laboratory consistent with the laboratory record keeping procedures for that laboratory for a period of not less than 5 years and will be available to Ecology, within 24 hours, upon request.

Ecology and ORP understand and agree that the activities discussed above do not restrict ORP and the TOC from taking any and/or all steps necessary as ORP and the TOC deem appropriate to protect its workforce in response to data and information generated by an IH monitoring plan or incidents as they might arise during waste retrieval. Ecology and ORP also understand and agree that the preceding sampling and analysis discussion is presented to ensure ORP is achieving the agreed to sampling and analysis for the protection of the public and its workers and does not modify the exemption from the requirements of 40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities," and 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities," Subpart CC, granted to ORP under 40 CFR 265.1080(b)(6). Therefore, this discussion does not imply any change to the respective authority of either Ecology or ORP regarding the sampling, analysis, monitoring, and control of airborne emissions from Hanford Site tanks.

The results from drywell monitoring, as well as a summary and analysis of this monitoring, including tools used, calibration, boreholes logged, depth of logging, frequency, logging rate, and data analysis will be submitted to Ecology within the retrieval data report in accordance with Appendix I of the HFFACO.

4.2.1.2. Leak Detection Using SST Liquid Level Measurement. SST level measurement data are normally limited during periods when active retrieval operations are not being performed due to the strategy of minimizing liquid in the tank. In addition, because of the dished bottoms of the tanks and the location of the level instrumentation near the side in the C-100 series SSTs, waste levels cannot be measured below approximately 12,000 gal. However, should conditions exist where a continuous liquid surface measurement is available (e.g., a pump fail prior to removing as much liquid as practical from the tank and replacement of the pump cannot occur immediately) this measurement could provide an additional means of leak detection superior to either drywell monitoring or HRR. SST Liquid level measurement can be used for leak detection during waste retrieval under the following conditions:

1. The tank level gauge must be an Enraf level gauge of the type normally used in tank farms

2. There must be a liquid surface under the Enraf plummet, with no part of the plummet touching any waste solids or the tank bottom

3. There are no active retrieval operations being performed

4. The tank is not being actively exhausted except as required to meet air permit requirements*

5. The measured waste level is not increasing, such as can occur if liquid is slowly draining from waste solids above the liquid surface

~~5.~~6. During periods when the Enraf is used for leak detection the Enraf level will be recorded at least once every calendar day.

* If the exhaust is applied to the tank for > 7 days and causes a significant level decrease rate, moisture logging will be evaluated as an alternative leak detection method.

Material balance will not be credited for SST leak detection during waste retrieval activities.

4.2.1.3. High-Resolution Resistivity. HRR will be used for leak detection during the retrieval of the remaining waste in C-108, and the retrieval of waste in C-102, C-104, C-107 and C-112. The equipment operates continuously except when down for repairs, calibrations, electrical outages, or similar reasons. Should a problem occur which renders the HRR leak detection system inoperable, drywell monitoring would be used as a backup means of leak detection, within the conditions specified in Figure 4-3 and 4.2.1.1.

The HRR method uses geophysical resistivity measurements as a means to detect changes in baseline soil moisture levels. The electrical resistivity of the soil around and beneath a waste

4.6 MITIGATION STRATEGY

Mitigation strategy including a response plan to a detected leak (identify responses to various leak rates) including notifications and provisions for obtaining approval of any remedial actions.

4.6.1 Leak Mitigation for Waste Retrieval Tank Leak

The leak mitigation strategy (i.e., reduction of leak loss potential) is to minimize the liquid volume within the tank during waste retrieval operations. Leak minimization for a waste retrieval tank leak will be provided by actions taken during waste retrieval. These include the following:

- The in-tank liquid inventory during waste retrieval will be less than liquid level present in the tank before interim stabilization activities were undertaken.
- Addition of liquid to the retrieval tank is minimized and liquid pools that form are removed as practical.
- Liquid inventories during sluicing retrieval operations will be removed between waste retrieval campaigns. Liquid inventories during heel removal operations will be maintained to the limits specified in the process control plan.
- Waste is retrieved to the extent practical by working from the center of the tank outwards.
- Evaluating HRR system data as specified in Section 4.2.1.3.
- Equipment handling controls are used to minimize the potential for dropping equipment into the tank, which could penetrate the tank bottom during installation.
- Maintaining a benchmark level in the tank. The waste level shall not exceed this benchmark. The benchmark level is defined in the process control plan.

If there is a need to operate the system longer than currently planned to demonstrate the limit of the technology to recover waste that is difficult to retrieve, the basic leak minimization step is still to limit the volume of any free liquid in the tank.

The 'timeliness' of any leak response action is dictated in part by how often the HRR data (or drywell monitoring data when used as a backup means of leak detection), are reviewed. Until a potential leak is noted there is no leak response, only the steps enumerated above to minimize the leak potential and leak volume. Anomalies noted during HRR data review are evaluated for leak potential. When this data review indicates an unexplained anomaly exists that may be caused by a potential tank leak, all liquid additions to the tank are stopped and the leak assessment process is begun.

The leak assessment process steps are:

HNF-3484, 2009, *Double-Shell Tank Emergency Pumping Guide*, Rev. 10, Washington River Protection Solutions, LLC., Richland, Washington.

HNF-EP-0182, 2005, *Waste Tank Summary Report for Month Ending February 28, 2005*, Rev. 203, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-IP-1266, *Tank Farms Operations Administrative Controls*, Latest Revision, Washington River Protection Solutions, LLC, Richland, Washington.

HNF-SD-WM-DQO-001, 2010, *Data Quality Objectives for Tank Farms Waste Compatibility Program*, Rev. 17, Washington River Protection Solutions, LLC, Richland, Washington.

HNF-SD-WM-ER-474, 2002, *Tank Characterization Report for Single-Shell Tank 241-C-107*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-SD-WM-ER-541, 1998, *Tank Characterization Report for Single-Shell Tank 241-C-112*, Rev. 1B, COGEMA Engineering Corporation, Richland, Washington.

HNF-SD-WM-ER-651, 1998, *Preliminary Tank Characterization Report for Single-Shell Tank 241-C-102: Best-Basis Inventory*, Rev. 0A, COGEMA Engineering Corporation, Richland, Washington.

HNF-SD-WM-ER-679, 2000, *Tank Characterization Report for Single-Shell Tank 241-C-104*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-SD-WM-OCD-015, *Tank Farm Waste Transfer Compatibility Program*, Latest Revision, Washington River Protection Solutions, LLC, Richland, Washington.

HNF-SD-WM-TI-707, 2004, *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessment*, Rev. 4, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-SD-WM-TSR-006, *Tank Farms Technical Safety Requirements*, Latest Revision, Washington River Protection Solutions, LLC, Richland, Washington.

HW-72743, 1978, "75'-0" Dia. Storage Tanks T-U-B&C Arrangement," Rev. 19, U.S. Department of Energy, Richland, Washington.

LA-UR-97-311, 1997, *Waste Status and Transaction Records Summary (WSTRS)*, Rev. 4, Los Alamos National Laboratory, Los Alamos, New Mexico.

M-045-09-01, 2010, Federal Facility Agreement and Consent Order Change Control Form, U. S. Department of Energy, Office of River Protection, Richland Washington

OSD-T-151-00007, *Operating Specifications for the Double-Shell Storage Tanks*, Latest Revision, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-21753, 2005, *C Farm 100-Series Tanks, Retrieval Process Flowsheet Description*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-21895, 2008, *241-C-103 and 241-C-109 Tanks Waste Retrieval Work Plan*, Rev. 3C, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-22392, 2009, *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan*, Rev. 2, Washington River Protection Solutions, LLC. Richland, Washington.

RPP-22491, *Industrial Hygiene Vapor Technical Basis*, Latest Revision, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-22520, 2008, *241-C-101, 241-C-105, 241-C-110, and 241-C-111 Tanks Waste Retrieval Work Plan*, Rev. 4, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-23403, 2009, *Single-Shell Tank Component Closure Data Quality Objectives*, Rev. 4, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-27869, *Building Emergency Plan for Tank Farms*, Latest Revision, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-29002, 2006, *Double-Shell Tank Waste Analysis Plan*, Rev 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-30121, 2006, *Tank 241-S-102 High-Resolution Resistivity Leak Detection and Monitoring Test Report,* Rev 0-A, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-32477, *High Resolution Resistivity Leak Detection Data Processing and Evaluation Methods and Requirements,* Latest Revision, Washington River Protection Solutions, LLC, Richland, Washington.RPP-33116, 2008, *241-C-110 Tank Waste Retrieval Work Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington

RPP-50910, 2011, *Single-Shell Tank Waste Retrieval Limit of Technology Definition for Modified Sluicing*, Rev. 0, Washington River Protection Solutions, LLC., Richland, Washington.

RPP-CALC-43416, 2010, *An Evaluation of Single-Shell Tank 241-C-107 for the Addition of a Large Penetration in the Tank Dome*, Rev. 0, Washington River Protection Solutions, LLC. Richland, Washington.

RPP-CALC-47657, 2010, *Single-Shell Tanks Large Penetration Addition: Tank 241-C-107 Dome and Haunch Comparative Analysis,* Rev. 0, Washington River Protection Solutions, LLC. Richland, Washington.

RPP-PLAN-23827, 2010, *Sampling and Analysis Plan for Single-Shell Tanks Component Closure*, Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-SPEC-39989, 2010, *Performance Specification for The Mobile Arm Retrieval System for Tank 241-C-107,* Rev. 2, Washington River Protection Solutions, LLC. Richland, Washington.

RPP-SPEC-41963, *Construction Specification for Installation of A Large Riser on A Single-Shell Tank,* Rev. 1A, Washington River Protection Solutions, LLC. Richland, Washington.

TFC-ENG-CHEM-D-42, *Tank Leak Assessment Process*, Latest Revision, Washington River Protection Solutions, LLC. Richland, Washington..

TFC-ENG-CHEM-P-47, 2005, *Single-Shell Tank Retrieval Completion Evaluation*, Rev. A-1, CH2M HILL Hanford Group, Inc., Richland, Washington.

TFC-ENG-STD-26, 2004, *Dilution and Flushing Requirements*, Rev. A, CH2M HILL Hanford Group, Inc., Richland, Washington.

TFC-ESHQ-ENV_FS-C-01, *Environmental Notification*, Latest Revision, Washington River Protection Solutions, LLC, Richland, Washington.TFC-ESHQ-ENV-STD-03, 2005, *Air Quality – Radioactive Emissions*, Rev. A-1, CH2M HILL Hanford Group, Inc., Richland, Washington.

TFC-ESHQ-ENV-STD-04, 2004, *Air Quality Program – Non-Radioactive Emissions*, Rev. A, CH2M HILL Hanford Group, Inc., Richland, Washington.

TFC-OPS-MAINT-C-01, 2005, *Tank Farm Contractor Work Control*, Rev. G-2, CH2M HILL Hanford Group, Inc., Richland, Washington.

TFC-OPS-OPER-C-24, *Occurrence Reporting and Processing of Operations Information*, Latest Revision, Washington River Protection Solutions, LLC, Richland, Washington.

TFC-OPS-WM-C-10, 2004, *Contaminated Equipment Management Practices*, Rev. A, CH2M HILL Hanford Group, Inc., Richland, Washington.

TFC-PLN-07, 2005, *Dangerous Waste Training Plan*, Rev. A-6, CH2M HILL Hanford Group, Inc., Richland, Washington.

TFC-PLN-~~43~~34, ~~2005,~~ ~~*Tank Farm Contractor Health and Safety Plan*~~*Industrial Hygiene Exposure Assessment Strategy*, ~~Rev. A-3~~Latest Revision, ~~CH2M HILL Hanford Group, Inc.~~Washington River Protection Solutions, LLC, Richland, Washington.

TO-320-022, *Operate Model 503DR Hydroprobe Neutron Moisture Detection*, Latest Revision, Washington River Protection Solutions, LLC, Richland, Washington.

Toxic Substances Control Act of 1976, 15 USC 2601, et seq.

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

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Change Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

<table>
<tr><td colspan="3">1. Document Title and Number: RPP-22393, Rev. 6A, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tanks Waste Retrieval Work Plan</td></tr>
<tr><td rowspan="2">2. Minor Field Change:
(Section 12.4 HFFACO Action Plan)
☐ Yes: (WRPS Signature Only -- Attach signed form to Primary Document for record purposes)

X No: Proceed to Box 3</td><td>3. Document Issue Date:

05/21/12</td><td rowspan="2">5. Notice Number: 2012-08</td></tr>
<tr><td>4. Document Modification Notice Date: 09/05/12</td></tr>
<tr><td>6.
Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?)

☐ Yes X No</td><td>7.
Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan?

☐ Yes X No</td><td>8. (Check only one box)
☐ Significant Modification
(Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.)
Minor Modification
X Requires modification of the document
X Can be accomplished with Modification Notice.</td></tr>
<tr><td colspan="3">9. Description and Justification of Change:

Change Description: A change is needed to specify that the modified sluicing waste retrieval system for tank C-102 will use an extended reach sluicer (ERSS) with high pressure water capability. The ERSS was shown to be effective for C-112 retrieval operations. High pressure water is enhancing retrieval of C-107. Since high pressure water will be available, the second retrieval technology is being changed from chemical dissolution to high pressure water.

Justifications:
• Abbreviations and Acronyms—Added ERSS
• Section 3.0, pg 3-1—identified ERSS as the modified sluicing tool and changed the C-102 second technology to high pressure water
• Section 3.1.1, pg 3-2—added description of high pressure water purpose
• Section 3.1.3, pg 3-13—added description of ERSS operation
• Section 3.1.3, pg 3-14 and 3-15 —added ERSS to limit of technology discussion
• Section 3.1.4, pg 3-16—Added C-104 to list of tanks using chemical dissolution and deleted C-102
• Section 3.3 pg 3-22 to 3-23—added justification for high pressure water selection as the second technology
See the attached redline strikeout pages.</td></tr>
</table>

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Change Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

10. Impact of Change:

The change allows the Tank Operations Contractor to use high pressure water as the second retrieval technology for C-102.

11. Additional Requirements and/or Provisions

Approvals

Washington River Protection Solutions, LLC	Office of River Protection	State of Wash., Dept. of Ecology
☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date
☑ Final Approval Date 10/25/12	☒ Final Approval Date 10/25/12	☐ Final Approval Date

Notes

1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision
2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 11, prior to final approval of this modification.

LIST OF TERMS

Terms

High Pressure Water in the context of this document means any water supplied at a higher pressure than the raw water supply pressure.

Abbreviations and Acronyms

1C	bismuth phosphate first-cycle decontamination
ALARA	as low as reasonably achievable
BBI	best-basis inventory
CH2M HILL	CH2M HILL Hanford Group, Inc.
COPC	constituent of potential concern
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERSS	Extended Reach Sluicing System
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
HI	hazard index
HIHTL	hose-in-hose transfer line
HRR	high-resolution resistivity
IH	Industrial Hygiene
ILCR	incremental lifetime cancer risk
LDM	leak detection and monitoring
ORP	Office of River Protection
PrHA	Process hazards analysis
PUREX	plutonium-uranium extraction
RCRA	*Resource Conservation and Recovery Act of 1976*
RMS	retrieval monitoring system
SST	single-shell tank
TBP	tributyl phosphate
TOC	tank operations contractor
UPR	unplanned release
WMA	waste management area
WRS	waste retrieval system

Units

%	percent
Ci/kg	curies per kilogram
Ci	curie
Ci/L	curies per liter
°F	degrees Fahrenheit
ft	foot
ft^3	cubic feet

3.0 PLANNED WASTE RETRIEVAL TECHNOLOGY

This section provides a description of the primary and secondary waste retrieval technologies for retrieving the waste from tanks C-102, C-104, C-107, C-108, and C-112. The rationale for selection of primary and secondary technologies is provided in Section 3.3. However, in accordance with Appendix C, Part 1 of the Decree:

> "If 360 cubic feet is reached with the first retrieval technology, the first retrieval technology shall be used to the "limits of technology" and a second retrieval technology shall not be required."

The primary technology is the first technology deployed for waste retrieval.

The primary technology for C-102, C-104, C-108, and C-112 will be modified sluicing. For C-102 the modified sluicing will be done with an Extended Reach Sluicer (ERSS). If required to meet the tank residual waste conditions in the Decree, the second technology for ~~C-102,~~ C-104, C-108 or C-112 will be a chemical retrieval process. The second technology for C-102 will be high pressure water deployed with the ERSS. The primary technology for C-107 will be sluicing with supernate or water. The second technology will be high-pressure water spray. Both of these technologies will be deployed via MARS-S. The MARS-S is designed to implement both the primary and secondary technology when needed. Retrieval activities will switch from one technology to the other as required to reach the Consent Decree residual waste goal.

In accordance with the Decree, Appendix C, Part 1:

> "If the waste residual goal of 360 cubic feet is not achieved using the established two technologies, an additional retrieval technology established in a revised TWRWP shall be deployed to the "limits of technology;" provided that DOE may request that the State agree that DOE may forego implementing a third retrieval technology if DOE believes implementing such technology is not practicable under the criteria set forth above [in Appendix C, Part 1 of the Decree]. If DOE and Ecology are unable to reach agreement, the resolution of the issue of whether a third retrieval technology shall be deployed shall be resolved through the dispute resolution process set forth in Section IX of this Decree."

3.1 SYSTEM DESCRIPTION

This section provides a description of the waste retrieval systems (WRS) and how they will be operated. Continued design development and incorporation of lessons learned may lead to changes in the design and/or operating strategy.

3.1.1 Physical System Description

The WRS will consist of a modified sludge sluicing system to mobilize and retrieve waste from tanks C-102, C-104, C-108, and C-112. The sluicing system will consist of two (or more) sluice nozzles and a slurry pump in each tank. The sluice nozzles or hydraulic sluicers will be controlled from a control trailer located near the tanks. The sluice nozzles will be installed in existing tank risers. The sluice nozzles will have the capability to direct liquid at various locations in the tanks. The C-102 WRS will have the capability to use high pressure water to break apart hard agglomerations of waste. The flow rate through the sluice nozzles will be adjusted based on the pump-out rate so that the rate of liquid introduction will approximately equal the rate of solution removal with the objective of minimizing the liquid waste volume in the retrieval tank.

The WRS for tank C-107 will be the Mobile Arm Retrieval System-Sluicing (MARS-S). Standard modified sluicing is maintained as an alternate WRS for C-107 in the event this first deployment of the MARS-S has to be halted. The MARS-S sluicing process consists of an extendable robotic arm suspended from a large central riser added to the tank and serves as the deployment platform for two separate retrieval technologies. The MARS-S is a mobile arm capable of rotating and extending in the tank. The system is equipped with two technologies to mobilize the waste and direct it to a pump for removal. For one technology, the end of the arm is equipped with sluice nozzles that direct supernate and/or water onto the waste surface from a short distance away, and directs the mobilized waste slurry backwards to a slurry pump. A second technology provided by the MARS-S is the addition of high pressure water spray nozzles that serve to break up hard waste agglomerations and direct them to the slurry pump. The slurry pump may use a backstop that can capture the slurry waste and is equipped with more supernate and water nozzles to further break the waste up for removal by the pump.

The waste retrieved from tanks C-102, C-104, C-107, C-108, and C-112 will be transferred to a DST. To minimize the overall volume of waste requiring storage in the DST system, the waste retrieval project plans to use DST supernate as the primary sluice liquid (see Section 3.1.2 for operating description). The WRS will also have the capability to use raw water for sluicing with valving change or minor modifications.

The waste retrieval plan as of October 2010 for using DSTs for waste receipt and as source tanks for supernate recycle is shown in Figure 3-1. The DSTs were selected based on their location, available space, and existing or planned equipment upgrades. Additional detail on the planned use of supernate during waste retrieval is discussed in Section 3.2.

DST to the SST. All waste transfers, including transfer of waste from the C farm tanks to the DSTs and the transfer of supernate from DSTs back to C farm tanks, will be performed using transfer lines that provide secondary containment. The waste retrieval project currently plans to use overground hose-in-hose transfer lines (HIHTLs) and the *Resource Conservation and Recovery Act of 1976* (RCRA)-compliant DST transfer system.

3.1.3 Waste Retrieval System Operating Description

The overall WRS operating strategy will consist of reducing the SST waste inventories. The process will be monitored using closed-circuit television to facilitate waste retrieval and minimize any liquids in the tanks. Supernate will be used as the primary retrieval liquid. Raw water will be used in limited quantities as necessary for waste conveyance and transfer line flushing.

During routine modified sluicing operations, waste retrieval will be initiated by starting the supernate pump in the DST source tank and using the pumped supernate to provide sluicing fluid to the selected sluice nozzle. Initial sluicing will be focused in the center portion of the tank to minimize the time required to get liquid to the slurry pump to allow it to be started. The in-tank camera will be used to provide visual input for directing the sluice nozzle. The slurry pump in tank C-102, C-104, C-108, or C-112 will be started as soon as liquid from the sluicer operation reaches the area of the pump inlet and there is enough liquid present to prime and operate the pump. During waste retrieval, the flow of liquid into the tanks through the sluice nozzles will be controlled to both limit accumulation of liquid in the tank and to maximize waste retrieval efficiency. The slurry removed will consist of both mobilized tank waste and DST supernate used for mobilization. Maintaining a balanced pumping rate into and out of the tanks is integral to minimizing the liquid volume in the tanks and reducing the potential for leakage.

An additional technology provided by the ERSS is the capability to add high pressure water to break up particles that resist breakup or mobilization with the lower pressure supernate (or water) stream. High pressure water could be used at any time during the retrieval process but it is not envisioned that much will be needed until towards the end of retrieval.

During routine MARS-S operations, waste retrieval is similar to that for modified sluicing, with the exception that the supernate nozzles on the MARS-S will be located near the waste surface. The MARS-S arm will be moved radially and axially to reach all areas of the tank. The slurried waste is directed back to the central pump and removed from the tank. Nozzles located at the pump backstop are used to further break up waste particles. An additional technology provided by the MARS-S is the capability to add high pressure water to break up particles that resist breakup or mobilization with the lower pressure supernate (or water) stream. Water could be used at any time during the retrieval process but it is not envisioned that much will be needed until towards the end of retrieval.

If initial sluicing efforts show that tank C-102, C-104, C-107, C-108, or C-112 sludge is not readily mobilized, it may be necessary to add sufficient liquid to the tank(s) to cover the sludge and allow it to sit for a period of time to soften the solid waste before sluicing is resumed. It is not likely that there will be any need to soften the waste. Tank C-108 waste is estimated in the

BBI to be about 40 wt% water; tank C-102 waste is estimated to be 40 to 65 wt% water; and tanks C-104, C-107, and C-112 waste is estimated to be about 50 wt% water. The only reason to soften the waste would be if the surface had become so hard it resisted breakup by solution from the sluicing nozzles. Extensive dryout of the waste (not likely at the estimated water levels and the 70 to 100 °F waste temperatures) could cause some agglomeration of the material. The waste could also be held together with salt crystals from supernate that had evaporated. Should either of these occur and the waste not breakup effectively when hit with solution from the sluicing nozzles, adding liquid to the waste surface may be tried to soften it for retrieval. Liquid breaks down the bonds in dried out waste or dissolves most salt crystals. The supernate used will not be saturated at the start of retrieval in a tank and thus will be expected to dissolve such salts or break the crystal structure down sufficiently to permit retrieval.

The volume of free liquid added to soften any waste would be minimized by keeping the free liquid height above the waste to as small as practical. Any free liquid added beyond this would provide little benefit. The time period needed to soften the waste is unknown; it is expected to be a few days or longer.

Pumping during sluicing will maintain minimum liquid volume in the tanks. This will be performed by initially directing the nozzle flow towards the center of the tanks. As the sluice liquid contacts the tank waste, the sludge will be mobilized and retrieved via the slurry pumps. Typically, one sluicer will be operated at a time operating at a flow rate of approximately 60 to 120 gal/min.

During all field activities, standard operating procedures and safety precautions will be implemented to protect worker health and safety, the public, and the environment. In accordance with standard operating procedures, health physics and industrial health technicians will monitor conditions within the tank farm in accordance with approved monitoring plans.

When the level of residual solids gets low in the tank, the volume of solids removed per unit volume of sluicing fluid removed from the tank will be tracked. The units used will be selected by engineering personnel. Waste retrieval operations will continue in an effort to obtain the goal of 360 ft^3 or less of residual waste remains in the tank, and/or the limits of technology have been reached for this retrieval method. The project will determine when a tank retrieval is complete by following the Consent Decree requirements stating "that the recovery rate of that retrieval technology for that tank is, or has become, limited to such an extent that it extends the retrieval duration to the point at which continued operation of the retrieval technology is not practicable, with the consideration of practicability to include matters such as risk reduction, facilitating tank closures, cost, the potential for exacerbating leaks, worker safety and the overall impact on the tank waste retrieval and treatment mission."

Until a risk evaluation is available, the limit of technology for modified sluicing is defined in RPP-50910, *Single-Shell Tank Waste Retrieval Limit of Technology Definition for Modified Sluicing* as when the concentration of SST waste in the retrieved slurry sent to the DST is within, or bracketing, the range of 0 to 0.6 volume percent.

There is no limit of technology definition for an ERSS or MARS-S waste retrieval process. A limit of technology definition will not be developed until sufficient ERSS and MARS-S retrieval

operations have been performed to enable development of a justifiable definition. Until an ERSS MARS-S limit of technology definition is developed the same value used for modified sluicing in RPP-50910 is applied to MARS-S retrieval operations.

There is no limit of technology definition for a chemical retrieval process. A limit of technology definition will not be developed until sufficient chemical heel retrieval operations have been performed to enable development of a justifiable definition. It is estimated that this will take 3 to 4 heel retrieval operations.

Appendix C, Part 1 of the Decree defines the limit of technology as follows:

> "The "limits of technology" means that the recovery rate of that retrieval technology for that tank is, or has become, limited to such an extent that it extends the retrieval duration to the point at which continued operation of the retrieval technology is not practicable, with consideration of practicability to include matters such as risk reduction, facilitating tank closures, costs, the potential for exacerbating leaks, worker safety, and the overall impact on the tank waste retrieval and treatment missions."

For MARS-S, data for retrieval performance measurement used to show the limits of technology have been met will be used after implementation of one or both low pressure sluicing and high pressure water operations (each technology will not be evaluated separately for its limit of technology).

Ecology is notified in the Tri-Party Agreement project manager's monthly meeting when the limits of technology have been reached. Status reports are continued until waste retrieval operations cease. An SST waste retrieval evaluation form and a retrieval report are then prepared and issued and in accordance with the Decree, Part IV, B. 5:

> "When DOE completes retrieval of waste from a tank covered by this Decree, DOE will submit to Ecology a written certification that DOE has completed retrieval of that tank. For purposes of this Consent Decree, "complete retrieval" means the retrieval of tank waste in accordance with Part 1 of Appendix C and with the retrieval technology/systems that were established by Part 1 of the TWRWP either by approval of Ecology or after dispute resolution by the Court under Section IX of the Decree."

Following completion of waste retrieval and final tank flushing, the residual waste volume will be determined using the methodology defined in RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*, and RPP-PLAN-23827, *Sampling and Analysis Plan for Single-Shell Tanks Component Closure.*

3.1.4 Chemical Retrieval Process

Chemical retrieval process details are contained in the process control plan for each tank using a chemical retrieval process. When samples are available the retrieval process is tested on samples of tank waste. If hard heel samples are not obtained the hard heel composition is deduced from tank historical data. The hard heel volume to be treated is normally not known until sluicing retrieval is complete. The hard heel volume can be determined from visual observation, level sensors, or liquid displacement using tank level sensors. The composition and volume of the heel are used to determine the quantity and type of chemicals used for chemical retrieval process.

The chemical retrieval process may be a series of steps or a single action depending on how the waste reacts to the process. If a single step will dissolve sufficient solids to achieve the volume reduction mandated by the Decree, only one chemical retrieval process step will be deployed. The chemical retrieval process may include one or more of the following:

- water to remove compounds insoluble in the caustic liquids found in the tanks,
- high molarity caustic solution to break down aluminum hydroxide compounds, or
- other chemicals to aid the retrieval of sludge.

Ecology will be informed of the pre-retrieval estimated volume of liquid(s) to be added to the tank prior to the initial addition(s). Water additions for dissolution and volume reduction associated with a chemical retrieval process are separate actions from the heel rinse described in section 3.2.

Unlike modified sluicing, there is no operational data available that can be used to estimate the recovery rate for a limit of technology determination for a chemical retrieval process planned for ~~C-102,~~ C-104, C-108, or C-112. If the first step of a multiple step dissolution achieves the Decree volume target the limit of technology will be considered to have been met for the chemical retrieval process technology. Using unnecessary chemical retrieval process steps adds risk to worker safety and has retrieval schedule impacts, DST storage volume impacts, and thus possible mission impacts.

If the Decree target volume is not achieved, and all steps of the chemical retrieval process have been deployed as specified in the process control plan, the limit of technology will be considered to have been met for the chemical retrieval process provided the data shows that additional chemical retrieval process steps are not practicable.

Consideration for additional waste retrieval actions will be according to the Decree Appendix C, Part 1 as noted in section 3.0.

3.2 LIQUID ADDITIONS DURING WASTE RETRIEVAL

Supernate from DST AN-101, AN-106, or AZ-101 will be introduced to tanks C-102, C-104, C-107, C-108, and C-112 to mobilize sludge. Supernate will be added at a rate of approximately 60 (or less) to 120 gal/min. The retrieval liquid, along with tank solids, will be removed from these tanks at approximately the same rate. Utilizing recycled supernate to retrieve the waste from the tanks will minimize the overall volume of waste generated during the waste retrieval process. The modified sludge sluicing process will minimize the volume of liquid in the SST during waste retrieval operations.

The use of supernate will be limited by the following:

to sound tanks as identified in HNF-EP-0182 using the modified sluicing or MARS-S systems is acceptable. The mobile retrieval system uses vacuum to remove waste to the tank farm surface where liquid is added to enable the waste to be transferred as a slurry. Because of this difference, the mobile retrieval system or the MARS vacuum system (not described in this document) are currently the preferred waste retrieval technologies for known or suspected leaking tanks.

When modified sluicing or MARS-S sluicing are performed using DST supernate, the overall volume of waste requiring management (storage and/or volume reduction) in the DST system is reduced.

Modified sluicing is a proven technology that has been successfully demonstrated. The only volume added to the DST system is the volume of sludge removed from the SST, plus the water used for line flushes or other uses. There is no deployed process that is more effective.

The MARS-S sluicing system is expected to be an improvement over modified sluicing because it is believed capable of reducing the residual waste volume in a tank to below the Consent Decree limit without requiring an additional technology. The MARS-S enables close access to almost all of the waste in a tank to improve waste mobilization over that of modified sluicing. The first deployment of the MARS-S sluicing system will demonstrate the system capabilities, as well as provide time for making improvements if necessary prior to further deployment. After considering both candidate waste retrieval technologies and designation of the tanks as being sound, modified sluicing using recycled DST supernate was selected as the primary technology for deployment in tanks C-102, C-104, C-108, and C-112. The MARS-S sluicing system is selected for deployment on C-107. This will be the initial deployment for the MARS-S system. The operating experience will provide information for future deployment of the system.

The second technology alternatives, if necessary, should one be required for residual waste removal following modified sluicing, are an in-tank vehicle, high pressure water, and a chemical retrieval process.

Generally, an in-tank vehicle is desirable for large or monolithic particles since it can break these up for sluicing, while a chemical retrieval of larger aggregates may be slow or ineffective due to the small surface area for dissolution. ~~An~~ High pressure water or an in-tank vehicle is preferred as the heel volume increases because a chemical retrieval process may take up too much DST space and, for caustic or acid dissolutions, will have proportionally more impact to the DST space. A chemical retrieval process is preferable for heels where the volume is relatively low so the impact on DST space and the WTP throughput volume is less. A chemical retrieval process may also be preferable if the particles are small because the surface area for dissolution is greater and an in-tank vehicle may just push the fine particles around the tank.

A chemical retrieval process was selected as the second technology for C-104 and C-108 as it can be deployed in less time than an in-tank vehicle and because it is believed the estimated residual heel volume could be chemically reduced to below 360 ft^3 without causing a significant impact to the available DST space or the WTP throughput volume.

A chemical retrieval process was selected as the second technology for ~~C-102 and~~ C-112 as it can be deployed in less time than an in-tank vehicle when the primary technology is no longer effective and the tank residual waste volume in the Decree is exceeded.

High pressure water was selected as the second technology for C-102 as it can be deployed in less time than an in-tank vehicle when the primary technology is no longer effective and the tank residual waste volume in the Decree is exceeded.

Second technology selection inherently relies on past experience and assumptions on the tank waste characteristics that will be present after the first technology is deployed to its limits. If new data is obtained that shows chemical retrieval is not the preferred second technology for tanks C-104, C-108, C-102, and C-112 a TWRWP modification will be made to seek approval for the preferred technology.

The primary and second technologies selected are anticipated to provide the best methods to achieve the 360 cubic feet target volume goal specified in the Decree, when deployed to their "limits of technology." The "limits of technology" as defined in the Decree is noted in section 3.1.3.

3.4 ANTICIPATED PERFORMANCE GOALS

The retrieval technology equipment selected for tanks C-102, C-104, C-107, C-108, and C-112 will be designed, operated, and deployed to each of their limits of technology, as defined in this document, in an effort to obtain a waste residue goal of 360 cubic feet of waste or less for each tank in accordance with the Decree (see Table 3-2).

3.5 WASTE RETRIEVAL SYSTEM DIAGRAM

A preliminary diagram of the modified sluicing WRS in-tank components is provided in Figures 3-3 and 3-4. A preliminary diagram of the MARS-S sluicing WRS is provided in Figure 3-5. As noted in Section 3.1.1, the elevation in the AN tank farm is approximately 22 ft higher than the elevation in the C tank farm and the elevation in the AZ tank farm is approximately 25 ft higher than the elevation in the C tank farm.

3.6 WASTE RETRIEVAL SYSTEM FUNCTIONS AND REQUIREMENTS

This section defines the upper-level functions and corresponding requirements to which the tanks C-102, C-104, C-107, C-108, and C-112 WRSs must be designed and operated. This work plan is not a system specification that defines design criteria for the WRSs. However, the system specification for the tanks WRSs will be consistent with this work plan. The functions and requirements are provided in Table 3-3 and are focused on defining the upper-level requirements for the tanks.

1217515

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Change Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

1. Document Title and Number: RPP-22393, Rev. 6A, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tanks Waste Retrieval Work Plan		
2. Minor Field Change: (Section 12.4 HFFACO Action Plan) ☐ Yes: (WRPS Signature Only – Attach signed form to Primary Document for record purposes) X No: Proceed to Box 3	**3.** Document Issue Date: 05/21/12 **4.** Document Modification Notice Date: 10/04/12	**5.** Notice Number: 2012-11
6. Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?) ☐ Yes X No	**7.** Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan? ☐ Yes X No	**8.** (Check only one box) ☐ Significant Modification (Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.) Minor Modification X Requires modification of the document X Can be accomplished with Modification Notice.

9. Description and Justification of Change:

Change Description: A change is needed to update the tank C-102 ground water risk estimates as noted in Notice 2012-03.

Justifications:

- Section 7.0, pg 7-8--added reference to RPP-22521
- Section 9.0, pg 9-8—updated references
- Appendix A, pg A-1 to A-4— updated reference, deleted old plots and added revised plots
- Appendix A, pg A-5 to A-6—deleted outdated information speculating about scenarios
- Appendix A, pg A-7— added revised concentration numbers and deleted outdated information
- Appendix A, pg A-8—updated concentration and calculation values
- Apendix A, pg A-11—updated reference

See the attached redline strikeout pages.

10. Impact of Change:

Provides more accurate estimates of groundwater risk.

11. Additional Requirements and/or Provisions

WinA-C

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Change Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

Approvals		
Washington River Protection Solutions, LLC.	Office of River Protection	State of Wash., Dept. of Ecology
□ Provisional Approval[2] Date	□ Provisional Approval[2] Date	☑ Provisional Approval[2] Date
□ Final Approval E. LaRock 10/11/12 Date ELAROCK FOR DK SMITH	☒ Final Approval Date 10/11/12	☒ Final Approval Date 10/16/12

Notes

1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision

2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 11, prior to final approval of this modification.

is a hypothetical volume that represents neither an anticipated leak volume nor a leak detection limit. Tanks C-102, C-104, C-107, C-108, and C-112 are classified sound and are not anticipated to leak during waste retrieval. If a leak is detected, however, the risk graphs provided in Appendices A through E will allow the leak impacts to be estimated regardless of leak volume.

The retrieval leak impact graphs provided in the appendices were generated by applying Equation 7-1 over a range of hypothetical retrieval leak inventories for each indicator contaminant (RPP-22392 and RPP-22521). Because potential retrieval leak volumes are uncertain, the inventory range was selected to encompass a small leak on the low end and a large leak on the high end. Points of reference were added to the graphs to show the estimated current tank inventory and the estimated inventory associated with a hypothetical 8,000-gal. retrieval leak assuming sluicing with DST supernate as identified in Appendix A, B, C, D, and E of this document for the planned retrieval sequence (Figure 2-1) and receiver DST (Figure 3-1). The 8,000-gal. volume was used only for information purposes to provide a point of reference on the graphs.

Development of the tank-specific inventories shown as points of reference on the graphs for the individual tanks is discussed in the appendices. Current inventory values were taken from the BBI by downloading from the Tank Waste Information Network System (TWINS) database. Hypothetical retrieval leak inventory values were calculated from the best available published data source.

7.1.1.3. Contaminant Transport Simulations. The RPP-13774 analysis provides the most sophisticated currently available predictions of potential long-term groundwater impacts associated with tank waste retrieval and closure activities for WMA C. The groundwater contaminant concentrations used for the retrieval leak impact graphs were derived directly from the modeling output data from the RPP-13774 analysis.

Flow and transport were simulated in the RPP-13774 analysis using two-dimensional cross-sectional models. The cross-sections extended laterally to the tank farm fenceline and vertically downward through the vadose zone into the upper portion of the underlying aquifer. The simulations all assumed a final closure barrier was in place by 2050. The barrier was assumed to function at its design estimate recharge rate (0.5 mm/yr) for 500 years, after which recharge was assumed to increase to 3.5 mm/yr. The simulated cross-sectional groundwater concentrations were distributed uniformly along the length of the downgradient WMA C boundary. The simulations were carried out for a 10,000-year assessment period (i.e., from the year 2000 to the year 12000). The base case simulation results indicated the peak groundwater concentrations from retrieval leaks would arrive at the WMA C downgradient fenceline in the year 2082.

The RPP-13774 transport simulations were performed for the following four types of contaminant sources within WMA C:

- Past leaks from tanks
- Past leaks from ancillary equipment (i.e., past pipe leaks)
- Potential leaks during waste retrieval

RPP-21895, 2008, *241-C-103 and 241-C-109 Tanks Waste Retrieval Work Plan*, Rev. 3C, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-22392, 2009, *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan*, Rev. 2, Washington River Protection Solutions, LLC. Richland, Washington.

RPP-22491, *Industrial Hygiene Vapor Technical Basis*, Latest Revision, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-22520, 2008, *241-C-101, 241-C-105, 241-C-110, and 241-C-111 Tanks Waste Retrieval Work Plan*, Rev. 4, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-22521, *Tanks C-101, C-102, C-105, C-110, and C-111 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan*, Rev. 6, Washington River Protection Solutions, LLC., Richland, Washington.

RPP-23403, 2009, *Single-Shell Tank Component Closure Data Quality Objectives*, Rev. 4, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-27869, *Building Emergency Plan for Tank Farms*, Latest Revision, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-29002, 2006, *Double-Shell Tank Waste Analysis Plan*, Rev 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-30121, 2006, *Tank 241-S-102 High-Resolution Resistivity Leak Detection and Monitoring Test Report,* Rev 0-A, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-32477, *High Resolution Resistivity Leak Detection Data Processing and Evaluation Methods and Requirements,* Latest Revision, Washington River Protection Solutions, LLC, Richland, Washington.RPP-33116, 2008, *241-C-110 Tank Waste Retrieval Work Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington

RPP-50910, 2011, *Single-Shell Tank Waste Retrieval Limit of Technology Definition for Modified Sluicing*, Rev. 0, Washington River Protection Solutions, LLC., Richland, Washington.

RPP-CALC-43416, 2010, *An Evaluation of Single-Shell Tank 241-C-107 for the Addition of a Large Penetration in the Tank Dome*, Rev. 0, Washington River Protection Solutions, LLC. Richland, Washington.

RPP-CALC-47657, 2010, *Single-Shell Tanks Large Penetration Addition: Tank 241-C-107 Dome and Haunch Comparative Analysis,* Rev. 0, Washington River Protection Solutions, LLC. Richland, Washington.

RPP-PLAN-23827, 2010, *Sampling and Analysis Plan for Single-Shell Tanks Component Closure*, Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-SPEC-39989, 2010, *Performance Specification for The Mobile Arm Retrieval System for Tank 241-C-107,* Rev. 2, Washington River Protection Solutions, LLC. Richland, Washington.

A1.0 TANK C-102 PRE-RETRIEVAL RISK ASSESSMENT RESULTS

This appendix provides tank-specific pre-retrieval risk assessment results for tank C-102. The information presented was developed using the methodology described in Section 7.0. Groundwater pathway impacts are presented in Section A2.0. Inadvertent intruder impacts are presented in Section A3.0.

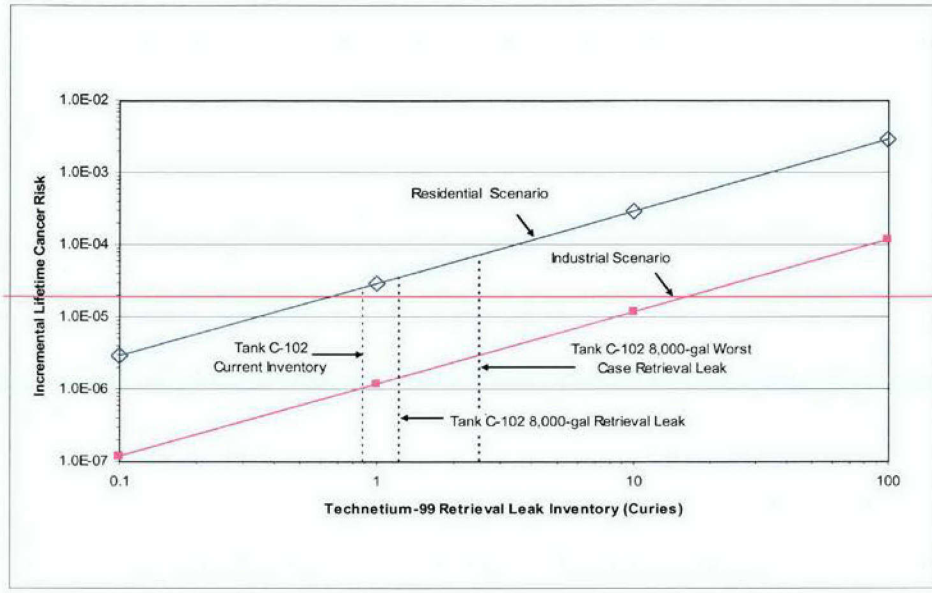
A2.0 GROUNDWATER PATHWAY IMPACTS

The groundwater pathway evaluation involved the development of a set of graphical tools to provide a basis for making informed decisions in the event a leak is detected or unexpected retrieval conditions arise during waste retrieval operations. This section provides and discusses the retrieval leak impact graphs generated for tank C-102. The methodology used to generate the graphs is described in Section 7.1.1. Calculation detail for the graphs is provided in RPP-~~22392~~22521 Rev. 6, *Tanks C-~~102~~101, C-~~104~~102, C-~~107~~105, C-~~108~~110, and C-~~112~~ 111 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan.*

A2.1 RETRIEVAL LEAK IMPACT GRAPHS

Figures A-1 through A-3 provide the tank C-102 waste retrieval leak impact graphs for the three indicator contaminants (technetium-99, hexavalent chromium, and nitrite) identified in Section 7.1.1.1.

Figure A-1. Tank C-102 Technetium-99 Risk Plot.



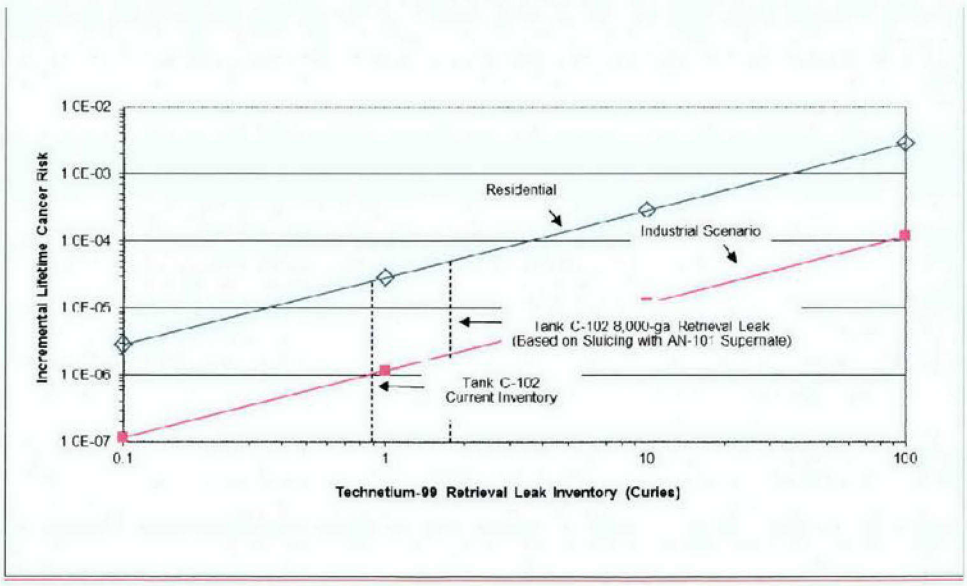
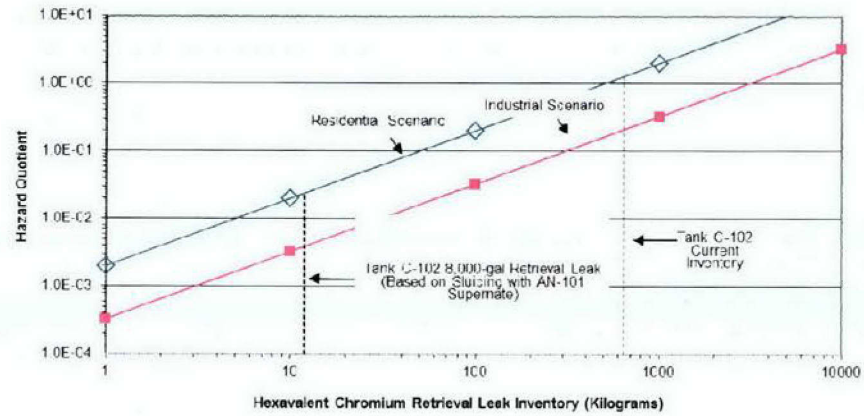


Figure A-2. Tank C-102 Hexavalent Chromium Hazard Quotient Plot.



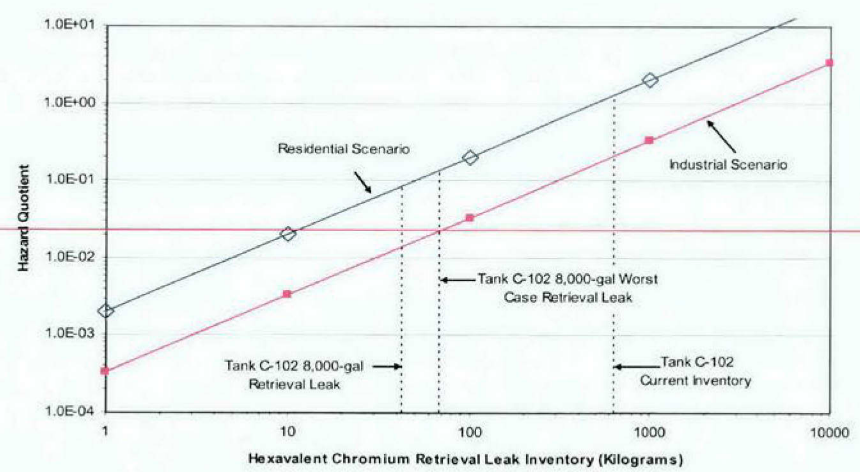
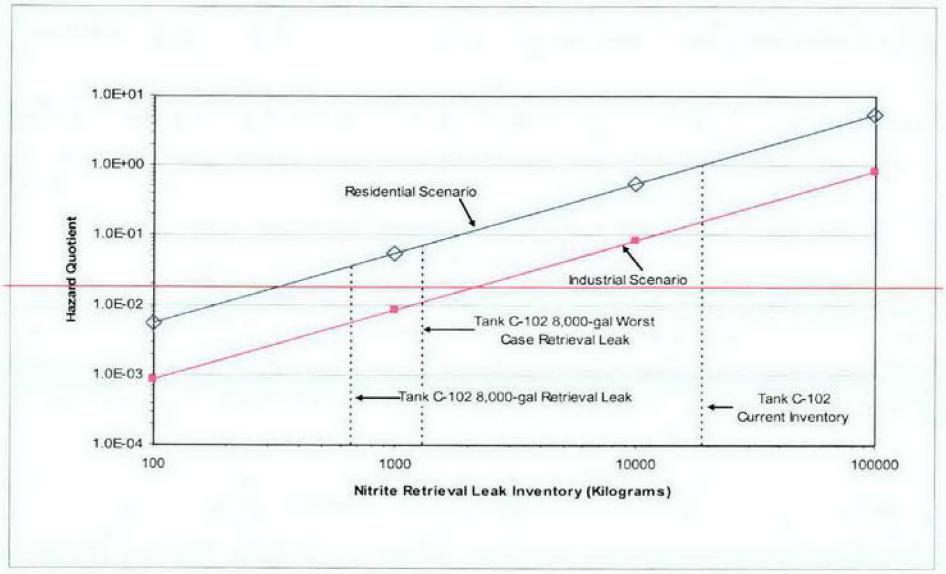


Figure A-3. Tank C-102 Nitrite Hazard Quotient Plot.



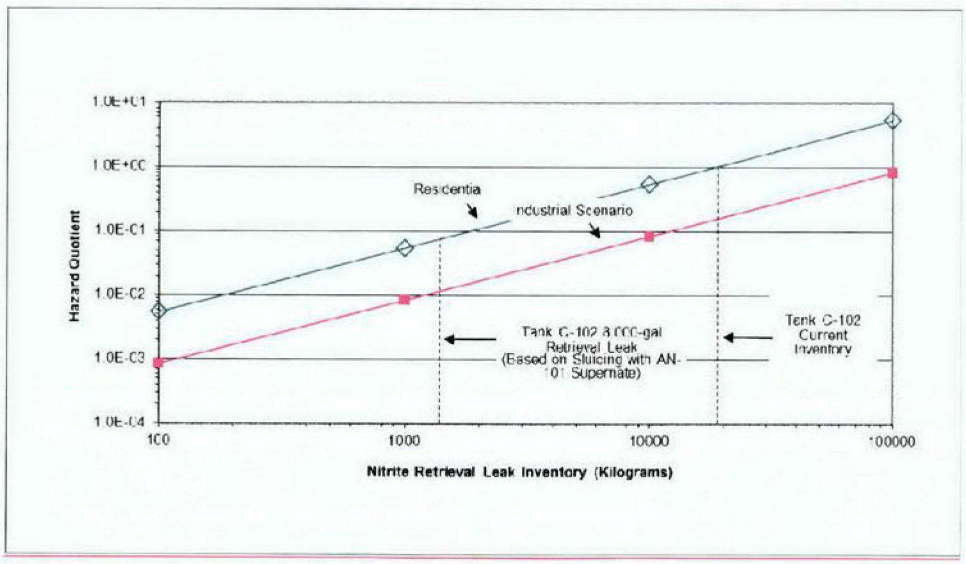


Figure A-1 shows the peak groundwater pathway incremental lifetime cancer risk (ILCR) from technetium-99 as a function of the amount of technetium-99 leaked from tank C-102 during waste retrieval. Figures A-2 and A-3 show the peak groundwater pathway hazard quotient from hexavalent chromium and nitrite, respectively, as a function of the amount of hexavalent chromium and nitrite leaked from tank C-102 during waste retrieval.

The ILCR and hazard quotient values shown on the graphs were based on the predicted peak groundwater concentrations at the waste management area (WMA) C downgradient fenceline. As discussed in Section 7.1.1.3, the projected arrival time of the peaks is approximately the year 2082 based on the supporting contaminant transport analysis in RPP-13774, *Single-Shell Tank System Closure Plan*. The graphs provide a retrieval leak risk picture for tank C-102 but do not include contributions from other WMA C sources. Projected impacts from other WMA C sources are discussed in Section 7.1.3.

Two sloped lines representing the industrial and residential scenarios were plotted on each graph. The datapoints for these lines were calculated as described in Section 7.1.1 over a range of technetium-99, hexavalent chromium, and nitrite values. Because potential retrieval leak volumes are uncertain, the inventory range was selected to encompass a small leak on the low end and a large leak on the high end. Selection of the inventory range was arbitrary and independent of any assumption on the type of retrieval fluid used (raw water or supernate).

Vertical dashed lines were added to each graph as points of reference to show the estimated current tank C-102 inventory and the inventory associated with a potential 8,000-gal. base case retrieval leak and an estimated worst case 8,000-gal. retrieval leak. The 8,000-gal. volume was a hypothetical volume used only as a point of reference and for consistency with previous analyses. It was not intended to represent anticipated retrieval leak volumes or leak detection limits for tank C-102.

~~The planning for tanks C-102, C-104, C-107, C-108, and C-112 waste retrieval as of mid March 2005 is given in Section 3.1.1. RPP-21753, *C Farm 100 Series Tanks, Retrieval Process Flowsheet Description*, provides an estimated flowsheet for the C tank farm waste retrieval process based upon this planning. However, there are numerous possible combinations of which single-shell tanks can go to which double-shell tanks (DSTs) and in which order.~~
~~These combinations are further complicated with the retrieval of other C farm tanks not included in this tank waste retrieval work plan. It is impractical to provide flowsheets and preliminary risk evaluations that look at all possible combinations of tanks and tank retrieval order when the end result is not expected to cause any significant change in the risk associated with the overall waste retrieval process. Therefore, the dotted lines in Figures A-1, A-2, and A-3 provide the calculated risk impacts for an 8,000-gal. retrieval leak based upon the retrieval plan in Section 3.1.1, and an assumed worst case 8,000-gal. retrieval leak.~~

~~The base case 8,000-gal. leak uses concentrations obtained from RPP-21753, with the sluicing supernate coming from the DSTs specified in Section 3.1.1. The assumed worst case 8,000-gal. leak for technetium-99 is based upon sluicing with a technetium-99 concentration of~~ $\cancel{8.3 \times 10^{-5}\ Ci/L}$~~. The assumed worst case 8,000-gal. leak for chromium is based upon sluicing with a chromium concentration of 2.3 g/L. The assumed worst case 8,000-gal. leak for nitrite is based upon sluicing with a nitrite concentration of 43 g/L.~~

~~The worst case technetium-99 concentration assumes sluicing with tank AY-101 supernate following waste retrieval from tank C-112. The worst case chromium concentration assumes~~

~~sluicing with tank AY-101 supernate only (the tank AY-101 supernate chromium concentration is sufficiently high that the supernate chromium concentration will be reduced as single-shell tank waste retrieval proceeds). The worst case nitrite concentration assumes sluicing with tank AY-101 supernate following waste retrieval from tanks C-104 and C-107. The worst case concentrations are estimates only and can vary with the amount of raw water added during waste retrieval or a number of other factors. The worst case concentrations are not based upon any planned waste retrieval sequence, they just represent more restrictive mixes of the five single-shell tanks with a receiver DST for the tanks discussed in this tank waste retrieval work plan.~~

~~Should the retrieval plan vary from that in Section 3.1.1, the Washington State Department of Ecology will be notified of the change via a change notice form, per Section 9.3 of the HFFACO Action Plan. A retrieval plan variation means: (1) altering the designated DST receiver tank for a given single-shell tank, or (2) making transfers from DSTs other than those listed in Section 3.1.1 into one of the Section 3.1.1 receiver DSTs, which will result in key indicator contaminant concentrations in the receiver DST liquid phase greater than those specified in RPP-21753 for the starting DST supernate concentration. A statement will be included on the change notice form that the estimated risk associated with the revised waste retrieval plan is bounded by the assumed worst case impact shown in Figures A-1, A-2, and A-3. Alternatively, if the 8,000-gal. retrieval leak risk for a revised retrieval plan may not be bounded by the assumed worst case impact shown in Figures A-1, A-2, and A-3, revised risk impacts will be provided.~~

In the event a leak is detected during waste retrieval, the leak monitoring system would be used to estimate the leak volume. The potential human health impacts from the leak could then be evaluated from the leak volume and estimated contaminant concentrations in the leak along with the graphs shown in Figures A-1, A-2, and A-3. Using the graphs, the impacts from leak inventories greater or lesser than those shown for the 8,000-gal. reference volume can be estimated rapidly by extrapolating from the impacts shown for the reference volume.

A2.2 INVENTORY

The reference lines shown in Figures A-1, A-2, and A-3 to indicate current inventory and retrieval leak inventory were developed from the best available data and information. Current inventories were taken from the best-basis inventory by downloading from the Tank Waste Information Network System (TWINS) database (http://twinsweb.pnl.gov/twins.htm). Retrieval leak inventories were calculated by multiplying the hypothetical retrieval leak volume (8,000 gal.) by the estimated retrieval leak fluid concentration. Waste was assumed to be retrieved from tank C-102 by sluicing with recycled supernate from DST ~~AY~~AN-101. The retrieval leak fluid concentrations for this retrieval scenario were developed using data from RPP-~~21753~~22521 Rev. 6 and are shown in Table A-1.

~~The RPP-21753 flowsheet description provides calculated time-phased contaminant concentrations in both the recycled supernate and the retrieved slurry. The flowsheet assumes a retrieval sequence and includes DST-to-DST transfers necessary to maintain waste volume~~

~~within overall DST space limits. The flowsheet also includes planned near-term waste retrieval actions that would affect the tank inventory (e.g., C farm 200-series tanks waste retrieval).~~

~~The retrieval leak fluid concentrations used to develop the estimated leak inventories shown on the graphs were taken from the predicted liquid phase concentrations given in RPP-21753. The predicted liquid phase concentrations and resulting tank C-102 leak inventories for the DST AY-101 recycled supernate retrieval scenario are shown in Table A-1. The table also shows leak inventories for a raw water retrieval scenario.~~

~~Table A-1. Tank C-102 Retrieval Leak Inventory Comparison for Different Sluicing Fluids.~~Estimate

~~Contaminant~~	~~Leak Fluid Concentration~~			~~Inventory in 8,000-gal. Retrieval Leak~~		
	~~Tank AY-101 Supernate~~ [a]	~~Raw Water~~ [b]	~~Units~~	~~Tank AY-101 Supernate~~	~~Raw Water~~	~~Units~~
~~Technetium-99~~	~~4.04E-05~~	~~3.29E-07~~	~~Ci/L~~	~~1.22E+00~~	~~9.96E-03~~	~~Ci~~
~~Hexavalent chromium~~	~~1.41E-03~~	~~1.83E-04~~	~~kg/L~~	~~4.26E+01~~	~~5.54E+00~~	~~kg~~
~~Nitrite~~	~~2.20E-02~~	~~4.20E-03~~	~~kg/L~~	~~6.65E+02~~	~~1.27E+02~~	~~kg~~

~~[a] Appendix D, Table D-3 from RPP-21753, 2005, *C Farm 100 Series Tanks, Retrieval Process Flowsheet Description*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.~~

~~[b] Addendum C1, Table 9 from RPP-13774, 2004, *Single Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.~~

Table A-1. Tank C-102 Retrieval Leak Inventory Estimate.

Contaminant	Leak Fluid Concentration *	Inventory in 8,000-gal. Retrieval Leak
Technetium-99	5.84E-05 Ci/L	1.77E+00 Ci
Hexavalent Chromium	3.9E-04 kg/L	1.18E+01 kg
Nitrite	4.59E-02 kg/L	1.39E+03 kg

* Concentrations from Table D-9 of RPP-22521, *Tanks C-101, C-102, C-105, C-110, and C-111 Long Term Waste Retrieval Work Plan*

~~Raw water retrieval leak inventories are given in Table A-1 to provide a perspective on the potential effects on retrieval leak impacts caused by sluicing with recirculated DST supernate. The raw water inventories shown are the inventories used for the RPP-13774 base case risk analysis. Those inventories were based on a hypothetical 8,000-gal. retrieval leak volume and retrieval leak fluid concentrations estimated using the Hanford Tank Waste Operations Simulator (HTWOS) model. Because retrieval leak human health impacts are proportional to inventory, comparing the inventory differences provides an indication of the differences in impacts between the two sluicing fluids. Table A-1 indicates raw water leak inventories would be appreciably lower than the supernate leak inventories for technetium-99 and slightly lower for hexavalent chromium and nitrite.~~

A2.3 SUMMARY OF IMPACTS FROM HYPOTHETICAL 8,000-GALLON RETRIEVAL LEAK

The technetium-99 inventory associated with a hypothetical 8,000-gal. retrieval leak from tank C-102 was estimated to be approximately 1.~~22~~77 Ci (RPP-~~22392~~22521 Rev. 6). As shown in Figure A-1, this corresponds to an ILCR of approximately ~~1.42~~2.05 $\times 10^{-6}$ for the industrial scenario and ~~3.46~~4.99 $\times 10^{-5}$ for the residential scenario. The peak technetium-99 groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately ~~103~~149 pCi/L.

The hexavalent chromium inventory associated with a hypothetical 8,000-gal. retrieval leak from tank C-102 was estimated to be approximately ~~42.6~~11.8 kg (RPP-~~22392~~22521 Rev. 6). As shown in Figure A-2, this corresponds to a hazard quotient of approximately ~~0.014~~4.00 x 10^{-3} for the industrial scenario and ~~0.084~~2.30 x 10^{-2} for the residential scenario. The peak hexavalent chromium groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately ~~0.004~~1.00 x 10^{-3} mg/L.

The nitrite inventory associated with an 8,000-gal. retrieval leak from tank C-102 was estimated to be approximately ~~665~~1390 kg (RPP-22392). As shown in Figure A-3, this corresponds to a hazard quotient of approximately ~~0.0055~~1.15 x 10^{-2} for the industrial scenario and ~~0.036~~7.40 x 10^{-2} for the residential scenario. The peak nitrite groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately ~~0.056~~1.17 x 10^{-1} mg/L.

A2.4 EXAMPLE CALCULATION

To illustrate the calculation method used for the retrieval leak impact graphs, the following example is provided. The example uses the industrial scenario ILCR result of ~~1.42~~2.05 $\times 10^{-6}$. Using Equation 7-1 from Section 7.1.1, the industrial scenario ILCR was calculated as the product of the technetium-99 inventory (Table A-1), the technetium-99 retrieval leak unit groundwater concentration factor (Table 7-2), and the technetium-99 industrial scenario unit risk factor (Table 7-3), as follows:

ILCR = (1.~~225~~77 Ci) · $(8.4 \times 10^{1}$ pCi/L per Ci$)$ · $(1.38 \times 10^{-8}$ ILCR per pCi/L$) = 1.42 \times 10^{-6}$

Complete calculation details are provided in RPP-22392.

A3.0 INADVERTENT INTRUDER IMPACTS

The starting inventories for the tank C-102 intruder calculation were the estimated radionuclide inventories remaining in the tank following retrieval to the Ecology et al. (1989), *Hanford Federal Facility Agreement and Consent Order* (HFFACO) interim retrieval goal of 360 ft^3 of residual waste. These inventories were taken from RPP-15317, *241-C Waste Management Area Inventory Data Package*, and are based on the selective phase removal inventory estimation

RPP-21753, 2005, *C-Farm 100 Series Tanks, Retrieval Process Flowsheet Description*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-22521, *Tanks C-101, C-102, C-105, C-110, and C-111 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan*, Rev. 6, Washington River Protection Solutions, LLC., Richland, Washington.

~~RPP-22392, 2005, *Tanks C-102, C-104, C-107, C-108, and C-112 Long-Term Human Health Risk Calculations to Support Tank Waste Retrieval Work Plan*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.~~

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Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Change Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

<table>
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<tr><td rowspan="2">2. Minor Field Change:
(Section 12.4 HFFACO Action Plan)
☐ Yes: (WRPS Signature Only – Attach signed form to Primary Document for record purposes)
X No: Proceed to Box 3</td><td>3. Document Issue Date:
05/21/12</td><td rowspan="2">5. Notice Number: 2013-05</td></tr>
<tr><td>4. Document Modification Notice Date: 5/06/13</td></tr>
<tr><td>6.
Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?)
☐ Yes X No</td><td>7.
Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan?
☐ Yes X No</td><td>8. (Check only one box)
☐ Significant Modification
(Check if the answer to question in <u>either</u> section 6 or 7 is "yes". Significant modifications require revision of the primary document.)
Minor Modification
X Requires modification of the document
X Can be accomplished with Modification Notice.</td></tr>
</table>

9. Description and Justification of Change:

Change Description: A change notice is needed to modify the TWRWP to allow an alternative leak detection method for tank C-102. During retrieval construction some water was added to tank C-102 and the tank already contained 62,000 gallons (see RPP-22393 Table 2-4) of interstitial liquid exceeding the interim stabilization criterion of 50,000 gallons. According to Figure 4-3 of the TWRWP, if a tank does not meet interim stabilization criteria, weekly moisture logging is required if the HRR is not available for daily operation. Tank C-102 is not in active retrieval so daily HRR monitoring is not warranted; however, instead of performing weekly moisture logging, this change would allow monitoring with the HRR system for 30 days once a quarter. HRR monitoring is preferred because the HRR is expected to have better coverage than the 5 drywells available for moisture logging. Weekly moisture logging will be used as a backup method to quarterly HRR monitoring. HRR will be used for daily monitoring when active retrieval starts as specified in the TWRWP.

Justifications:

- Section 4.2.1, pg 4-7—updated language for use of HRR.

See the attached redline strikeout pages.

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10. Impact of Change:

HRR will be used to detect leaks while C-102 contains interstitial liquid volume greater than the interim stabilization criteria and during active retrieval. If weekly drywell monitoring is used 12 leak detection

WMA-C

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monitoring checks would be performed. If the HRR is used during the same period, up to 30 leak detection monitoring checks can be obtained. The deployed HRR system uses surface electrodes to provide more comprehensive monitoring for the portions around C-102 for which there are no drywells.
11. Additional Requirements and/or Provisions
Approvals

Washington River Protection Solutions, LLC.	Office of River Protection	State of Wash. Dept. of Ecology
☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date
☑ Final Approval Date 5/15/13	☑ Final Approval Date 5/15/13	☒ Final Approval Date 5-15-13

Notes

1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision
2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 11, prior to final approval of this modification.

4.2.1 Description of Proposed LDM System Configuration Used During Waste Retrieval

(Physical and Operating)

a. Describe the proposed LDM system configuration to be used during waste retrieval.

The leak detection and monitoring (LDM) method for C-102, C-104, C-107, C-108 and C-112 during retrieval uses deployment of a high-resolution resistivity (HRR) LDM system with drywells and the tank thermocouple as electrodes. The HRR system will be fully implemented administratively as well as physically implemented in the field when used.

Established drywell logging methods were used to survey the drywells surrounding C-108 prior to the start of retrieval, and will be used to survey the drywells surrounding C-102, C-104, C-107 and C-112 before the start of retrieval in these tanks. Drywell monitoring will be used as a backup means of leak detection if the HRR system becomes inoperable. The use of drywell logging as a backup is specified in 4.2.1.1.

Under limited conditions, as specified in 4.2.1.2, SST liquid level measurement may also be used for leak detection and monitoring.

Figure 4-3 is a logic chart showing what leak detection method(s) are used, and when with one exception for C-102. In lieu of weekly moisture logging that is required because the C-102 interstitial liquid volume exceeds the interim stabilization criteria (HNF-EP-0182), HRR may be used for 30 days once a quarter prior to the start of retrieval. Any other changes to leak detection will be approved on a tank-by-tank basis. Details of the methods shown in Figure 4-3 are provided in 4.2.1.1 through 4.2.1.3.

LDM systems consisting of standard leak detection arrangements are used for transfer lines and pits.

The LDM system used for the receiver DST is the same one described in Section 4.1.3.

Any resulting changes to LDM activities described in this TWRWP will be approved by Ecology within 24 hours through the Change Notice form.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Change Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

1. Document Title and Number: RPP-22393, Rev. 6A, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tanks Waste Retrieval Work Plan		
2. Minor Field Change: (Section 12.4 HFFACO Action Plan) ☐ Yes: (WRPS Signature Only – Attach signed form to Primary Document for record purposes) x No: Proceed to Box 3	**3.** Document Issue Date: 05/21/12 **4.** Document Modification Notice Date: 5/08/13	**5.** Notice Number: 2013-06
6. Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?) ☐ Yes x No	**7.** Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan? ☐ Yes x No	**8.** (Check only one box) ☐ Significant Modification (Check if the answer to question in either section 6 or 7 is "yes". Significant modifications require revision of the primary document.) Minor Modification x Requires modification of the document x Can be accomplished with Modification Notice.

9. Description and Justification of Change:

Change Description: A change is necessary to include updates that have been made in other TWRWPs. A full revision of RPP-22393, incorporating all approved modifications to revision 6A is planned.

Justifications:

- Pg viii—added trademark note
- Section 2.5, pg 2-13--clarified reference
- Section 3.1.3, pg 3-15—added requirement to provide basis and rationale for continued operation
- Section 3.8, pg 3-28--Updated IQRPE requirement reference.
- Section 4.1.2, pg 4-4 to 4.5– Deleted reference to outdated PNNL groundwater monitoring plan and reference and added current reference.
- Section 4.2, pg 4-6—Updated cross reference.
- Section 4.2.1.1, pg 4-11—Added new hydroprobe procedure reference.
- Section 5.0, pg 5-1--Updated air permit reference.
- Section 9—Updated references

See the attached redline strikeout pages.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Change Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

10. Impact of Change: The changes make RPP-22393 consistent with other recently modified TWRWPs.
11. Additional Requirements and/or Provisions

Approvals

Washington River Protection Solutions, LLC.	Office of River Protection	State of Wash., Dept. of Ecology
☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date
☒ Final Approval Date 10/8/13	☒ Final Approval CJK Date 10-8-2013	☒ Final Approval Date 10/15/13

Notes

1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision

2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 11, prior to final approval of this modification.

LIST OF TERMS

Terms

High Pressure Water in the context of this document means any water supplied at a higher pressure than the raw water supply pressure.

Abbreviations and Acronyms

1C	bismuth phosphate first-cycle decontamination
ALARA	as low as reasonably achievable
BBI	best-basis inventory
CH2M HILL	CH2M HILL Hanford Group, Inc.
COPC	constituent of potential concern
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERSS	Extended Reach Sluicing System
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
HI	hazard index
HIHTL	hose-in-hose transfer line
HRR™	high-resolution resistivity
IH	Industrial Hygiene
ILCR	incremental lifetime cancer risk
LDM™	leak detection and monitoring
ORP	Office of River Protection
PrHA	Process hazards analysis
PUREX	plutonium-uranium extraction
RCRA	*Resource Conservation and Recovery Act of 1976*
RMS	retrieval monitoring system
SST	single-shell tank
TBP	tributyl phosphate
TOC	tank operations contractor
UPR	unplanned release
WMA	waste management area
WRS	waste retrieval system

™ High-Resolution Resistivity (HRR) is a trademark of hydroGEOPHYSICS, Inc., Tucson, Arizona.
™ Leak Detection and Monitoring (LDM) is a trademark of hydroGEOPHYSICS, Inc., Tucson, Arizona

estimates developed using the Hanford Defined Waste (HDW) Model (RPP-19822, *Hanford Defined Waste Model – Revision 5.0).*

- The above meets the requirement in Section 2.1.3 of Appendix I of the HFFACO that requires those contaminants accounting for at least 95% of the impact to groundwater risk be addressed.
- The BBI is the best available data; however, the Part A Permit provides a list of constituents that may or may not be present in the SSTs. To address this uncertainty, a post-retrieval sample will be taken of the residual waste for all constituents identified in the Ecology-approved sampling and analysis plan, pursuant to the requirements of that sampling and analysis plan.

There are currently no plans to perform additional characterization (e.g., sampling and analyses) of the waste in tank C-102, C-104, C-107, C-108, or C-112 to support waste retrieval and transfer. Sampling and analyses of the waste from each of the tanks will be performed at or near the end of waste retrieval activities in support of component closure activity actions. Sampling and analysis activities associated with component closure actions will be defined through the planned component closure data quality objectives process and described in the associated waste sampling and analysis plans yet to be developed and to be approved by Ecology.

Meeting the informational requirements for waste transfers meets the substantive requirements of WAC 173-303-300, "General Waste Analysis." Compliance with the following documents is required before initiating a waste transfer:

1. RPP-29002, *Double-Shell Tank Waste Analysis Plan*. SST transfers into the DSTs for any reason must meet the waste acceptance criteria presented in this plan. This plan is written pursuant to WAC 173-303-300(5) and U.S. Environmental Protection Agency (EPA) guidance document OSWER 9938.4-03, *Waste Analysis at Facilities That Generate, Treat, Store and Dispose of Hazardous Waste.*

2. Waste Stream Profile Sheet (RPP-29002~~, Attachment A~~). The sheet addresses the applicable sections of WAC 173-303-300; 40 CFR 761, "Polychlorinated Biphenyls (PCBs). Manufacturing, Processing, Distribution, Commerce, and Use Prohibitions"; 40 CFR 268, "Land Disposal Restrictions"; and WAC 173-303-140, and also requires a waste compatibility assessment pursuant to HNF-SD-WM-DQO-001, *Data Quality Objectives for Tank Farms Waste Compatibility Program*, to meet WAC 173-303-395(1).

2.5.1 Tank C-102 Operating History

The following information is taken from HNF-SD-WM-ER-651, *Preliminary Tank Characterization Report for Single-Shell Tank 241-C-102: Best-Basis Inventory*. The purpose of HNF-SD-WM-ER-651 is to summarize the information on the historical uses, current status, and sampling and analysis results of waste stored in tank C-102.

operations have been performed to enable development of a justifiable definition. Until an ERSS MARS-S limit of technology definition is developed the same value used for modified sluicing in RPP-50910 is applied to MARS-S retrieval operations.

There is no limit of technology definition for a chemical retrieval process. A limit of technology definition will not be developed until sufficient chemical heel retrieval operations have been performed to enable development of a justifiable definition. It is estimated that this will take 3 to 4 heel retrieval operations.

Appendix C, Part 1 of the Decree defines the limit of technology as follows:

> "The "limits of technology" means that the recovery rate of that retrieval technology for that tank is, or has become, limited to such an extent that it extends the retrieval duration to the point at which continued operation of the retrieval technology is not practicable, with consideration of practicability to include matters such as risk reduction, facilitating tank closures, costs, the potential for exacerbating leaks, worker safety, and the overall impact on the tank waste retrieval and treatment missions."

For MARS-S, data for retrieval performance measurement used to show the limits of technology have been met will be used after implementation of one or both low pressure sluicing and high pressure water operations (each technology will not be evaluated separately for its limit of technology).

Experience has shown that unexpected waste forms and tank conditions may be encountered and that equipment performance can degrade with time. The ORP will inform Ecology at least every 2 weeks, through normally scheduled meetings, about unexpected waste forms, behavior and tank conditions along with retrieval equipment performance changes that would impact overall retrieval rates and retrieval volume. If a normally scheduled meeting does not occur Ecology will initiate a meeting for this information exchange.

At these meetings, ORP will provide to Ecology the basis and rationale for continuing retrieval when it is suspected that waste form behavior, tank condition and/or equipment performance has diminished significantly or performance impacted the ability of the deployed equipment to operate in order to meet the waste residual goal of 360 ft^3.

Ecology is notified in the Tri-Party Agreement project manager's monthly meeting when the limits of technology have been reached. Status reports are continued until waste retrieval operations cease. An SST waste retrieval evaluation form and a retrieval report are then prepared and issued and in accordance with the Decree, Part IV, B. 5:

> "When DOE completes retrieval of waste from a tank covered by this Decree, DOE will submit to Ecology a written certification that DOE has completed retrieval of that tank. For purposes of this Consent Decree, "complete retrieval" means the retrieval of tank waste in accordance with Part 1 of Appendix C and with the retrieval technology/systems that were established by Part 1 of the TWRWP either by approval of Ecology or after dispute resolution by the Court under Section IX of the Decree."

a tank system in accordance with WAC-173-303-040, "Definitions." The waste tank system equipment is described in Section 3.1.1.

A written integrity assessment, reviewed and certified by an IQRPE, attesting that the transfer-related equipment and associated transfer lines are suitable for use during waste retrieval operations will be prepared in accordance with WAC 173-303-640(3), "Design and Installation of New Tank Systems or Components," and submitted to Ecology following completion of the design and field installation of the WRS. This includes verification that the subject equipment meets the requirements set forth in WAC 173-303-640(3) and WAC 173-303-640(4), "Containment and Detection of Releases." If additional systems or additional transfer line systems are used, each system will be evaluated by an IQRPE. The design provided to the IQRPE for review will include all new or existing transfer systems, structures or components, including secondary containment (e.g., central caisson if used) and leak detection equipment used for waste transfer lines.

The requirements for an IQRPE assessment and the permitting decision logic for new equipment or repairs/upgrades to equipment will be performed in compliance with TFC-ESHQ-ENV_PP-C-11, ~~*IQRPE*~~ *Independent Qualified Registered Professional Engineer Assessment Process* ~~(currently in draft) or successor document~~.

Risers were reviewed as part of the original SST System Integrity Assessment (RPP-10435). SST system components (e.g., risers, pits, etc.) that were identified as part of the SST system for the original Integrity Assessment are not part of the retrieval system (unless specifically identified as such) and do not require a separate or additional integrity assessment if the function of the equipment doesn't change from its original purpose (e.g., the original purpose of risers is to provide tank access) and changes to the component are not outside the original component design basis and specifications.

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4.1.2 Groundwater Monitoring

Identify the number and location of groundwater monitoring wells associated with the Waste Management Areas (WMA). Summarize current groundwater monitoring activities.

Groundwater monitoring at WMA C was begun in 1990 using four RCRA groundwater monitoring wells constructed in 1989 (299-E27-12, 299-27-13, 299-E27-14, and 299-E27-15). ~~The groundwater beneath the C tank farm has been monitored since 2001 in accordance with the RCRA groundwater monitoring plan established in 2001 (PNNL-13024, *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site*). Figure 4-2 provides a plan view of the C tank farm and the surrounding RCRA groundwater monitoring wells. There are nine groundwater monitoring wells surrounding the C tank farm (four new wells were constructed in 2003). Since June 2002, groundwater sampling for the groundwater wells 299-E-27-7, 299-E-27-12, 299-E-27-13, 299-E-27-14, and 299-E-27-15 has been performed on a quarterly basis (PNNL-13024, ICN-1). Since December 2003, new groundwater monitoring wells 299-E-27-4, 299-E-27-21, 299-E-27-22, and 299-E-27-23 have also been sampled on a quarterly basis.~~ Additional monitoring wells have been added since 1989. A current list of the WMA C groundwater wells can be found in DOE/RL-2009-77. The wells are sampled quarterly to meet prior agreements made with Ecology. Quarterly samples are analyzed at a minimum for anions, cyanide, inductively coupled plasma metals, gross beta, ^{99}Tc, and total uranium, and a low-level gamma scan is performed. Sampling is conducted in accordance with DOE/RL-2009-77 and DOE/RL-2001-49.

The quarterly groundwater monitoring that is currently performed is adequate for the purpose of supplementary data collection during waste retrieval. Ecology is provided quarterly groundwater monitoring sample results in the quarterly and annual groundwater monitoring reports. These reports were previously issued by Pacific Northwest National Laboratory (e.g., results from the groundwater monitoring at the C tank farm for the third quarter of 2006 are reported in PNNL-16349, *Quarterly RCRA Groundwater Monitoring Data for Period July through September 2006*), in 2007 they started being issued by Fluor Hanford.

If a leak is detected during retrieval, groundwater monitoring frequency will be reevaluated in accordance with the regulatory requirements in WAC 173-303, "Dangerous Waste Regulations."

4.1.2.1 Use of Groundwater Monitoring for Retrieval Process Control.

(1) Evaluate the use of appropriately located existing groundwater monitoring wells for retrieval process control.

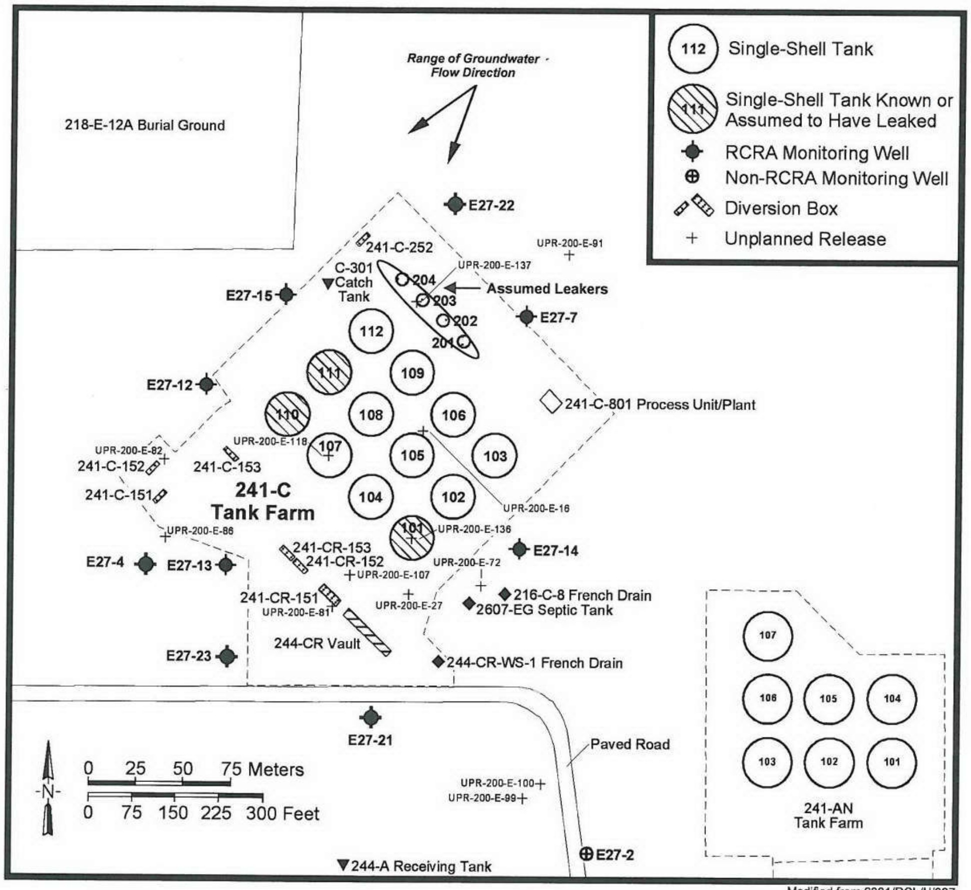
Based on the limitations of flow transport calculations and the time required for a retrieval leak to show up in groundwater samples, groundwater monitoring data will not be used for retrieval process control, but is available, for background reference information only, through the site groundwater monitoring program.

4.1.2.2 Groundwater Sampling Prior to and Following Retrieval.

(2) *Ensure that appropriately located existing groundwater monitoring wells will be sampled within a two month period prior to and following the retrieval (quarterly sampling satisfies this requirement).*

~~PNNL-13024, ICN-1, requires q~~Quarterly groundwater sampling is performed for the C-farm groundwater monitoring wells. In accordance with 04-TPD-083, "*Agreement on Content of Tank Waste Retrieval Work Plans*" (04-TPD-083 – letter), it was agreed to in writing by ORP, Ecology, and the tank farm contractor that quarterly groundwater sampling satisfies the TWRWP outline requirement C.1.b.(2) (this wording is in italics at the start of Section 4.1.2.2) to take groundwater samples within a 2-month period prior to and following retrieval.

Figure 4-2. Waste Management Area C and Regulated Structures.*^



* Adapted from Figure B.18 in PNNL-14548, 2004, *Hanford Site Groundwater Monitoring for Fiscal Year 2003*, Pacific Northwest National Laboratory, Richland, Washington.

^The most current list of groundwater monitoring wells can be found in DOE/RL-2009-77

4.1.3 Existing Tank Level Monitoring Equipment and Activities

Identify existing level measurement instrumentation in the subject tank and receiver tank. Identify ongoing tank level monitoring activities.

Tanks C-102, C-104, C-107, C-108 and C-112 currently have operable Enraf level gauges installed. The DST receiver tanks also have the same type of level gauge installed. Each DST receiver tank annulus has leak detection devices installed such as conductivity gauges, Enraf level gauges or similar instruments for detection of leaks from the primary tank liner.

The waste levels in tanks C-102, C-104, C-107, and C-112 while in storage mode (and C-108 when it was in storage mode) are monitored for intrusion on a quarterly basis using an ENRAF level gauge (OSD-T-151-00031, *Operating Specifications for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection*). The basis for in-tank leak detection and intrusion monitoring is provided in RPP-9937, *Single-Shell Tank System Leak Detection and Monitoring Functions and Requirements Document*.

The primary level monitoring in the receiver DST is performed as described in OSD-T-151-00031. The annulus leak detector instruments provide indication of tank leaks as described in OSD-T-151-00031.

Level monitoring for the tank receiving the exhauster condensate, if not the SST being retrieved, will be performed as specified in the applicable Ecology approved TWRWP for that tank.

4.2 PROPOSED LEAK DETECTION MONITORING SYSTEM DESCRIPTION

This section provides a description of the leak detection and monitoring (LDM) system that will be deployed at tank s C-102, C-104, C-107, C-112, and the remaining C-108 waste retrieval operations, along with a description of how the system will be operated.

The definition of when a tank is changed from storage mode to retrieval mode is provided in OSD-T-151-00031. A tank is considered to be officially in retrieval status if one of two conditions is met: either waste has been physically removed from the tank by retrieval operations or, preparations for retrieval operations are directly responsible for rendering a primary leak detection or intrusion monitoring device out of service.

When all waste removal operations have been completed, a final waste volume measurement obtained, and all post-retrieval monitoring required by this document completed, the tank retrieval status is maintained but retrieval leak detection is complete and the tank is monitored for intrusion as specified in Section 6.~~3~~0.

percent moisture in the soil. Use of the handheld moisture gauge does not require truck access into the tank farm and is more practical for frequent use.

The RAS truck was specifically designed for routine gamma monitoring against the baseline established from the spectral gamma logging system data. The RAS uses a series of three interchangeable NaI(Tl)-based scintillation detectors for measurement over the range from background levels to about 10^5 pCi/g ^{137}Cs. The RAS records counts in specific energy ranges as well as total gamma activity. Although it does not have the energy resolution capability of the spectral gamma logging system, it is mounted on a smaller truck and collects data at a faster rate.

The RMS is a modular, portable logging unit capable of concurrent measurement of gross gamma activity and neutron moisture content. The RMS will have calibrated neutron moisture and gross (total) gamma detectors on a combined probe. It will provide dual data logs over preselected depth intervals in the drywells. The overall size and portability of the RMS will minimize interference with surface equipment, and the capability of collecting both moisture and gamma data in a single log run can result in a significant reduction in the cost of monitoring activities when compared to obtaining separate neutron and gamma logs. The RMS also provides for electronic data recording. When implemented, the RMS may be substituted for the handheld moisture gauge and may also be used in place of truck-mounted logging systems. Drywells with very high gamma activity (none of the seven around tank C-110 are in this category) may still require the use of the high rate logging system that is part of the SGLS, but it is possible that a high rate detector can be developed for the RMS. Development of the RMS is complete but as of mid 2008 it is not yet available for deployment. It is anticipated that the RMS will have a measurement range from background up to 100,000 pCi/g ^{137}Cs and 0 to 25 vol% moisture content.

The SGLS logging system was used to establish baseline conditions in 1995-2000. This logging system is based on a liquid nitrogen cooled high purity germanium detector, which provides excellent gamma energy resolution for identification and quantification of individual radionuclides from background levels (method detection limit about 0.1 pCi/g ^{137}Cs under typical conditions) up to about 10,000 pCi/g ^{137}Cs. A high rate detector with internal and external shields is available to extend the measurement range to about 10^9 pCi/g ^{137}Cs.

The SGLS truck can also be used to operate a neutron moisture logging system, which measures in situ vadose zone moisture over the range of 0 to about 25 vol% moisture content. The neutron moisture logging system uses a similar source-detector relationship as the handheld moisture gauge.

It takes about one shift of operation to obtain moisture logging data from all the drywells around a tank with the hand-held moisture probe. It takes about one shift of operation to obtain RAS data from one drywell.

The handheld moisture gauge will be deployed by qualified personnel in accordance with TO-320-022, *Operate Model 503DR M1 HP-2 or M1 HP-3 Hydroprobe Neutron Moisture* ~~*Detection*~~*Gauge* or TO-320-060, *Operate Model 503DR M1 HP-4 Hydroprobe Neutron Moisture Gauge.*

5.0 REGULATORY REQUIREMENTS IN SUPPORT OF RETRIEVAL OPERATIONS

Retrieval of waste from the C-Farm SSTs will be performed under the requirements of the Decree, *Atomic Energy Act of 1954*, RCRA, Chapter 70.105 RCW and its implementing regulations, and WAC-173-303. The SSTs do not provide secondary containment and are not compliant with RCRA and Chapter 70.105 RCW interim facility standards of Subpart J of 40 CFR 265. The SSTs are currently authorized to continue operations under Chapter 70.105 RCW pending closure in accordance with WAC 173-303-610, "Closure and Post-Closure," under the authority of the HFFACO Milestone M-45-00, "Complete Closure of all Single Shell Tanks Farms." Except as otherwise modified by HFFACO Milestone M-45-00, DOE conducts day-to-day operations of the SSTs in accordance with the interim facility standards established in WAC-173-303-400(3), "Interim Status Facility Standards." WAC 173-303-400(3) incorporates by reference the interim status performance standards set forth by the EPA in 40 CFR 265. Additionally, the SSTs are governed by federal regulations promulgated under the authority of the *Atomic Energy Act of 1954* and various DOE directives incorporated into the contract between ORP and the TOC (DE-AC27-08RV14800 for current TOC). These requirements are implemented through operating plans and procedures by the TOC.

Interim status facility standards in WAC 173-303-400(3)(a) incorporate, by reference, the interim status standards set forth by EPA in 40 CFR 265 Subpart J for tank systems. Elements of the interim status standards relevant to the WRS along with the WRS features and/or operating plans and procedures are summarized in Table 5-1.

If necessary, DOE will seek approval to retrieve waste that could contain polychlorinated biphenyls from tanks C-102, C-104, C-107, C-108, and C-112 using supernate from the receiver DST and transfer the resulting slurry to the respective receiver DST from EPA before initiating waste retrieval operations. DST supernate is classified as polychlorinated biphenyl remediation waste in accordance with Ecology et al. (2000), *Framework Agreement for Management of Polychlorinated Biphenyls (PCBs) in Hanford Tank Waste*. Because the DST supernate is polychlorinated biphenyl remediation waste, the retrieval of waste from SSTs, when using DST supernate, requires a Risk-Based Disposal Approval, approved by EPA, pursuant to the *Toxic Substances Control Act of 1976*.

The ventilation system(s) used during waste retrieval operations are designed to pass air through the tank, thereby reducing condensation and fog within the tank. The ventilation systems required by Washington State Department of Health include a heater, prefilter, demister, two high-efficiency particulate air filters and test sections, exhaust fan, and stack. Details of the ventilation systems are provided in ~~AIR 09-704, *Categorical Tank Farm Facility Waste Retrieval and Closure: Phase II Waste Retrieval Operations (including as amended in updates)* and DE05NWP-002R2, *Approval of Criteria and Toxics Air Emissions Notice of Construction (NOC) Application for Hanford Single-Shell Tank Waste Retrieval (as amended in updates)*~~*00-05-006, Hanford Site Air Operating Permit,* as amended and succeeded.

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Project Title/Work Order		EDT No. N/A
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